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Olin CHEMICALS

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Phone: (615) 336-4000

October 21, 1993

VIA FEDERAL EXPRESS

Kenneth A. Lucas
Remedial Project Manager
United States Environmental Protection Agency
345 Courtland Street Northeast
Atlanta, Georgia 30365

Re: Feasibility Study
Olin Chemicals/McIntosh Plant Site
McIntosh, Alabama

Dear Mr. Lucas:

This letter transmits the Feasibility Study (FS) report for the subject site to the Environmental Protection Agency for its review and approval. Olin submits this report under paragraph VII.F. of the Administrative Order on Consent (AOC). The FS report was prepared for Olin by Woodward-Clyde Consultants, Baton Rouge, LA. The report summarizes the development, screening, and detailed analysis of remedial alternatives for the site. The report also incorporates EPA's September 2 comments on the draft FS report, as resolved at our meeting of September 28. Attachment 1 details how these comments were incorporated.

I would like to call your attention to one point included in the FS. The area west of the former CPC plant was identified in the Remedial Investigation (RI) report as a potential continuing source of groundwater contamination based on the elevated concentrations of chlorinated benzenes in the soil. Consequently, potential soil action levels (PSALs) were calculated for this area. In developing remedial alternatives for this area, more accurate topographic maps were used and it was found that the area was actually smaller than that used in calculating the PSALs. This changed the modeling results such that this area is not a potential continuing source of groundwater contamination. The alternatives have been retained in Sections 3 and 4 of the FS, but notes have been added to the text and tables explaining the above situation.

Please let me know if you have any questions regarding this submission.

Sincerely,
OLIN CORPORATION

J. C. Brown
Manager, Environmental Technology

cc: W. A. Beal
D. E. Cooper (2)
L. S. Casteel (w/o att.)
A. S. Karlin
W. G. McGlasson (w/o att.)
J. L. McIntosh (w/o att.)
T. B. Odom

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Attachment

ATTACHMENT 1 4 9 0 0 1

NOTES REGARDING INCORPORATION OF EPA COMMENTS OF SEPTEMBER 2, 1993 INTO THE FEASIBILITY STUDY REPORT FOR OLIN CHEMICALS/MCINTOSH PLANT SITE MCINTOSH, ALABAMA

This attachment describes how the draft Feasibility Study (FS) report, submitted to EPA on May 5, 1993, was revised in accordance with EPA's comments of September 2 and agreements made in a meeting on September 28. This serves as Olin's response to EPA's comments as well as a guide to which sections of the FS report were changed in response to the comments. Revisions are numbered the same as EPA's comments in the attachment to the September 2 letter, except for the revisions described below made in response to the cover letter. The section and table numbers referred to herein may not be the same as those in the draft FS report because material has been added to the FS report in response to EPA's comments.

COVER LETTER

1. The draft FS report of May 5, 1993, and the Potential Soil Action Level (PSAL) report of June 23, 1993, were combined. The PSAL report is included as Appendix F and summarized in Section 2.2.3 of the FS report.

2. EPA and Olin agreed to a revised submission date forty-four days after Olin's receipt of EPA's letter.

ENCLOSURE A

GENERAL COMMENTS

1. Remedial alternatives were developed for the specified SWMUs/AOCs in accordance with agreements documented in Olin's letter of September 30. Section 1.3.1.2 summarizes the information from the Remedial Investigation (RI) report, Section 1.4.1 presents a quantification of the effect on groundwater

from these units, Section 3.2.2 presents development of alternatives, and Section 4.2.4 presents the analysis of the alternatives.

2. Discussion of Land Disposal Restrictions (LDRs) added to Section 2.2.2.3, and discussion has been added for the appropriate alternatives in Section 4.0.

3. Olin acknowledges NOAA's comments and understands NOAA's position. Olin believes that the RI report, especially the ecological assessment in Section 6.0, supports, despite the presence of site-related chemicals of concern in OU-2 water, sediments, and biota, that the ecosystem has not been unacceptably affected. However, it is clear that additional data regarding effects needs to be collected and EPA and Olin have been discussing what data are required. Olin disagrees that any potential threat to trust resources from the contamination in OU-2 sediments was disregarded.

SPECIFIC COMMENTS

1. Sections 1.6 and 2.2.1 were revised and Table 1-12 was added to revise the FS report in accordance with EPA's comment.

2. Sections 1.6 and 2.2.1 were revised and Table 1-12 was added to revise the FS report in accordance with EPA's comment.

3. The discussion of uncertainty and technical impracticality was moved to the implementability section of the Executive Summary.

4. Remedial alternatives were developed for the specified SWMUs/AOCs in accordance with agreements documented in Olin's letter of September 30. Section 1.3.1.2 summarizes the information from the Remedial Investigation (RI) report, Section 1.4.1 presents a quantification of the effect on groundwater from these units, Section 3.2.2 presents development of alternatives, and Section 4.2.4 presents the analysis of the alternatives.

5. Section 1.2.1.2 was revised in accordance with agreements documented in Olin's letter of September 30.

6. Section 2.2.5 was revised and modeling was conducted (see Appendix A) in accordance with agreements documented in Olin's letter of September 30.

7. Sections 1.3.2.3 and 2.2 were revised in accordance with EPA's comment.

8. Section 1.2.4 referring to the extent of the plume and Section 1.4.1.2 referring to the potential for the dense brine to migrate downward into the Miocene aquifer were revised in accordance with EPA's comment.

   The statement regarding low concentrations in pore water referred to in EPA's comment was in context of pore water from deeper soils in the vicinity of the area west of the former CPC plant. It was not intended to refer to all pore water at the site now or in the past, and bears no relationship to the fact that the groundwater has been contaminated by other sources.

   Sections 1.3.2.3 and 2.2 were revised in accordance with EPA's comment.

9. Table 1-6 was revised in accordance with EPA's comment.

10. Section 2.2.3 was revised in accordance with EPA's comment.

11. Section 2.2.5 was revised and modeling was conducted (see Appendix A) in accordance with agreements documented in Olin's letter of September 30.

12. Table 2-6 presents a comparison of constituent concentrations to AWQS. Additionally, Section 2.2.5 was revised and modeling was conducted (see Appendix A) in accordance with agreements documented in Olin's letter of September 30.

13. Table 3-3 of the PSAL report in Appendix F was revised in accordance with agreements documented in Olin's letter of September 30.

14. No revisions were made to the FS report. This is in accordance with agreements documented in Olin's letter of September 30.

15. No revisions were made to the FS report. This is in accordance with agreements documented in Olin's letter of September 30.

16. The depth of remediation was changed to 23 feet throughout the FS report.

17. Table 2-5 was revised in accordance with EPA's comment.

18. The directive number was changed in accordance with EPA's comment.

19. Sections 3.2.1 and 4.2.3 were revised in accordance with EPA's comment, adding alternatives for this area.

20. Section 2.3.4 was revised in accordance with agreements documented in Olin's letter of September 30.

21. Section 2.4.3 was revised in accordance with EPA's comment.

22. Table 2-1 was revised in accordance with EPA's comment.

23. Section 2.4 was revised in accordance with EPA's comment.

24. Section 3.1 and Table 2-10 were revised in accordance with EPA's comment.

25. More discussion was provided in Table 2-10 as a basis for screening out this technology.

26. Section 2 tables were revised in accordance with EPA's comment.

27. A footnote was added to Tables 2-18 through 2-25 in accordance with EPA's comment.

28. Section 2 tables were revised in accordance with EPA's comment.

29. Section 3.0 was revised in accordance with EPA's comment.

30. Section 1.2.4 was added in accordance with EPA's comment.

31. No revisions were made to the FS report, which is in accordance with agreements documented in Olin's letter of September 30.

32. Section 3.1 was revised in accordance with EPA's comment.

33. An analysis of injection effects was added to Appendix A.

34. Section 4.2 was revised in accordance with EPA's comment.

35. Section 4.2.1.2 was revised in accordance with EPA's comment.

36. Section 4.2.2 was revised in accordance with EPA's comment.

37. No revisions were made to the FS report, which is in accordance with agreements documented in Olin's letter of September 30.

38. Section 4.2.5 was revised in accordance with EPA's comment.

39. The basis of the statement that the Basin is a depositional area in discussed in Section 1.4.2. Future data collection to allow an estimate of the deposition rate is described in Section 4.2.5.2. These are in accordance with agreements documented in Olin's letter of September 30.

40. Section 4.2.1.3 was revised in accordance with EPA's comment.

41. Sections 4.2.2.2 and 4.2.2.3 were revised in accordance with EPA's comment.

42. Sections 1.6 and 2.2.1 were revised and Table 1-12 was added to quantify the ecological risks to the extent possible given the data collected under the approved work plan. No revisions were made to the FS regarding the second part of EPA's comment. The number of fish that would reside in the Basin long enough to become contaminated and then move into the river would be insignificant when compared to the number of fish in the river. That is, the risks estimated in the baseline risk assessment for consumption of Basin fish are conservative enough to account for the insignificant increase that may result from some fish moving from the Basin into the river.

43. Section 4.2.5.3 was revised in accordance with EPA's comment.

44. The paragraph following the cost table for Alternative E was revised to explain that the difference is the handling and off-site disposal of debris from the current wastewater ditch.

45. Section 4.3.1 was revised to eliminate language that seemed to rule out the possibility of selecting both groundwater and soil alternatives.

46. Section 4.2.5.5 was clarified relative to the sediment's classification as hazardous waste.

47. Appendix G was revised in accordance with EPA's comment.

48. Text in Appendix G for the appropriate alternatives was clarified regarding the varying percentages and the nature of unlisted items.

49. Mobilization was included in the "per foot" cost of standard, vertical wells. Mobilization for the horizontal well was separate because it is specialized technology and requires substantial mobilization. The FS report was not revised.

50. Appendix G was revised in accordance with EPA's comment.

ENCLOSURE B

GENERAL COMMENTS

Introductory Paragraph

EPA and Olin disagreed on the appropriateness of the SOLUTE model. In accordance with agreements documented in Olin's letter of September 30, no revisions were made to the FS report or PSAL report since both PESTAN and SOLUTE results were already included.

1. Table 1-3 in the FS was revised in accordance EPA's comments.

2. See response to Introductory Paragraph above.

3. See response to Introductory Paragraph above.

4. See response to Introductory Paragraph above.

SPECIFIC COMMENTS

1. The FS report was revised to include a list of acronyms.

2. The location of these borings were included in the revised FS report.

3. The location of these borings were included in the revised FS report.

4. See response to Introductory Paragraph above.

5. See response to Introductory Paragraph above.

6. The citation was revised and included in the reference list in the revised FS report.

7. See response to Introductory Paragraph above.

8. Table 3-3 of Appendix F, the PSAL report, describes the basis of calculation of these parameters.

9. See response to Introductory Paragraph above.

10. See response to Introductory Paragraph above.

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronyms and abbreviations used in the Feasibility Study are as follows:

ACGIH	American Conference of Governmental Industrial Hygienists
ACL	Alternate Concentration Limits
ADEM	Alabama Department of Environmental Management
AOC	Area of Concern or Administrative Order by Consent
ARARs	Applicable or Relevant and Appropriate Requirements
BCM	BCM Engineers
BGS	Below Ground Surface
CAD	Contained Aquatic Disposal
CAMU	Corrective Action Management Unit
CAP	Corrective Action Program
CDF	Confined Disposal Facility
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (also known as Superfund) as amended in 1986
CPC	Crop Protection Chemicals
CRQL	Contract Required Quantitation Limit
CSMS	Center for Subsurface Modeling Support
CWA	Clean Water Act
DO	Dissolved Oxygen
DOTD	U. S. Department of Transportation and Development
EPA	U. S. Environmental Protection Agency
FDA	Food and Drug Administration
FS	Feasibility Study
FWS	Fish and Wildlife Service
HA	Health Advisories
HDPE	High Density Polyethylene
HEA	Health Effects Assessments
HSWA	Hazardous and Solid Waste Amendments
IGWMC	International Ground Water Modeling Center
K	Hydraulic Conductivity
LDR	Land Disposal Restriction
MCL	Maximum Contaminant Level: Established under the Safe Drinking Water Act (SWDA)
MCLG	Maximum contaminant level goal: Established under the Safe Drinking Water Act
MSL	Mean Sea Level
MTR	Minimal Technological Requirement
NCP	National Oil and Hazardous Substances Contingency Plan
NIOSH	National Institute of Occupational Safety and Health
NPDES	National Pollution Discharge Elimination System

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

NPL	National Priority List (of CERCLA)
NWFS	National Wildlife and Fisheries Service
OSHA	Occupational Safety and Health Act
OU-1	Operable Unit 1 (all Olin Property except OU-2)
OU-2	Operable Unit 2 is a natural basin on the floodplain of the Tombigbee River, the wetlands on Olin property around the basin, and the wastewater ditch leading to the basin.
PCNB	Pentachloronitrobenzene
PR	Preliminary Review
PRG	Preliminary Remediation Goals
PSAL	Potential Soil Action Level
PVC	Polyvinyl Chloride
Q_1	Upper Quaternary Clay Unit
Q_2	Quaternary Alluvial Aquifer
RA	Risk Assessment
RAO	Remedial Action Objectives
RCRA	Resource Conservation and Recovery Act
REL	Recommended Exposure Limit
RFA	RCRA Facility Assessment
RfD	The reference dose (RfD) is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime.
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
RMCL	Recommended Maximum Concentration Limit
RME	Reasonable Maximum Exposure
ROD	Record of Decision (documents selection of remedy)
RRAOTM	Revised Remedial Action Objectives Technical Memorandum
RSD	Risk-Specific Doses
RTASTM	Remedial Alternatives, Alternatives screening Technical Memorandum
SARA	Superfund Amendments and Reauthorization Act of 1986. (See CERCLA)
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SETM	Source Evaluation Technical Memorandum
SMCL	Secondary Maximum Contaminant Level
SNARLS	Safe Drinking Water Committee, Drinking Water and Health
S/S	Stabilization/Solidification
SWMU	Solid Waste Management Unit

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)

TAL	Target Analyte List
TBC	To-Be-Considered
TCAN	Trichloroacetonitrile
TCL	Target Compound List
TDS	Total Dissolved Solids
TIC	Tentatively Identified Compounds
TLV	Threshold Limit Values
Tm_1	Tertiary (Miocene) confining unit
Tm_2	Tertiary (Miocene) Aquifer
TOC	Total Organic Carbon
TSS	Total Suspended Solids
UIC	Underground Injection Control
USACE	U. S. Army Corps of Engineers
USDA	U. S. Department of Agriculture
VISITT	Vendor Information System for Innovative Treatment Technologies
WCC	Woodward-Clyde Consultants

EXECUTIVE SUMMARY

This feasibility study (FS) report presents the results of the evaluation and analysis of potential remedial alternatives to prevent or mitigate the migration, release or threatened release of contaminants from Olin Corporation's McIntosh, Alabama plant site. Woodward-Clyde Consultants prepared the feasibility study for Olin, which signed an Administrative Order by Consent (AOC), effective May 9, 1990, with the U. S. Environmental Protection Agency to satisfy the National Contingency Plan under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The AOC divided the site into two operable units. Operable Unit 1 (OU-1) is the plant area (all Olin property except OU-2). Operable Unit 2 (OU-2) is a natural basin on the floodplain of the Tombigbee River, the wetlands on Olin property around the basin, and the wastewater ditch leading to the basin. This FS report addresses potential remedial alternatives for both operable units.

SETTING

Olin has produced chlor-alkali chemicals at McIntosh since 1952, first with a mercury-cell process, and now with a diaphragm-cell process. Crop protection chemicals (CPC), basically chlorinated organics, were produced from 1952 to 1982. Wastewater discharge, solid waste management, and material handling loss resulted in groundwater, soil, and sediment contamination, consistent with the materials used at the site. Two groundwater aquifers underlie the site: a shallow Alluvial Aquifer (down to 100 feet below grade) and a deep Miocene Aquifer (below 180 feet), separated by a thick clay layer. Olin has operated a pump-and-treat Resource Conservation and Recovery Act (RCRA) corrective action program (CAP) since 1987 to remove contamination from the Alluvial Aquifer. Wastewater was discharged through the basin until 1974, leaving concentrations of mercury and hexachlorobenzene in the ditch and basin sediments. The closest residents are south of the site, in the direction of natural groundwater flow, and some drink water from shallow water wells.

REMEDIAL ACTION OBJECTIVES

For the current and likely future pathways in both operable units, the maximum estimated cancer risk and hazard index were 8.4 x 10^{-5} and 0.49, which are lower than the remedial action objectives of 10^{-4} and 1.0, respectively. Exposure to a hypothetical future resident in OU-1 (child and adult) was also evaluated; the maximum estimated cancer risk and hazard index were 6.7 x 10^{-3} and 48.9 for the hypothetical future resident. Olin asserts that this scenario is unlikely because the potential for the site to become residential is virtually nonexistent. Risk-based preliminary remediation goals (PRGs) were developed for the hypothetical child receptor to provide risk managers with information about potential risks if this industrial site were to become residential and if residents were to drink on-site groundwater at current concentrations.

The overall terrestrial and aquatic ecosystems of OU-2 are considered healthy. In view of dietary exposure calculations, it is improbable that any terrestrial or amphibious higher vertebrate populations in OU-2 are adversely affected by exposures. Preliminary remediation goals for potentially affected media were developed from the applicable or relevant and appropriate requirements (ARARs). To meet the preliminary remediation goals, remedial alternatives were considered for OU-1 groundwater, OU-1 soils and OU-2 sediments.

OU-1 groundwater remedial alternatives were developed for restoration of groundwater to ARARs. Chemical-specific ARARs included the Safe Drinking Water Act maximum contaminant levels (MCLs) and maximum contaminant level goals (MCLGs). The legally enforceable groundwater cleanup standards (which are based on MCLs) that have been established at the site for the ongoing RCRA corrective action program were also identified as potential ARARs.

OU-1 soil remedial alternatives were developed for various areas found in the site characterization to contain hazardous substances. These areas generally correspond to several of the designated SWMUs/AOCs at the site. The alternatives are grouped by areas identified as potential continuing sources of groundwater contamination and those not so identified. The old plant (CPC) landfill and the area west of the former CPC

plant were identified as potential continuing sources of groundwater contamination[1]. The old plant landfill drainage ditch, sanitary landfills, lime ponds, mercury cell plant, and well sand residue area were found in the site characterization to contain hazardous substances, but were not identified as potential continuing sources of groundwater contamination.

OU-2 sediment remedial alternatives were developed to reduce exposure of fish and other biota to contaminants and to meet the surface water ARARs. Water quality criteria were identified as potential chemical-specific ARARs for the basin. The NPDES permit discharge limits, which Olin currently complies with, were identified as potential chemical-specific ARARs for the wastewater ditch.

SUMMARY OF REMEDIAL ALTERNATIVES

General response actions and potential remedial technologies were evaluated. Potential technologies and process options were then selected for assembling the remedial alternatives. Initially, 43 alternatives were assembled (excluding no action). These 43 alternatives were screened based on effectiveness, implementability and cost, and 27 alternatives were retained for detailed analysis: three for OU-1 groundwater, fifteen for OU-1 soil and nine for OU-2 sediment. Detailed analysis was performed using these criteria: overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume; short-term effectiveness; implementability; and cost.

OU-1 GROUNDWATER ALTERNATIVES

The assembled groundwater alternatives were designed to increase the rate of contaminant removal through extraction or enhanced extraction and would be

[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils, indicating that remedial action is not required for protection of groundwater.

implemented to augment the RCRA CAP. The following groundwater alternatives were retained for the detailed analysis:

Alternative A	-	No Action With Continuation of Existing RCRA CAP
Alternative C1	-	Extraction/Treatment/Discharge (Vertical Extraction Wells)
Alternative C3	-	Extraction/Treatment/Discharge (Vertical and Horizontal Extraction Wells)

Overall Protection of Human Health and the Environment — All the OU-1 groundwater alternatives would be protective because they would be implemented in conjunction with the existing RCRA CAP. Olin is committed by a legally enforceable RCRA post-closure permit to operate the ongoing CAP until the established cleanup standards are achieved. The RCRA CAP effectively controls off-site migration of the plume and prevents exposing residents living downgradient to contaminated groundwater.

Compliance With ARARs — All the OU-1 groundwater alternatives would comply with ARARs. The RCRA cleanup standards, which are based on MCLs, were identified as chemical-specific ARARs. Olin is legally required to attain these standards. The groundwater alternatives could be implemented to comply with the identified action- and location-specific ARARs.

Long-Term Effectiveness and Permanence — Groundwater alternatives C1 and C2 would both accelerate contaminant removal. Alternative C1 would use conventional vertical wells to remove contaminants from the Alluvial Aquifer in the old plant (CPC) landfill area and the area of mercury-containing dense brine. Alternative C3 would use a vertical well in the old plant (CPC) landfill area and a horizontal well for brine removal, which should be more effective than the vertical well.

Reduction in Toxicity, Mobility and Volume — The groundwater alternatives would reduce mobility and remove contaminants from the aquifer. There would be a greater reduction with Alternative C3 because there would be direct removal of the mercury-containing dense brine.

Short-Term Effectiveness — There would be only minimal adverse short-term effects associated with the groundwater alternatives.

Cost — The total present worth cost for groundwater alternatives C1 and C3 was estimated as moderate (less than $5,000,000).

OU-1 SOIL ALTERNATIVES

The following OU-1 soil alternatives were retained for the detailed analysis:

Alternative A - No Action

OLD PLANT (CPC) LANDFILL

Alternative C - Containment (Improve Capping)
Alternative D - In Situ Stabilization-Solidification/Containment
Alternative E - Excavation/Stabilization-Solidification/Containment
Alternative F - Excavation/Off-Site RCRA Disposal
Alternative G1 - Excavation/On-Site Thermal Treatment/Disposal

AREA WEST OF FORMER CPC PLANT

Alternative C - Containment (Extend Existing Cap)
Alternative D - In Situ Stabilization-Solidification/Containment
Alternative E - Excavation/Stabilization-Solidification/Containment
Alternative F - Excavation/Off-Site RCRA Disposal
Alternative G - Excavation/On-Site Thermal Treatment/Disposal

SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative B1	-	Institutional Actions (Cap Inspection/Maintenance, Groundwater Monitoring near Sanitary Landfills)
Alternative B2	-	Institutional Actions (Cap Inspection/Maintenance, Expanded Groundwater and Surface Water Monitoring)
Alternative C1	-	Containment (Sanitary Landfills and Lime Ponds)/ Institutional Actions
Alternative C2	-	Containment/Consolidation (Sanitary Landfills, Lime Ponds and Well Sand Residue Area)/Institutional Actions

Overall Protection of Human Health and the Environment — All the retained soil alternatives would be protective of human health and the environment. The baseline risk assessment indicated that the total excess lifetime cancer risks and hazard indexes for OU-1 soil exposure pathways were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risk and 1.0 hazard index) for current and likely future conditions. Although the soils in the old plant (CPC) landfill may be a continuing source of groundwater contamination, each alternative would include continued operation of the RCRA CAP until the established cleanup standards are achieved.

Compliance With ARARs — All the OU-1 soil alternatives would comply with ARARs. The RCRA cleanup standards, which are based on MCLs, were identified as chemical-specific ARARs. Olin is legally required to attain these standards. The soil alternatives could be implemented to comply with the identified action- and location-specific ARARs.

Long-Term Effectiveness and Permanence — For the old plant (CPC) landfill, the soil removal alternatives (E, F and G1) would provide the most long-term effectiveness and permanence for organic contaminants because they specify removal and treatment or disposal of the soil and fill/waste material above 15 feet. However, the RI data indicated that contaminant migration occurs from zones below 15 feet in certain

portions of the landfill, and the 15- to 23-foot zone is addressed with in situ stabilization/solidification for all four (D, E, F, G1) of these soil alternatives. The long-term threat to groundwater is considered low based on the concentrations and characteristics of chemicals in the soil.

Alternatives F and G for the area west of the CPC plant would be effective because they specify removal and destruction or disposal of contaminants. Stabilization/ solidification alternatives (D and E) would have marginal, if any, increased effectiveness over capping. Stabilization/solidification would be effective at permanently immobilizing contaminants, thus reducing contaminant migration to the groundwater, but the detected soil concentrations in the area were below the potential soil action levels (PSALs), which were developed for protection of groundwater.

All of the assembled soil alternatives for the sanitary landfills, lime ponds and the well sand residue area would provide adequate long-term effectiveness and permanence because no unacceptable risks to human health and the environment were identified for current and likely future conditions with the no action alternative. Alternative C2 would be most effective at ensuring continued protectiveness because it provides improved containment at the sanitary landfills, the lime ponds and the well sand residue area. Alternative C1 would be only sightly less effective because it does not include containment of the well sand reside area, but the well sand is a cemented material with little potential to leach.

Reduction in Toxicity, Mobility and Volume — On-site thermal treatment (Soil Alternative G1) would result in the most reduction in mobility, toxicity and volume in the old plant (CPC) landfill area because the contaminants above 15 feet would be destroyed. All of the old plant (CPC) landfill alternatives would show a similar reduction in mobility for the soils below 15 feet, the zone that exhibited the most potential for contaminant migration to the groundwater. Alternatives that reduce contaminant mobility are appropriate for this SWMU because mobility to the groundwater is the only potential long-term threat posed by OU-1 soils.

On-site thermal treatment (Alternative G) would also show the greatest reduction in toxicity, mobility and volume for the area west of the former CPC plant. On-site

stabilization/solidification (Alternatives D and E) would result in a reduction in mobility but soil concentrations in the area were below the PSALs, indicating remedial action is not required for protection of groundwater. The capping alternative (Alternative C) would result in a reduction in mobility from decreased infiltration.

For the sanitary landfills, lime ponds, mercury cell plant and well sand residue area, Alternatives C1 and C2 would result in the greatest reduction in mobility due to the improved capping. Alternative C2 would provide only slightly more reduction than C1 because of containment of the well sand material, from which constituents are not very mobile under existing conditions. Alternatives B1 and B2 include cap maintenance programs to ensure that no increase in mobility would occur.

Short-Term Effectiveness — Alternatives that would involve excavation [Alternatives E, F and G1 in the old plant (CPC) landfill and Alternatives E, F and G1 in the area west of the CPC plant] would have the most potential for adverse short-term effects during construction because of the intrusive work and direct handling of the material. Soil Alternative D for both areas would also involve intrusive work. There would be minimal to no adverse short-term effects associated with the other soil alternatives.

Implementability — The excavation alternatives in the old plant (CPC) landfill and area west of the CPC plant would be difficult to implement because of the potential debris present in the landfill and the relatively confined area west of the CPC plant. Similarly, in situ stabilization/solidification (Alternative D for both areas) would be moderately difficult to implement because it also involves intrusive activity. On-site thermal treatment of the excavated soil would also be difficult to implement, primarily because of the specialized equipment required and complexity of the operation. The containment alternatives could be more readily implemented and the institutional action alternatives are easily implementable.

Cost — The total present worth cost for Soil Alternative C in the old plant CPC landfill was estimated as moderate (less than $5,000,000). The estimated costs for soil alternatives D, E, F, and G in this area ranged from high to very high (about $20,000,000 to $112,000,000).

The total present worth cost for the alternatives in the area west of the former CPC plant ranged from less than $500,000 for capping to about $15,000,000 for onsite thermal treatment.

For the institutional alternatives to address the sanitary landfill, lime ponds, mercury cell plant and well sand residue area, the total present worth costs were estimated in the range of $2,500,000 to $4,000,000. The two containment alternatives' costs were estimated at about $7,000,000.

OU-2 SEDIMENT ALTERNATIVES

The following OU-2 sediment alternatives were retained for the detailed analysis:

Alternative A	-	No Action
Alternative B	-	Institutional Actions

BASIN

Alternative C	-	Backfilling
Alternative D	-	Dredging/Covering (Contained Aquatic Disposal)
Alternative E1	-	Dredging/Disposal (Mechanical Dewatering)
Alternative E2	-	Dredging/Disposal (Confined Disposal Facility)

WASTEWATER DITCH

Alternative C1	-	Containment (Backfill)
Alternative E	-	Excavation/Disposal
Alternative G1	-	Excavation/On-Site Thermal Treatment/Disposal

Overall Protection of Human Health and the Environment — All the OU-2 sediment alternatives (including no action) are considered protective. All total excess lifetime cancer risks and hazard indexes for human receptors with potential exposure in OU-2 (sediment, surface water and fish) were below the risk-based remedial action objectives. The overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. Since

the sources of the site constituents of concern have been effectively eliminated, maximal impacts and risks have probably already occurred and the OU-2 ecosystems are in a state of natural recovery. The institutional action alternative includes sedimentation studies to monitor the rate of sediment deposition and assess the effectiveness of natural recovery.

Compliance With ARARs — Water quality criteria were identified as potential ARARs for the basin. The wastewater ditch is used to route Olin's wastewater and storm water, and the NPDES discharge permit limits, which Olin currently complies with, are potential ARARs. The OU-2 sediment alternatives for both the basin and the wastewater ditch could be implemented to comply with all identified action- and location-specific ARARs. Compliance with the Endangered Species Act may be critical in the implementation of the basin alternatives. Compliance with Section 404 of the Clean Water Act may be critical in the implementation of both the basin and wastewater ditch alternatives.

Long-Term Effectiveness and Permanence — Backfilling the basin and establishing a wetlands (Basin Alternative C) would afford the highest degree of long-term effectiveness and permanence of any of the basin alternatives. Although the dredging/disposal alternatives would involve removal of contaminated sediments from the basin ecosystem, they are considered less effective and permanent than backfilling, because with any dredging alternative there would be residual contamination from resuspension and dissolution. Also, the long-term benefits to the ecosystem would be questionable for the dredging alternatives because there would be a complete alteration of the basin bathymetric profile, eliminating the shallow margin habitats.

The wastewater ditch sediment alternatives that would include removal (Alternatives E and G1) would provide the most long-term effectiveness and permanence because the contaminated soils would be removed from the ditch.

Reduction in Toxicity, Mobility and Volume — Basin Alternatives C, D, E1 and E2 would all reduce the mobility of the constituents. Basin Alternative C would be most effective at reducing the mobility because with each of the dredging alternatives, the residual contamination from resuspension could possibly be mobilized. The dredging

and removal alternatives (Basin Alternatives E1 and E2) would result in a decreased volume of contaminated sediments in the basin. Alternatives for reducing mobility by isolating the contaminants (either covering the sediments or backfilling) are also considered appropriate alternatives because the potential for exposure of biota to constituents was identified as the only potential long-term threat for the basin sediments.

Wastewater Ditch Sediment Alternative G1, which would include on-site thermal treatment, would provide the most reduction in mobility and toxicity because the contaminants would be destroyed. For Alternative E, contaminants would be removed and placed in a landfill, where the mobility would be reduced. The remedial action objective is to prevent contaminated sediment transport down the wastewater ditch, and reduction in mobility by backfilling would also satisfy this objective.

Short-Term Effectiveness — The basin dredging and backfilling alternatives would cause extensive, adverse, short-term impacts due to a virtual removal of the benthic community and destruction of a large percentage of the aquatic organisms. There would also be the potential for sediment transport to the Tombigbee River. With dredging there would be a probable short-term increase in fish tissue concentrations due to resuspension and dissolution of contaminants in the water column.

The wastewater ditch alternatives that include excavation (E and G1) would have the most short-term adverse effects because they would cause disturbances of the contaminated sediment with potential transport down the ditch during construction. Contaminated sediments would not be handled directly for Wastewater Ditch Alternative C1.

Implementability — Basin Alternative D would be difficult to implement and would require specialized contractors and equipment for the subaqueous capping. The dredging/disposal alternatives (E1 and E2) would use more standard construction practices for the dredging and dewatering. However, these alternatives would also be difficult to implement due to the large volume of sediments that would be dredged and dewatered. Residual contamination would exist from resuspension of sediment and dissolution as a result of any of the dredging alternatives (D, E1 and E2) and the implementability of Alternative C is uncertain because of the potential problems

associated with backfilling over the soft sediments in the basin (i.e., complete covering of the contaminated sediments may not be practical). These factors may make it technically impractical from an engineering perspective to meet the surface water ARARs, and a waiver may be justified.

The wastewater ditch alternatives involving excavation (E and G1) would be difficult to implement because the saturated, contaminated sediments would have to be handled. After excavation, on-site thermal treatment (Alternative G1) would be more difficult to implement than disposal (Alternative E). Backfilling (Alternative C1) would be more readily implementable.

Cost — The total estimated present worth costs for the basin alternatives were estimated as moderate (less than $5,000,000) for Alternative B. Backfilling (Alternative C) and Covering (Alternative D) were estimated as moderate to high in cost (both at about $15,000,000). The estimated costs for the dredging/disposal alternatives (Alternatives E1 and E2) were very high (between $50,000,000 and $60,000,000).

The total estimated present worth costs for the wastewater ditch sediment alternatives ranged from moderate (about $5,000,000) for Alternative C1 to very high for the other two alternatives; E1 was estimated at about $40,000,000, and G1 was estimated at about $85,000,000.

Section 1

1.1 PURPOSE AND ORGANIZATION OF REPORT

Olin Corporation is conducting a Remedial Investigation/Feasibility Study (RI/FS) at its McIntosh, Alabama facility under the oversight of the U. S. Environmental Protection Agency (EPA). The Olin McIntosh site is an active chemical production facility that was placed on the National Priority List (NPL) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) because of contamination resulting from past operations. The objectives of the RI/FS are to determine the nature and extent of contamination, characterize any threat to public health, welfare or the environment, and develop remedial alternatives. This feasibility study (FS) report presents the results of the evaluation and analysis of potential remedial alternatives to prevent or mitigate the migration, release or threatened release of contaminants from the site.

This FS is organized as follows:

- Section 1.0: Introduction - This section presents the site background information and summarizes the results of the remedial investigation and the baseline risk assessment. Questions regarding summary statements in Section 1.0 should be resolved by reference to the RI report submitted to EPA on July 30, 1993 (WCC, 1993).

- Section 2.0: Identification and Screening of Technologies - This section presents the remedial action objectives (RAOs) and general response actions for the potentially affected media and identifies and screens potential technology types and process options.

- Section 3.0: Development and Screening of Alternatives - This section describes the rationale for assembling alternatives from the

technologies in Section 2.0; the assembled alternatives are then screened based on cost, effectiveness and implementability.

- Section 4.0: Detailed Analysis of Alternatives - This section provides an individual analysis of the assembled alternatives based on the criteria identified in the Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA, 1988a) and presents a comparative analysis among the assembled alternatives.

This FS is being conducted in conformance with EPA guidance (EPA, 1988a) and the amended RI/FS work plan for the site, which was submitted to EPA on May 25, 1991 and approved on July 17, 1991.

1.2 SITE DESCRIPTION

The Olin Chemicals McIntosh plant is located approximately 1 mile east-southeast of the town of McIntosh, in Washington County, Alabama. A site location map is presented in Figure 1-1. The property is bounded on the east by the Tombigbee River, on the west by land not owned by Olin west of U. S. Highway 43, on the north by the Ciba-Geigy Corporation plant site and on the south by River Road. The Olin McIntosh plant is an active chemical production facility. The main plant and associated Olin properties cover approximately 1,500 acres, with active plant production areas occupying approximately 60 acres.

Olin operated a mercury cell chlor-alkali plant (constructed in 1951) on a portion of the site from 1952 through December 1982. In 1952, Calabama Chemical Company began operation of a chlorinated organics plant on property immediately south of Olin. In 1954, Olin acquired Calabama and in 1955 began construction of a pentachloronitrobenzene (PCNB) plant on the acquired property. The plant was completed and PCNB production was started in 1956. The McIntosh plant was expanded in 1973 to produce trichloroacetonitrile (TCAN) and 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (Terrazole®). The PCNB, TCAN and Terrazole® manufacturing areas were collectively referred to as the crop protection chemicals (CPC) plant. In 1978, Olin began operation of a diaphragm cell caustic soda/chlorine

plant, which is still in operation. The CPC plant and mercury cell chlor-alkali plant were shut down in late 1982.

The McIntosh plant today produces chlorine, caustic soda, sodium hypochlorite and sodium chloride and blends and stores hydrazine compounds. Current active facilities at the plant include: a diaphragm cell chlorine and caustic production process area; a caustic concentration process area; a caustic plant salt process area; a hydrazine blending process area; shipping and transport facilities; process water storage, transport and treatment facilities; and support and office areas.

Olin mines a salt dome through a series of brine production wells located to the west of the active plant facility. The salt dome cap rock is at a depth of approximately 500 feet below the surface in the area. The dome is approximately 4,500 feet in diameter and greater than 2 miles deep. Nine brine wells have been completed in the salt dome for the production of brine. The first six wells were associated with the mercury cell chlor-alkali plant and are no longer in service. The other three brine production wells were developed in a different portion of the salt dome, have been used exclusively for the diaphragm cell plant, and are still in use. A tenth cavity was developed in the dome by Olin for use by the Alabama Electric Cooperative to store high-pressure (1200 psi) air for off-peak power production. An eleventh cavity is being developed for use by Baygas Incorporated to store natural gas.

The Olin McIntosh plant currently monitors and reports on numerous facilities within the plant that are permitted through the EPA and the Alabama Department of Environmental Management (ADEM). These include water and air permits as well as a Resource Conservation and Recovery Act (RCRA) post-closure permit. The RCRA post-closure permit requires groundwater monitoring for closed RCRA units, including the weak brine pond, the stormwater pond and the brine filter backwash pond. The post-closure permit also requires corrective action for releases of 40 CFR 261 Appendix VIII constituents from any solid waste management units (SWMUs) at the facility. There are no active RCRA units at the facility. Olin also has permits for three injection wells for mining salt and a neutralization/percolation field.

In September 1984, Olin's McIntosh plant site was placed on the National Priority List of CERCLA or "Superfund." Groundwater contamination at the site has been established based on the results of various investigations. Mercury and chloroform are the principal contaminants identified at the site. Mercury contamination was evidently caused by the operation of the mercury cell chlor-alkali plant during the period 1952 to 1982. The chloroform contamination is probably a degradation product from the operation of the TCAN plant from 1973 to 1982.

Investigations have also indicated contamination in an approximate 65-acre natural basin, herein referred to as the "basin," located on the Olin property east of the active plant facilities. This basin received plant wastewater discharge from 1952 to 1974.

Two operable units have been designated for the facility. Operable Unit 1 (OU-1) is the plant area (all of the Olin property except the area defined as OU-2). Operable Unit 2 (OU-2) is the basin, including the floodplain within the Olin property line and the wastewater ditch leading to the basin. Figure 1-2 is a facility layout map delineating the boundaries of the two operable units.

Descriptions of the two operable units are presented in the following sections. These descriptions, which are summarized from the RI report (WCC, 1993), are based on a review of information from previous investigations and data obtained during the RI site characterization activities.

1.2.1 Operable Unit 1

Operable Unit 1 consists of the active production facility and the upland area of Olin property. The active facility area comprises approximately 60 acres and is relatively flat, with surface elevations of about 40 to 50 feet above mean sea level (msl). The areas in OU-1 beyond the active production facilities include predominantly undeveloped areas to the north and northwest and the brine well field to the west. The most distinctive topographic feature is a steep bluff located approximately 4,000 feet east of the main plant area. This bluff defines the edge of the low-lying OU-2 floodplain area.

OU-1 contains closed, inactive, and active SWMUs. Seventeen of these SWMUs were identified in the amended RI/FS work plan and are shown on Figure 1-2. Subsequently, EPA conducted a RCRA Facility Assessment (RFA) that listed 52 SWMUs and six areas of concern (AOCs). The list of SWMUs in the RFA report includes the seventeen SWMUs in OU-1 that were described in the amended work plan.

Olin has conducted numerous closure and removal activities to reduce or eliminate the potential for releases from the SWMUs. These include nine clean closures and one in-place closure under 40 CFR 265. The closed and clean-closed SWMUs are summarized in the table below. More details of the units and the closure activities were presented in the RI report (WCC, 1993).

SWMUs CLOSED OR CLEAN-CLOSED UNDER 40 CFR 265

Name	Date Constructed or Date Unit Began Handling Hazardous Waste	Approval by ADEM	Approval by U. S. EPA
1. Stormwater pond (clean-closed)	1976	May 1, 1986	April 28, 1986
2. Brine filter backwash ponds (clean-closed)	1972	May 1, 1986	April 28, 1986
3. Pollution abatement (pH) pond (clean-closed)	1976	August 14, 1985	August 13, 1985
4. Weak brine pond (closed)	1952	August 9, 1987	June 24, 1987
5. Mercury waste pile storage pad (clean-closed)	1980	March 12, 1985	(ADEM had Interim Status Authority)
6. TCAN hydrolyzer (clean-closed)	1980	March 21, 1984	(ADEM had Interim Status Authority)
7. Mercury drum storage pad (clean-closed)	1980	March 12, 1985	(ADEM had Interim Status Authority)
8. Chromium drum storage pad (clean-closed)	1980	February 25, 1986	March 31, 1986

SWMUs CLOSED OR CLEAN-CLOSED UNDER 40 CFR 265			
Name	**Date Constructed or Date Unit Began Handling Hazardous Waste**	**Approval by ADEM**	**Approval by U. S. EPA**
9. PCB/Hexachlorobenzene storage building (clean-closed)	1978	February 25, 1986	March 31, 1986
10. Hazardous waste drum (flammable) storage pad (clean-closed)	1979	February 25, 1986	March 31, 1986

The amended work plan listed ten SWMUs that were not regulated under 40 CFR 265 and that have been identified within OU-1. These are summarized below:

Name	Status
Sanitary Landfills (2)	Closed, 1978 and 1984
Old Plant (CPC) Landfill	Closed 1976, Cap Improved 1984
Diaphragm Cell Brine Pond and Overflow Basin	Active
Ash Ponds (3)	1 Active and 2 Inactive
Lime Ponds (2)	Inactive (Closed in 1978 prior to RCRA)
Hexachlorobenzene Spoil Area	Removed Under CERCLA Emergency Removal Action, 1990

Olin was issued its federal EPA RCRA post-closure permit on July 7, 1986. On September 1, 1986, ADEM issued a state hazardous waste permit to Olin. EPA retained authority for the 1984 Hazardous and Solid Waste Amendments (HSWA) portions of the post-closure permit, which included the HSWA Corrective Action Program. The first phase of the HSWA Corrective Action Program is a RCRA Facility Assessment (RFA). The RFA at the McIntosh facility was conducted by an EPA contractor and consisted of a preliminary review (PR) of files from EPA Region IV and ADEM and a visual site inspection (VSI) on June 17 and 18, 1991. A draft RFA report

was provided to Olin on October 30, 1991. Olin made comments, and a final RFA report was provided to Olin on February 4, 1992. The RFA lists 52 SWMUs and six areas of concern (AOCs).

The RFA provided recommendations to EPA for requiring work at 17 SWMUs and 6 AOCs. The recommended additional work ranged from Olin providing additional documentation on individual SWMUs/AOCs to conducting RCRA Facility Investigations (RFIs). Olin met with EPA on February 19, 1992 to discuss additional sampling activities, including activities related to the RFA recommendations. Table 1-1, at the end of this section, summarizes the RFA recommendations, along with Olin's method of addressing these recommendations. Based on the RFA recommendations, sampling was conducted at the following SWMUs/AOCs, which were not described as SWMUs in the amended work plan:

SWMU	Description of Unit	Date of Operation
Old Plant (CPC) Landfill Drainage Ditch	Unlined ditch that connected former CPC landfill to wastewater ditch. Closed in connection with CPC landfill.	Operated 1954-1977; closed in 1977.
Crop Protection Chemicals (CPC) Plant	Former location of CPC plant that included PCNB, TCAN and Terrazole® manufacturing areas. Area was decommissioned and dismantled and covered with an approximate 2-foot-thick recompacted clay cap.	Operated 1954-1982; decommissioned, dismantled and capped in 1984.
Mercury Cell Plant	Area that was the site of the structures and operations for the former mercury cell chlor-alkali plant. Decommissioning included removal of all aboveground structures. The concrete pads and foundations were left in place; the sumps and trenches were backfilled with clay, and the area was covered with asphalt.	Operated 1952-1982; decommissioned and then capped in 1986.
Well Sand Residue Area	Mounds of well sand residue deposits from development and operation of the brine wells for the mercury cell chlor-alkali process. These sands are residues of the natural insoluble material from the salt domes.	Operated 1952-1968.

SWMU	Description of Unit	Date of Operation
Strong Brine Pond	Location of former process unit that was a holding pond for the strong brine process fluid for use in the mercury cell plant. Removal of this process pond was conducted by dewatering and scraping out the material in the pond. The material was then placed in the weak brine pond, which was closed in place under 40 CFR 265. The strong brine pond area was then graded flat, capped, and vegetated.	Operated from 1952 to 1982; removed in 1985.

Surface Features and Drainage

Figure 1-3 shows the surface drainage patterns in OU-1. The active production areas of the plant are relatively flat. The land surface elevation is approximately 40 to 50 feet above mean sea level (msl). A topographic high of greater than 50 feet msl extends from the northern to the southern extent of Olin's property, west of the production facility and east of the brine well field. This topographic high creates a drainage divide that defines the two major surface water drainage pathways within the Olin property. The most distinctive topographic feature is a steep bluff located approximately 4,000 feet east of the main plant area. This bluff defines the edge of the low-lying floodplain area, which is about 25 feet lower in elevation than the upland areas immediately to the west.

West of the drainage divide described in the above paragraph, the majority of surface runoff drains west to low-lying areas in the vicinity of the brine well field and continues westward across Highway 43, discharging into Bilbo Creek. Additional surface water runoff to the southwest along Industrial Road also discharges to Bilbo Creek, which is a tributary of the Tombigbee River.

Surface runoff east of the drainage divide flows east and southeast to the Olin wastewater ditch, which discharges into the Tombigbee River farther to the southeast. The elevation in this drainage area varies from about 40 feet msl on the plant site to about 3 feet msl in the wastewater ditch at the basin.

Drainage east of the drainage divide and west of Industrial Road, including the treated effluent from corrective action wells CA1 and CA2 (see Figure 1-4 for well locations), flows eastward beneath Industrial Road into the main plant area. From here, flow continues eastward to an NPDES-permitted discharge at the beginning of the wastewater ditch located at the southeast corner of the facility. Surface runoff from the active production areas of the plant drains to the southeast through a system of culverts and ditches to the wastewater ditch. Drainage from the CPC plant and adjacent areas flows north and eastward to the wastewater ditch. Surface runoff from the active ash pond area and properties to the east drains eastward and northward into the wastewater ditch.

Runoff from the northern portions of the site east of the drainage divide, including the sanitary landfills, flows eastward to a low-lying area between the plant area and the basin. The majority of the low area drains to the southeast to the wastewater ditch and then to the Tombigbee River. However, the northern portion of this low area flows to one of the ponded areas connected to the basin to the north. There is also a small east-west drainage divide in the northeast corner of the Olin property. Flow to the north of this divide is to the Ciba-Geigy property.

1.2.1.1 Site Geology

The McIntosh area is underlain by alternating beds of unconsolidated-to-consolidated sedimentary rocks that are collectively hundreds of feet thick. The general dip of these rocks is southwesterly at 30 to 50 feet per mile and is locally interrupted by folds, faults and salt domes. The McIntosh salt dome is the most distinctive structural feature of the area.

The near-surface sediments are Recent alluvium and Quaternary alluvial terrace deposits (80 to 100 feet thick) that consist of beds of sand, gravel, silt and clay, which form the Alluvial Aquifer system. The underlying Miocene series is composed of alluvial deposits of fine-to-coarse-grained gravel, sand and sandstone and beds of gray-to-varicolored clay. The Miocene series varies in thickness from less than 275 feet above the McIntosh dome to as much as 600 feet farther away from the dome.

Lithologic data from the borings, soil test hole logs, soil boring logs from Olin monitor wells, and driller's logs from water wells were used to evaluate the lithologic characteristics of the near-surface strata at the Olin site. Figure 1-4 shows the locations of monitor wells and corrective action wells at the facility. North-south and east-west geologic cross sections of the near-surface stratigraphy beneath the site were developed and are presented in Figures 1-5 and 1-6.

The Quaternary alluvial sediments are divided into two units, designated Q_1 and Q_2. The Olin site is located within the outcrop area of the upper Quaternary clay unit (Q_1). The lithology of Q_1 is variable, but is composed primarily of red-brown, yellow-brown, and gray, silty/sandy plastic clay; the silt and sand content varies and generally increases with depth. Thin, probably discontinuous sand and silt lenses occur interbedded with the clay. The thickness of Q_1 varies from less than 10 feet to about 60 feet, as illustrated on the cross sections.

The Alluvial Aquifer (Q_2) in the main plant area varies in thickness from an average of about 55 feet to 80 feet, thinning in the west plant area to approximately 37 feet at the location of monitor well DH3. The Alluvial Aquifer is divided into two zones. The upper zone of the Alluvial Aquifer is composed primarily of very fine to fine-grained, silty quartzose, subangular-to-subrounded sand. The lower zone of the aquifer is composed of fine-to-very-coarse, orange-brown, quartzose, cherty, subangular-to-subrounded sands containing varying amounts of fine-to-large gravel. Although composed predominantly of sands, Q_2 also contains some thin beds of clay or silty, gravelly clay. One of these beds, a gravelly, silty plastic clay and gravelly sand, can be traced by its fine-grained lithology. This thin clayey sand ranges from approximately 3 feet to 10 feet thick beneath the southern part of the main plant area. However, this fine-grained unit apparently pinches out or becomes sandier in other parts of the plant site.

The Tertiary (Miocene) units addressed in this study are designated Tm_1 and Tm_2. In water well and stratigraphic test hole logs, the Miocene confining unit (Tm_1) is described as consisting of clays, sandy clays, or clayey sands. Although the lithology may be complex, the material is predominantly clay, with various amounts of discontinuous sand, silt, or sometimes fine gravel. Boring logs from wells that penetrate the upper

Miocene confining unit indicate that this unit is laterally continuous beneath the Alluvial Aquifer and approximately 80 to 100 feet thick. Figure 1-7 is a structure contour map that illustrates the surface configuration of the top of the Miocene confining unit. The elevation of this unit varies from about -20 ft msl to -58 ft msl across the site. In the area to the west of the active facilities, there is a general north-south trending linear high at about elevation -20 ft msl. The elevation of the unit decreases farther to the west and southwest to about -50 ft msl in the brine field area. On the eastern side of the linear ridge, there is a general east-west trend in the structure of the unit, with a structural low directly to the southwest of the brine ponds at about elevation -40 ft msl, and another low in the vicinity of corrective action well CA4 at about -58 ft msl. It should be noted that the definition of the structure presented in Figure 1-7 is dependent on the number of borings (with logs available) that penetrated the Miocene confining unit, as well as the locations of these borings.

Thick clay sequences in Tm_1 occur at the top and base of the unit, and one 20-foot thick sand occurs near the middle of the unit. The upper clay consists of blue-gray, sometimes mottled, silty, hard plastic clay with minor amounts of sand. Six undisturbed samples of this upper clay were obtained for laboratory permeability testing during the 1982 S&ME investigation. These tests indicate that the vertical permeability of the upper clay is extremely low, with vertical hydraulic conductivities (K) of less than 1×10^{-5} feet per day (less than 1×10^{-8} cm/sec) (S&ME, 1982).

The Miocene Aquifer (Tm_2) is composed primarily of thick-bedded coarse sand and gravel beds. However, a sandy clay does occur within this unit, as shown on the boring log from WW12. The attitude of the upper boundary of this aquifer is nearly horizontal in the main plant area; however, in the west plant area there is a pronounced southeastward dip, from -114 feet msl in well DH3 to -166 feet msl in well DH1 (see Figure 1-6). These differences are interpreted to be related to structural deformation associated with the underlying dome.

1.2.1.2 Site Hydrogeology

The Alluvial Aquifer is generally unconfined throughout the area. Based on single well response tests, the hydraulic conductivity was estimated to be between 4 ft/day and

40 ft/day. The calculated hydraulic conductivity from a pumping test of corrective action well CA3 was 578 ft/day (ERM, 1989). The CA3 area is one of the most transmissive areas of the Alluvial Aquifer at the site, and 578 ft/day is considered an upper-range value for hydraulic conductivity. The specific yield is estimated to be 0.20, based on grain size analyses.

Figure 1-8 depicts the potentiometric surface of the upper zone of the Alluvial Aquifer based on water elevations from the September 1991 RI sampling. Groundwater in the Alluvial Aquifer generally enters the site from the north. The southerly flow is divided into southeast and southwest components by a groundwater divide oriented north-south through the center of the plant site. The occurrence of this groundwater divide, which was present prior to implementation of the corrective action program, is believed to be related to the structure of the top of the upper Miocene clay (Figure 1-7). As discussed previously, there is a general north-south trending linear high in the structure west of the active facilities. Structural lows occur both to the southwest and to the southeast. Groundwater entering the site west of the structural high preferentially flows to the southwest and groundwater entering the site east of the structural high preferentially flows to the southeast. The groundwater divide is further influenced by groundwater recovery from the corrective action wells.

Flow to the east of the groundwater divide is to the east and southeast, discharging to the basin in the northern portion of the site. Farther south, flow continues in a southeasterly direction toward corrective action wells CA3, CA4, and CA5, where groundwater recovery creates radial flow to these wells. In off-site areas southeast of the facility, groundwater discharges to the Tombigbee River. On the western side of the groundwater divide, flow is south and southwest toward the groundwater recovery area created by corrective action wells CA1 and CA2. A hydraulic mound farther to the west deflects westerly flow to the south in the brine field area.

The potentiometric data indicate that Olin's corrective action program is effective at controlling migration of contaminants from any known past or current sources. There is limited hydraulic influence from the corrective action wells in the northeast area of the site, in the vicinity of the sanitary landfills. Groundwater flow in the area is to the east-southeast and not directly toward the corrective action well. However, the sanitary

landfills have not been identified as a source of groundwater contamination, and the groundwater flow patterns indicate that the existing monitor well network should detect any releases from these landfills.

The groundwater flow patterns are affected by the seasonal rises in the Tombigbee River. During periods of high river stage, instead of groundwater discharging eastward, the basin and Tombigbee River become recharge areas and groundwater flow is to the west toward the active facility.

The upper Miocene Aquifer (Tm_2) contains two main artesian sands that are separated by a clayey unit ranging from 10 to 20 feet thick. The sands are considered as one hydrogeologic unit due to a natural hydraulic connection and connection by gravel-packed wells. The combined transmissivity of the two sands is considered to be in excess of about 25,000 square feet per day (ft^2/day) (S&ME, 1982).

The regional gradient of the Miocene Aquifer is to the east-southeast (DeJarnette, 1989). However, Olin continuously pumps two Miocene Aquifer process water wells. The effect of pumping process water wells on the potentiometric surface of the Miocene Aquifer was evaluated with the analytical groundwater model WELFLO (Walton, 1989). Based on this analysis, which is presented in the RI report, groundwater flow in the Miocene Aquifer is predicted to be toward the process water wells across the plant area.

1.2.2 Operable Unit 2

OU-2 consists of a basin, the floodplain within the Olin property line, and the wastewater ditch leading to the basin. The basin is a natural oxbow lake lying within the floodplain of the adjacent Tombigbee River. During the seasonal high water levels (approximately 4 to 6 months per year), the basin is inundated by, and thus becomes contiguous with, the adjacent river.

The plant wastewater ditch currently carries the NPDES discharge and storm water runoff from the manufacturing areas, as well as from some of the west, east and southeast nonmanufacturing areas of Olin property to the Tombigbee River. From 1952 to 1974, plant wastewater discharge was routed through the basin and then to the

Tombigbee River. In 1974, a discharge ditch was constructed (approximately 800 feet long during the nonflood season) to reroute the wastewater directly to the Tombigbee River, bypassing the basin itself. Also at this time, a sheet pile weir was constructed at the southern outlet of the basin to the river. This weir was constructed to control the water level in the basin and to keep the wastewater stream from discharging into the basin during low river stages.

Drainage

The watershed for the basin within the floodplain area is limited to the area defined as OU-2. North of OU-2, flow is restricted by a ditch that diverts water around the basin to the Tombigbee River during nonflood conditions. The basin is connected to the two ponded areas north of it. Surface water runoff drains from within the OU-2 floodplain to the ponded areas and to the basin. Surface water also drains eastward to the southernmost ponded area from the west upland area.

The southern outlet of the basin is connected to the Tombigbee River. Fluctuations in river stage will cause fluctuations in the basin water elevations. During periods of rising elevation (i.e., when the elevation of the river exceeds the basin weir elevation) drainage is from the basin to the ponded areas. During periods of falling water elevation, flow is from the ponded areas to the basin. River stage fluctuations may occur due to storm events, seasonal variations or tidal influences.

River Stage Data

The basin and surrounding wetlands lie within the floodplain of the Tombigbee River. During seasonal high water levels (averaging 4 to 6 months per year), the basin and wetland areas are inundated, becoming contiguous with the adjacent Tombigbee River. Historical river stage data from the U. S. Corps of Engineers, Coffeeville Station, located approximately 42 miles (58 river miles) north of McIntosh, were obtained by Olin and are presented on a hydrograph (time versus river stage) in Figure 1-9. As shown on the hydrograph, there is a seasonal rise in water elevations, beginning as early as November and lasting until as late as August of the following year. Over the previous five high-water events, river stages have risen an average of about 30 feet.

Although these data were obtained from 42 miles north of McIntosh, it is believed that the fluctuations in river stage in the vicinity of the site are similar. Figure 1-9 shows that river levels were well above the basin weir (elevation 3.18 feet msl), inundating the basin and the entire wetland area within Olin property during these periods.

Bathymetry

The most significant feature of OU-2 is the basin. During Phase I of the RI, a bathymetric survey was conducted in the basin to define its bottom configuration. Using the basin floor depth profiles from the survey and a computer contouring program (SURFER®), a contour map of the basin floor was generated and is presented in Figure 1-10.

The most recognizable feature of the basin floor is a relatively steep-sided topographic low in the northwestern portion. Water within this low is as deep as 38.5 feet. The remainder of the basin floor (approximately two-thirds of the basin area) is relatively flat, sloping gently to the north and west. Water depth is less than 6 feet in these gently sloping areas.

Description of Sediments

A total of eight subsurface sediment cores were collected from OU-2 during the RI. A geologic cross section, presented in Figure 1-11, was created from descriptions of cores completed in the basin and the former wastewater ditch. A relatively thin unit consisting of tan, black and dark gray, silty clays and clayey silts was encountered in all five cores, with a maximum thickness of 5 feet in the vicinity of core C3, which is located in the former discharge ditch to the basin. The unit gradually thins to approximately 1 foot thick in the eastern half of the basin at core C1. Interspersed throughout this unit are fine-, medium-, and coarse-grained sands up to 1.5 inches thick. The thicker portions of this silty clay/clayey silt unit encountered near C2 are interpreted to be deposits of sediment carried down the wastewater ditch, possibly the result of increased sedimentation due to plant operations. Construction and excavation of surface sediments at the plant site would have increased the sediment load that is

carried by surface runoff to the basin, resulting in the lens-shaped sedimentary feature described above.

A dark gray, organic, silty clay unit was encountered in all cores at approximately the same elevation (about -3 to -4 feet msl). This silty clay unit is interpreted to be floodplain deposits of the adjacent Tombigbee River. A dark gray, medium-to-fine sand was encountered in the bottom 6 inches of core C1. Sand was also found in the bottom of core CI7, located to the north of C1. However, no sands were encountered in borings from the western half of the basin.

Three cores were completed in the wastewater ditch: two at location OD15 about 2,000 feet downstream of the NDPES outfall, and one at the base of the outfall (OD25). The sediment encountered at OD15 consisted of about 0.5 feet of sand, underlain by soft, unconsolidated silty clay to a depth of about 5.0 feet. A stiff, silty clay was encountered from 5.0 feet to the total depth of the deepest core (11 feet). The stiff clay is interpreted to be the Q_1 Quaternary clay deposit. The sediment descriptions for core OD25 indicated approximately 1 foot of loose organic silt and clay with sand, underlain by a 1-foot layer of stiff, sandy clays, followed by 1 foot of firm, fine-to-medium sands. These two lower layers (stiff clays and firm sands) are indicative of the upland Quaternary alluvial sediments of Q_1 which exist beneath the site. Therefore, there appears to be only about 1 foot of ditch sediment overlying the Q_1 deposits at this location.

1.2.3 Site History

The mercury cell chlor-alkali plant was constructed by Mathieson Alabama Chemical Corporation (owned by Mathieson Corporation, a predecessor to Olin Corporation) in 1951. The mercury cell plant produced chlorine and caustic soda. In 1954, Olin acquired and began operating the organics chemical plant, which was originally constructed in 1952 by Calabama Chemical Company on property adjacent to the mercury cell plant. The organics chemical plant initially manufactured monochlorobenzene. In 1956, Olin completed construction of the pentachloronitrobenzene (PCNB) plant. The organics plant was expanded in 1973 to produce trichloroacetonitrile (TCAN) and 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole

(Terrazole®). The PCNB, TCAN and Terrazole® manufacturing areas were collectively referred to as the Crop Protection Chemicals (CPC) plant.

In 1977, Olin constructed a diaphragm cell caustic soda/chlorine plant, which is still in operation. The CPC plant and mercury cell plant were shut down in late 1982. The McIntosh facility continues to operate and produces chlorine, caustic soda, sodium hypochlorite, and sodium chloride and blends and stores hydrazine compounds.

When the facility came under RCRA regulation in 1980, Olin had already implemented a groundwater investigation program. The investigation was expanded in 1981-82 at the request of ADEM. Chlorinated organic compounds (including chloroform) and mercury were detected in the shallow groundwater. Olin conducted a series of groundwater assessment investigations to determine the nature and extent of contamination and began a RCRA groundwater monitoring program.

During 1982, Olin shut down the CPC and mercury cell chlor-alkali plants. The CPC plant was decommissioned and dismantled and the site was capped under a plan submitted to and approved by ADEM. The chlor-alkali plant was decommissioned and dismantled in several phases from 1982 until 1986.

The Olin McIntosh plant was inspected by an EPA contractor in 1982 and 1983 to calculate a Hazard Ranking System score. The plant was placed at position number 320 on the National Priority List (NPL) and has since been changed to number 505.

From 1984 through 1985, Olin closed or clean-closed ten designated SWMUs. Each closure plan was reviewed and approved by EPA and/or ADEM. Closures were certified at completion and releases from financial responsibility were obtained. In 1987, with EPA/ADEM approval, Olin initiated a RCRA Corrective Action Program (CAP), consisting of five groundwater pumping wells in the Alluvial Aquifer, with treatment systems located centrally or at the well. Since implementation of the CAP, groundwater contamination has been observed to decrease at the RCRA compliance boundaries. A discussion of the effectiveness of the CAP is presented in Section 1.2.4.

During 1988 Olin closed four of six former mercury cell brine wells under its underground injection control (UIC) permit. The other two mercury cell brine wells (Brine Well No. 1 and Brine Well No. 2) had been plugged in 1972 and 1985, respectively. Plugging of these wells was also approved under the UIC permit. The closed wells were all associated with the former mercury cell chlor-alkali plant, and the cavities contain brine with a low concentration of mercury.

In June 1989, EPA and Olin agreed that all data and information developed in the course of Olin's extensive RCRA compliance activities would be collated into a CERCLA Remedial Investigation (RI) formal report consistent with the October 1988 EPA guidelines (EPA, 1988a). A risk assessment (RA) was also conducted using these data and information. Olin submitted this report to EPA in November 1989 (ERM, 1989). On January 15, 1990, Olin received a special notice letter from EPA requiring development of the scope of work for the RI/FS. In response to the special notice letter, the scope of work for the RI/FS was developed and submitted to EPA in April 1990. On May 9, 1990, an administrative order of consent (consent order) became effective for the performance of the RI/FS at the Olin Chemicals McIntosh facility. The scope of work was attached to the consent order. A work plan was developed in partial fulfillment of the work items to be performed under the jurisdiction of the consent order and submitted on December 15, 1990. EPA commented on the work plan on April 4, 1991; an amended work plan was submitted to EPA on May 25, 1991 and was approved by EPA on July 17, 1991.

Following approval of the amended work plan, Phase I activities began with a bathymetric survey of the basin conducted over a four-day period from July 22 through July 25, 1991. This was followed by Phase I sediment and surface water sampling conducted in OU-2 from August 6, 1991 through August 30, 1991. A one-time sampling of selected monitor wells and corrective action wells within OU-1 was completed during the period September 9 through September 19, 1991. A vegetative stress survey involving vegetation sampling and detailed ground surveys for endangered and threatened plant species existing within OU-2 was also performed in September 1991. A macroinvertebrate study and fish sampling was performed during the period November 4 through 8, 1991. Phase II sediment sampling in OU-2 was completed on November 13 and 14, 1991. The Phase III work, conducted in August and September

of 1992, consisted of sampling soils in OU-1 and surficial sediments, core sediments and macroinvertebrates in OU-2.

The following is a list of the major deliverables that have been submitted to EPA as part of the RI/FS.

Report/Plan/Memorandum	Date
RI/FS Work Plan	12/15/90
Amended Work Plan	05/25/91
Revised SAP, Macroinvertebrate and Fish Sampling	09/06/91
Hazardous Substance Indicator Parameter Technical Memorandum	12/19/91
Phase III SAP	04/02/92
Revised Remedial Action Objectives Technical Memorandum	04/30/92
Candidate Technologies Technical Memorandum	05/14/92
Exposure Assessment Technical Memorandum	06/02/92
Environmental Evaluation Technical Memorandum	07/15/92
Remedial Technologies, Alternatives Screening Technical Memorandum	10/06/92
Treatability Study Work Plan/SAP	10/16/92
Draft RI Report	02/19/93
Draft FS Report	05/05/93
RI Report	07/30/93

These documents provide the basis for evaluating potential remedial alternatives.

1.2.4 RCRA Groundwater Corrective Action Program

The corrective action program began operating in September of 1987. The system includes five 10-inch diameter PVC interceptor wells that screen the saturated thickness of the Alluvial Aquifer. The wells are designated as CA and their locations are shown on Figure 1-4.

Each well is equipped with its own treatment system. The discharge from corrective action well CA1 is pumped to a natural draft air stripper to reduce the volatile organic concentrations. Corrective action well CA1 is not equipped for mercury removal

because it is located beyond the boundary of the extent of mercury contamination. Discharge from the air stripper flows to the main plant effluent ditch. The discharge from CA2 is pumped to a forced draft air stripper for volatile organic reduction. The stripper then overflows to a single gravity box filter with 8,000 pounds of activated carbon for mercury removal. Final discharge from the carbon bed flows to the main plant effluent ditch. Treatment facilities for CA3 are similar to CA2, except that the CA3 discharge from the carbon bed is routed through a separate pH adjustment system before entering the main plant effluent. Water from CA4 requires treatment for volatile organics with a forced draft air stripper. No mercury removal is required at CA4, and the effluent from the stripper is to NPDES-permitted Outfall 001C. CA5 is also discharged through a forced draft air stripper to reduce volatile organic concentrations. The stripper then overflows to a single gravity box filter with 8,000 pounds of activated carbon for mercury reduction. The discharge from the carbon bed is routed to the same pH adjustment system as CA3 effluent before entering the main plant effluent. The treated effluent from all five corrective action wells flows through the wastewater ditch and ultimately to the Tombigbee River.

Olin operates the wells and treatment systems as integral parts of its chemical manufacturing operations. Olin utilizes one operator per shift to operate the treatment systems, the corrective action wells, and all other NPDES treatment systems throughout the plant. Additionally, Olin has developed and implemented a preventative maintenance program for the corrective action wells and treatment systems.

Since implementation of the CAP, the interceptor wells have been operating within the following pumping rates:

Corrective Action Well	Approximate Pumping Range (gpm)
CA1	100-150
CA2	80-100
CA3	100-110
CA4	40-60
CA5	150-180

The CAP has removed a total of approximately 1.6×10^9 gallons of water from September 1987 through April 1993.

The potentiometric data as described in Section 1.2.1.3 show that corrective action wells CA1 and CA2 have established a large single cone of depression. CA4 and CA5 have also established individual cones of depression. However, a cone is not evident in the CA3 area on the upper zone potentiometric maps. The lower zone potentiometric map, depicted in the RI report (WCC, 1993) does show a cone around corrective action well CA3.

Hydrographs were constructed for the following wells: WP2A, E3, PE3, BR10, PL10S and WP9A, and used to evaluate the drawdown produced by the CAP. These hydrographs are presented in Appendix A. Monitor well WP2A is located near the cone of depression produced by CA1 and CA2; monitor well E3 is located near CA5 and monitor well PE3 is located near CA3. Hydrographs from these three wells show a distinct lowering of the water table after the corrective action program began in September 1987. The water elevations stabilized around the fourth quarter of 1988, at approximately 2 to 4 feet lower than the pre-corrective action elevations. The potentiometric data indicate that there has been a lowering of the water table within the total area surrounded by the five corrective action wells. Monitor well BR10, which is near the center of this area and approximately 2,500 feet from the closest corrective action well, showed a lowering in water elevation of about 2 to 4 feet.

Water elevations in monitor well PL10S, which is situated between CA4 and the Tombigbee River, show little change. The influence of the adjacent Tombigbee River probably has masked any effects from the pumping. Water elevations in background monitor well WP9A have decreased approximately 2 feet.

Olin's quarterly RCRA monitoring programs consist of collecting samples from 37 monitor wells and analyzing the samples for mercury (from all 37 wells) and organics (from 21 of these wells). Although the system has only been operating for about six years, the RCRA and RI data were used to develop the following observations regarding the system's effectiveness:

- The system has significantly lowered the water table, and is effective at controlling contaminant migration from any known past or current sources. Distinct cones have been developed in both the upper and lower zones of the Alluvial Aquifer at four of the five corrective action wells.

- There is limited hydraulic influence from the corrective action wells in the northeast area of the site, in the vicinity of the sanitary landfills. Well CA3 does not show a distinct zone of influence in the upper zone, but does in the lower. Groundwater flow in the area is to the east-southeast and not directly toward the corrective action well. However, based on the groundwater sampling results and the Phase III soil sampling, the sanitary landfills are not considered a source of groundwater contamination, and the groundwater flow patterns indicate that the existing monitor well network should detect any releases from these landfills. (See Section 1.4.1 for a discussion of the potential for contaminant migration from the sanitary landfills.)

- Distinct cones of influence have been developed at wells CA1 and CA2 in both the upper and lower zones. These wells would capture any westward and southwestward movement of the mercury and organic plumes.

- The CAP is effective at controlling migration of the mercury plume to the south as shown by the time versus concentration curves. Monitor well E1 had increasing concentrations from about 1984 to 1988, followed by a steep decline. This decline is attributed to the effect of corrective action well CA5, situated about 600 feet to the northeast of E1, and started up in 1987. Appendix A shows the time verses concentration curve for monitor well E1.

- The CAP has had limited hydraulic effects to the east of PL10S, in the southeastern area of the facility, due to its close proximity to the river. Mercury concentrations have ranged from 1.0 to 3.8 μg/l and

chloroform from 40 μg/l to 100 μg/l with no apparent upward or downward trends for either constituent. However, there are no known sources in the area and it is expected that concentrations will eventually decrease with continued pumping.

- The mercury concentration data from the weak brine pond area show slight decreasing trends in the monitor wells screened in the upper zone, which suggest that contamination is being removed at a rate higher than it is being released to the groundwater. These trends are shown on the time versus concentration curves for MP9, BR7, and BR8.

- There are no apparent trends in mercury concentrations for wells screened in the lower zone of the Alluvial Aquifer in the weak brine pond area. It is concluded that dense, mercury-containing brine that sank to the top of the Miocene clay constitutes a secondary source of mercury in the area. Accumulated brine at the base of the aquifer would explain the higher chloride and mercury concentrations in the lower zone as compared to the upper zone Alluvial Aquifer wells. The existing corrective action system, which includes wells screened over the entire saturated thickness of the Alluvial Aquifer, would have limited effectiveness at removing the dense brine.

- There have not been any apparent decreases in concentrations of organics in the old plant (CPC) landfill area. Based on the absence of downward trends in organic concentrations from wells near the closed landfill, this area was identified as a potential continuing source of organic groundwater contamination.

The calculated time to cleanup the Alluvial Aquifer to the RCRA groundwater protection standards is 25 to 27 years, as described in Olin's RCRA post-closure permit. From Figure 1-14, an estimate can be made of the total volume of water within the mercury plume boundaries (above a concentration of 2.0 μg/l). (This area generally encompasses the extent of the organic plume also). The plume dimensions are approximately 6,800 feet (east-west direction) by 1,800 (north-south direction) or

approximately 1.22 x 10^7 square feet. Assuming a saturated thickness of 50 feet and porosity of 30 percent (Driscoll, 1986), there is approximately 1.83 x 10^8 cubic feet or about 1.4 x 10^9 gallons of affected groundwater. Therefore, the five corrective action wells have pumped approximately one pore volume of water during the six years of operation (based on the removal of 1.6 x 10^9 gallons of water from September 1987 through April 1993 described above). As would be expected, one pore volume has not caused a significant decrease in the areal extent of the plume based on the 2.0 μg/l mercury contour. This is somewhat due to fluctuations in the data at these low concentrations and how the boundary of the plume is interpreted. There have been significant decreases in concentrations in perimeter wells located near the edge of the plume adjacent to corrective action wells. This is illustrated by the time versus concentration curve for E1 as discussed above and also by PE3D, which has shown a decrease in concentrations from the 10 μg/l range in 1985 to about 2 μg/l. One exception is PL10S, where concentrations have remained essentially constant due to the relatively flat gradient in this area caused by the seasonal influence of the Tombigbee River. About 2,300 pounds of organics and about 114 pounds of mercury have been recovered during the operating period. A table summarizing the estimated recovered mass is presented in Appendix A.

The observations presented in this section indicate that the CAP is effective at controlling contaminant migration. This FS includes evaluation of alternatives for modification of the CAP to accelerate contaminant removal.

1.3 NATURE AND EXTENT OF CONTAMINATION

1.3.1 Operable Unit 1

The nature and extent of contamination in OU-1 were evaluated using data for constituents present in the groundwater and information about potential sources of groundwater contamination. Potential source areas were evaluated by examining trends in quarterly groundwater data from 1987 until 1991 and conducting subsurface soil sampling at SWMUs. On-site wells were sampled to characterize the constituents in the groundwater, and off-site domestic wells were sampled to evaluate whether there has been off-site impact to groundwater. The horizontal and vertical extent of

contamination was interpreted from the on-site RI and RCRA sampling data and the off-site domestic well sampling data. The results and interpretations of the source evaluation and groundwater sampling activities are summarized in this section.

1.3.1.1 Potential Contaminant Sources

The source evaluation included an extensive review of the RCRA quarterly groundwater data to evaluate trends in chemical concentrations that may indicate the presence of continuous, significant sources of groundwater contamination. Potential sources were also evaluated using the results of the RI Phase III soil sampling.

For the source evaluation, Olin's quarterly RCRA sampling data from the second quarter of 1987 to the second quarter of 1991 were reviewed. The review revealed a potential continuing source of organics, the old plant (CPC) landfill. A possible secondary source of mercury, the dense brine that migrated downward through the Alluvial Aquifer beneath the weak brine pond area, was also revealed. No previously unknown sources were identified.

1.3.1.2 OU-1 Soils

Subsurface soil samples were collected from the following SWMUs/AOCs during the Phase III sampling activities to assess whether these areas are continuing sources of groundwater contamination:

- Old plant (CPC) landfill
- Former CPC plant area
- Sanitary landfills
- Lime ponds
- Strong brine pond
- Former mercury-cell plant
- Old plant (CPC) landfill drainage ditch
- Well sand residue area

Figure 1-12 shows the Phase III sampling locations. The details of the sampling procedures and the sampling results are presented in the draft RI report (WCC, 1993). The sampling results are summarized below. A fate and transport analysis, summarized in Section 1.4.1, was performed to quantitatively assess whether these SWMUs/AOCs are continuing sources of groundwater contamination.

Old Plant (CPC) Landfill

The site of the old plant (CPC) landfill (Figure 1-2) was utilized from 1954 until 1972 to neutralize acidic wastewater from CPC plant operations. Neutralization was conducted by directing the wastewater over piles of oyster and clam shells. The flow was then routed by an overflow ditch to the main plant wastewater ditch. Plant personnel indicate that the former landfill also received organic wastes from the CPC plant consisting of hexachlorobenzene and trichloroacetonitrile residue. It is reasonable to assume that other organic wastes from monochlorobenzene production were also placed in this unit. From 1972 to 1977 the site was used for disposal of general plant debris such as paper, cardboard, wood, small metal containers, scrap plastic and rubber items from the entire plant. There are no records to indicate that the former landfill ever received any mercury sludges. The mercury sludges were managed in the weak brine pond. The landfill area is approximately 300 x 400 feet and is estimated to have had an 8,000-cubic-yard capacity. In 1977, prior to RCRA, the landfill was closed with a clay cap, topsoil, and grass, as approved by the ADEM. The cap was upgraded in 1984 to address erosion problems that had occurred. During the upgrade, a 2-foot-thick layer of compacted clay was placed; a 3- to 6-inch layer of topsoil was placed over the clay cap and the area was vegetated. A 3-foot-deep cutoff of recompacted clay was keyed into native clay around the entire perimeter of the landfill to limit leachate migration from the landfill.

During the RI Phase III sampling, four soil borings were completed in the landfill area through the residual waste material and underlying clay aquitard and 20 feet into the unsaturated sand above the Alluvial Aquifer (Figure 1-12). The soil and residual waste samples were analyzed for the EPA's Contract Laboratory Program (CLP) Target Compound List (TCL) volatile organics, TCL semivolatile organics, TCL pesticides/PCBs and the selected Target Analyte List (TAL) constituents.

Boring logs from the old plant (CPC) landfill soil samples are presented in Appendix B. The lithologic descriptions from these borings indicate that the landfill area is overlain by topsoil and a 2- to 4-foot-thick clay cap. Silty clay fill material, from about 4 to 12 feet thick, was encountered beneath the clay cap in each of the borings. This fill layer contains residue of the waste that was disposed of in the landfill. Shell, rock and wood fragments were found throughout the fill. In boring BOP2, the fill/waste layer also contained about 6 feet of a lime-like substance. Saturation at the base of the fill/waste layer was apparent in three of the four borings. The most distinct saturated layer was encountered at boring BOP1, located in the northwest corner of the landfill. An approximately 9-foot-thick zone of very wet, loose silt/clay, with little or no apparent strength, was found beneath the fill/waste material. A stiff, gray, red and brown clay ranging from 3 to 17 feet thick was encountered beneath the fill/waste and saturated zones in all borings. Each boring penetrated 20 feet into the reddish yellow, fine-to-coarse-grained unsaturated sand above the Alluvial Aquifer. The sand was described as damp to wet at the base of the borings. Total depths for the four landfill borings ranged from 40 to 48 feet below ground surface.

Fill/Waste Material. Table 1-2 summarizes TCL and selected TAL constituents analyses of the fill/waste material from the old plant (CPC) landfill. Based on the Phase III analytical results, the fill/waste material generally contains less than 0.1 percent chlorinated organics. The constituents most frequently detected in the samples included the following TCL organic compounds: chlorobenzene, the dichlorobenzene isomers, 1,2,4-trichlorobenzene, 1,2,4,5-tetrachlorobenzene, and hexachlorobenzene. Hexachlorobenzene was detected in the fill/waste samples at concentrations from 13 mg/kg to 170 mg/kg. The three dichlorobenzene isomers ranged from not detected to 120 mg/kg. The other TCL chlorinated benzenes ranged from not detected to 32 mg/kg. None of the pesticide/PCB constituents were reported at concentrations greater than 1.0 mg/kg.

Clay and Unsaturated Sand. Table 1-3 summarizes the TCL and TAL results for samples collected from the clay and the unsaturated sand above the Alluvial Aquifer in the old plant (CPC) landfill area. A sample of the loose saturated silt/clay found in BOP1 was also collected for analysis, and the results are also summarized in Table 1-3.

The analytical results of the loose saturated silt/clay from BOP1 were similar to those of the fill/waste material. The TCL volatile and semivolatile constituents detected included chlorobenzene, benzene, chloroform, tetrachloroethene, dichlorobenzene isomers, 1,2,4,5-tetrachlorobenzene, 1,2,4-trichlorobenzene, phenol (estimated below the Contract Required Quantitation Limit, or CRQL), and hexachlorobenzene. Semivolatile chlorinated benzene concentrations ranged from 7.1 mg/kg for 1,3-dichlorobenzene to 140 mg/kg for hexachlorobenzene. The pH reported in this sample was 2.6, indicating acidic conditions.

The volatile organic compounds were more frequently detected in the clay than in the overlying fill/waste material; chlorobenzene was reported in all five clay samples at concentrations ranging from an estimated 0.007 mg/kg (below the CRQL) in BOP3 to 7.3 mg/kg in BOP1. The semivolatile compound hexachlorobenzene, detected at 170 mg/kg in a fill/waste sample, was detected in only one of the clay samples, at an estimated concentration below the quantitation limit of 0.4 mg/kg (BOP4). The dichlorobenzene isomers were reported in clay samples from the two western borings, at concentrations up to 74 mg/kg (for 1,4-dichlorobenzene in BOP4).

The TCL volatile and semivolatile organics detected in the sand above the Alluvial Aquifer included chlorobenzene, 1,1,1-trichloroethane, chloroform, benzene, the dichlorobenzene isomers, 1,2,4,5-tetrachlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, fluoranthene, and phenol. As in the clay, concentrations in the sand varied laterally and distinctly. The semivolatile chlorinated benzenes were detected in samples from the two borings on the western side of the landfill (BOP1 and BOP4), at concentrations up to 150 mg/kg for 1,4-dichlorobenzene, but were not detected in samples from the two eastern borings. Similarly, the volatile concentrations were higher in samples from the western borings BOP1 and BOP4, with chlorobenzene up to 46 mg/kg, but were less than 0.05 mg/kg in the sand samples from eastern borings BOP2 and BOP3.

Pesticide constituents were also reported in the clay and sand, at low concentrations similar to those in the fill/waste. Most reported pesticide values were estimated and below 0.01 mg/kg.

Vertical Distribution. The vertical distribution of the TCL chlorinated benzenes in the old plant (CPC) landfill area is illustrated in Figure 1-13. Three of the four borings (BOP2, BOP3 and BOP4) showed a distinct decrease in concentrations with depth. Chlorobenzene was the only TCL chlorinated benzene detected in the clay or sand from the two eastern borings, and concentrations in the sand samples were estimated below the CRQL. Approximately 140 to 340 mg/kg chlorinated benzenes were reported in the clay and the upper sample of the sand in BOP4. However, TCL chlorinated benzenes were not detected in the sample of the sand collected from the base of the boring.

Figure 1-13 shows no distinct decrease in concentrations with depth at boring BOP1. The distribution of constituents at BOP1 may be attributed to the presence of the loose saturated silt/clay zone from 12 to 21 feet. The material is described as very loose, with no apparent strength, and has a pH of 2.6. The clay structure and thus attenuation properties may have been affected by the acid neutralization activities that took place in the area prior to 1972. Because the occurrence of this zone appears to affect vertical migration and may affect any potential remedy for the landfill, an electrical resistivity survey was conducted in the area to define the limits of the zone. The results of this survey are presented in Appendix C.

Mercury/TAL Results. Mercury concentrations detected in the fill/waste samples are summarized below:

Boring	Sample Interval (ft)	TAL Mercury Concentration (mg/kg)
B0P1	10 - 12	<0.25
B0P2	2 - 8	57.1
B0P3	4 - 5	21.7
B0P4	4 - 6	406

Mercury was detected in the loose saturated silt/clay sample from BOP1 at a concentration of 0.42 mg/kg. Mercury was detected in only one of the five clay samples (BOP221 at 0.62 mg/kg) and was not detected in any of the samples of the sand above the Alluvial Aquifer. These data indicate that although the fill/waste matrix contains

some mercury, it is not present in the sand above the Alluvial Aquifer in the areas that were sampled, and therefore the landfill is not believed to be a continuing source of mercury to the groundwater. Further evaluation is presented in Section 1.4.1.

Tables 1-2 and 1-3 also present the selected TAL constituent (inorganic) results for samples collected from the old plant (CPC) landfill area. Considering analytical variability and natural variations in soils, the results indicate that TAL analytes (other than mercury) in the CPC landfill samples are generally within a range commonly found for naturally occurring soils.

Former CPC Plant

The former CPC plant was constructed in 1952 and initially manufactured monochlorobenzene, adding pentachloronitrobenzene (PCNB) in 1956. In 1973, the plant was expanded to produce trichloroacetonitrile (TCAN) and 5-ethoxy-3-trichloromethyl-1,2,4-thiadiazole (Terrazole®). The PCNB, TCAN and Terrazole® manufacturing areas were collectively referred to as the crop protection chemicals (CPC) plant. The CPC plant was shut down in 1982 for market economic reasons. In 1984, the business was sold and the plant area was decommissioned, dismantled and covered with an approximately 2-foot-thick recompacted clay cap and topsoil. The capped area was then vegetated. The plan for decommissioning and dismantling the CPC plant area was approved by ADEM in 1983 and the work was completed in accordance with that plan.

Two soil borings were completed at the western and southern boundaries of the former CPC plant area during Phase III of the RI (Figure 1-12). The two borings were drilled into the unsaturated sand above the Alluvial Aquifer. The boring logs are presented in Appendix B. The soil samples were analyzed for CLP TCL volatile organics, TCL semivolatile organics, TCL pesticides/PCBs, and the selected list of TAL constituents.

The borings encountered 10 to 12 feet of clay overlying unsaturated sands and silts above the Alluvial Aquifer. The boring to the south of the plant was completed to a depth of 20 feet; the one to the west of the plant was completed to 32 feet. Groundwater was not encountered in either of the borings.

The results of the TCL and TAL analyses are summarized in Table 1-4. Distinctly different results were obtained from the two borings. Chloroform and hexachlorobenzene were the only TCL constituents detected in the clay sample from the boring completed to the south of the former plant (BCP2). Both were reported at estimated concentrations below the CRQL. No TCL compounds were reported in the BCP2 samples from the unsaturated sand above the Alluvial Aquifer.

The boring completed west of the former CPC plant (BCP1) showed chlorobenzene at a maximum concentration of 0.54 mg/kg in the upper clay material. Benzene, carbon disulfide and chloroform were also detected in the clay, at concentrations less than 0.02 mg/kg. The detected TCL semivolatile chlorinated benzenes in the two clay samples ranged from an estimated concentration of 0.2 mg/kg for hexachlorobenzene to 750 mg/kg for 1,2,4,5-tetrachlorobenzene. Concentrations in BCP1 decreased with depth in the sand. Only two TCL chlorinated benzenes were detected in the bottom (sand) sample from BCP1 (30 to 32 feet): hexachlorobenzene at 1.5 mg/kg and 1,2,4,5-tetrachlorobenzene at an estimated concentration below the CRQL of 0.055 mg/kg.

Tetrachlorobenzene and pentachlorobenzene were the most frequently detected tentatively identified compounds (TICs) reported in samples from BCP2. The estimated concentrations in the 8- to 10-foot clay sample were 1,400 mg/kg for tetrachlorobenzene and 340 mg/kg for pentachlorobenzene. The compound 1,2,4,5 tetrachlorobenzene is not generally analyzed as a target compound, as was done for the CPC plant samples, and the TIC results do not specify the specific tetrachlorobenzene isomer. Therefore, the reported tetrachlorobenzene TIC may actually be the 1,2,4,5 isomer that is also reported with the TCL compounds. The BCP1 area is adjacent to the former railroad loading/unloading area, where tetrachlorobenzene was unloaded for use in the production of PCNB.

Table 1-4 also provides the inorganic results from the former CPC plant area borings. Mercury was not detected in former CPC plant area samples. The TAL results are generally within a range commonly found for naturally occurring soils.

Old Plant Landfill Drainage Ditch

The old plant landfill drainage ditch is a former ditch from the old plant (CPC) landfill (when it was used as an acidic wastewater neutralization pond) to the wastewater ditch. The sampling objective was to assess whether hazardous constituents have been released to the soils from this former ditch. There has been extensive earth work in the area associated with the closure of the old plant (CPC) landfill and there is no longer any surface remnants of the ditch. One shallow soil boring was completed at the estimated location of the old plant landfill drainage ditch as shown in Figure 1-12. The boring was to a depth of approximately 10 feet, and two composite soil samples were collected, one from the 0- to 1-foot interval and one from the 1- to 10-foot interval. The two composite samples were analyzed for CLP TCL volatile organics, TCL semivolatile organics, TCL pesticides/PCBs, and the selected list of TAL constituents. No TCL volatile constituents were detected in the two samples. Hexachlorobenzene was the only TCL semivolatile constituent detected: in the 0- to 1-foot sample at 5.6 mg/kg and in the 1- to 10-foot sample at 2.7 mg/kg. No PCB/pesticides were detected in the 0- to 1-foot sample. Two pesticide/PCB compounds were detected at low concentrations in the 1- to 10-foot sample: beta-BHC at 0.0024 mg/kg and 4,4'-DDE at 0.0051 mg/kg. Mercury was detected at 0.95 mg/kg in the 0- to 1-foot sample and at 10.2 mg/kg in the 1- to 10-foot sample. The TAL results are generally within a range commonly found for naturally occurring soils.

Sanitary Landfills

The sanitary landfills are two closed units that comprise about 12 acres. Cells at the landfill were dug 6 feet deep, which placed the bottom of the waste well above the water table. The landfills were intended for the disposal of only sanitary waste, trash, and debris. Three randomly-located borings were used to collect soil/waste samples from the landfills. Each boring penetrated the full waste depth (0 to 7 feet) and was composited for analysis. The samples were analyzed for CLP TCL volatile organics, TCL semivolatile organics TCL pesticides/PCBs, and the selected list of TAL constituents. The samples were also analyzed for TCLP mercury. The sanitary landfill boring logs are presented in Appendix B.

The sanitary landfill sample results are summarized in Table 1-5. The purpose of the sampling was to address the report cited by the RFA Contractor (CERCLA Draft File Summary), which suggested that the landfills received wastes containing hexachlorobenzene and mercury sludges. Hexachlorobenzene concentrations in the three samples ranged from 9.5 mg/kg to 44 mg/kg. Mercury concentrations ranged from 7.8 to 27.1 mg/kg. Mercury was not detected in the extract from the TCLP tests for any of the sanitary landfill samples. The total mercury and hexachlorobenzene concentrations probably reflect the disposal of contaminated fill and other debris that occurred from 1977 to 1984 when the landfills were active, rather than direct disposal of waste as suggested in the report cited by the RFA Contractor. The target chlorinated benzenes: chlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, and 1,3-dichlorobenzene were detected at low concentrations (< 10 mg/kg) in all three samples.

Pentachlorobenzene and pentachloronitrobenzene were tentatively identified in the sanitary landfill samples at estimated concentrations ranging from 1.0 mg/kg to 3.6 mg/kg for pentachlorobenzene and 0.16 mg/kg to 31 mg/kg for pentachloronitrobenzene. 2,3,4,5,6-pentachlorobenzamine was tentatively identified in the three samples, with estimated concentrations ranging from 0.25 mg/kg to 6.5 mg/kg.

Considering analytical variability and natural variations in soils, the results indicate that TAL analytes (other than mercury) in the sanitary landfill samples are generally within a range commonly found for naturally occurring soils.

Lime Ponds

The east and west lime ponds[1] were used exclusively to manage spent lime slurry used to absorb chlorine gas from various vent streams. Their use ceased in 1976 and they were closed in 1979 with ash for stabilization, a clay cap, topsoil and grass.

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[1] "Ponds" refers to the nature of these units during operation. They are now capped with a mounded above grade appearance, with no characteristic of a pond.

To assess the potential for the lime ponds to contribute mercury to groundwater, a boring was located near the center of each pond as shown in Figure 1-12. A composite sample was collected from the zone of lime waste encountered in each of the two ponds. The samples were analyzed for total and TCLP mercury because it was the only constituent of concern and no organics were handled in the units. The closed lime ponds are situated about 10 to 15 feet above natural grade. Based on the Phase III borings, the lime waste in these ponds is covered by 0.5 to 6.0 feet of clay/sandy clay and about 10 feet of ash. The ash was used as fill material when the ponds were closed and is described as saturated 6 to 8 feet below the surface. Considering that the water table in the area is about 25 to 30 feet below the lime waste, the ash is interpreted to be saturated from water that is perched on the lime waste and/or the underlying stiff clay layer. The estimated thickness of the lime waste from the borings was about 3.0 feet for the east pond and about 1.75 feet for the west pond. The sample results are summarized below:

Boring	Sample Interval (ft)	TAL Mercury Result (mg/kg)	TCLP Mercury Result (μg/l)
BL1	16 to 18	1.3	10
BL2	12 to 14	0.46	3

The results indicate that the lime wastes contain little mercury. In addition, the TCLP tests yielded leachate concentrations less than or equal to 10 μg/l mercury, indicating a low potential for mercury to be leached from the waste. The potential for migration of mercury from the lime ponds to the groundwater is quantitatively evaluated in Section 1.4.1.

Former Mercury Cell Plant

The former mercury cell plant area was the location of the mercury cell rooms until the plant was shutdown in 1982 and demolished in 1986. Decommissioning included removing all aboveground structures to grade, which consisted of the concrete bottom floor of the building. The sumps and trenches were filled with clay. Because the cell rooms had been potential sources of mercury releases during operation and to minimize rain water infiltration that might become contaminated, the floor was covered with a

synthetic roofing membrane (Durbigum®) and asphalt. To assess the potential for soils beneath this former building to continue to act as source of mercury to groundwater, six core samples were collected from the one acre area in an unbiased grid pattern (Figure 1-12). The cores were advanced 4 feet into the soils beneath the membrane/asphalt. The upper 4 feet was selected as representing the highest potential for containing mercury. One composite sample of the complete 4-foot interval was obtained from each boring and analyzed for mercury (total and TCLP). The results are summarized below:

Boring	Sample Interval (ft)	TAL Mercury (mg/kg)	TCLP Mercury (µg/l)
BMC1	0 to 4	<0.12	<2
BMC2	0 to 4	<0.12	<2
BMC3	0 to 4	<0.12	<2
BMC4	0 to 4	164	40
BMC5	0 to 4	0.38 0.16 (Duplicate)	<2
BMC6	0 to 4	3.4	<2

Total mercury was detected at three of the six sample locations. Leachable mercury from the TCLP test was detected in one sample (BMC4) at a concentration of 40 µg/l; the corresponding total mercury concentration reported in this sample was 164 mg/kg. The mercury detected in the soils is believed to be due to minor material handling losses that occurred during operations from 1952 to 1982. Although mercury occurs sporadically throughout the soils, the TCLP test indicates that it is not conducive to leaching. Section 1.4.1 presents a quantitative analysis of the potential for contaminant migration from subsoils beneath the mercury cell plant.

Strong Brine Pond

The strong brine pond was a former process unit that was removed in 1985. It was approximately 340 x 340 feet and constructed partially above-grade in natural clay. The strong brine pond was a holding pond for the strong brine process fluid that was removed from the brine wells for use in the mercury cell plant. The pond was sampled to assess whether mercury-containing brine seeped from the pond and contaminated the underlying soils to the extent that mercury can be leached to the groundwater. Two soil

borings were completed in the strong brine pond area, as shown in Figure 1-12. The borings were to a depth of 2 to 4 feet into the natural soils below the base of the pond. One sample of the natural soil from the base of each boring was collected and analyzed for TCLP mercury. Mercury concentrations from the TCLP leachate were 5 μg/l and 30 μg/l for the two samples. These results indicate that while some mercury has migrated to the natural soils beneath the former pond, the potential for this mercury to leach from the soils is low. The potential for vertical migration to groundwater from the strong brine pond is evaluated quantitatively in Section 1.4.1.

Well Sand Residue Area

Well sands were generated during the period from 1952 to 1968 from development and operation of the brine wells for the mercury cell chlor-alkali process. These sands are residues of the natural insoluble material from the salt domes. During early operation of the mercury cell plant, when the well sands were generated, they were deposited in mounds in an area referred to in the RFA as the well sand residue area. The well sand in these mounds is a cohesive granular material that has the consistency of sandstone. The well sand material was sampled to determine the mercury content and assess the leachability of any detected mercury. Samples were collected at ten randomly selected areas and depths within the mounds; the 10 individual samples were ground and composited into one sample for analysis (mercury and TCLP mercury). The total mercury concentration detected in the well sand composite sample was 20.1 mg/kg. Mercury was not detected in the leachate from the TCLP analysis. Although mercury is contained in the well sand, the mercury is not leachable (based on the TCLP test). Also, because of the well sand consistency, there is little potential for dust generation or exposure from incidental direct contact.

1.3.1.3 OU-1 Groundwater

As discussed in Section 1.2.1, there are two aquifers of concern at the Olin McIntosh site: the Alluvial Aquifer and the Miocene Aquifer. The Alluvial Aquifer has been well studied under many investigations since 1980. Based on these investigations, Olin implemented a groundwater corrective action program in 1987. The ongoing RCRA monitoring includes quarterly sampling of compliance and corrective action wells

screened in the Alluvial Aquifer. These results are reported to EPA and ADEM in semiannual reports.

Twenty-nine monitor wells and corrective action wells screened in the Alluvial Aquifer were sampled at the facility during the period September 9 through 19, 1991. The wells were sampled for the following constituents: mercury (total and dissolved), the selected list of 13 additional Target Analyte List (TAL) compounds (total and dissolved); Target Compound List (TCL) volatile organics; TCL semivolatile organics; TCL pesticides/PCBs and chloride.

Table 1-6 summarizes the maximum concentration and frequency of detection for TCL and selected TAL constituents (total) in the Alluvial Aquifer samples. For comparison to background and drinking water standards, Table 1-6 also provides the results from background well WP9A and the Primary Drinking Water Standard maximum contaminant levels (MCLs) for the constituents for which final MCLs have been established.

Mercury and organics (predominantly chloroform, chlorobenzene and the dichlorobenzene isomers) were reported in samples from the on-site monitor wells screened in the Alluvial Aquifer. The most frequently detected volatile constituents were chloroform, chlorobenzene, bromodichloromethane, and benzene. The dichlorobenzene isomers were the most frequently detected semivolatile compounds. No pesticide/PCB compounds were reported above a concentration of 6.0 μg/l. TCL organic constituents were not reported in the background well WP9A.

The horizontal extent of constituents was defined based on the RI sampling data and data from the RCRA groundwater sampling programs. Mercury is the primary inorganic constituent of concern at the facility and is therefore used to define the extent of inorganics. Chloroform can be used to define the extent of organics because it is found in all perimeter wells that contain organics and at concentrations higher than other organics (with one exception). The exception is at the west perimeter, where chlorobenzene was reported at a greater concentration than chloroform. Therefore, with the exception of the west perimeter where chlorobenzene was considered, chloroform was used to define the horizontal extent of organics.

The horizontal extent of mercury and chloroform in the groundwater is presented in Figures 1-14 and 1-15. These figures indicate that constituents are generally within the Olin property boundaries and there is not a continuous plume that extends to any off-site drinking water wells. Both mercury and chloroform were reported at concentrations higher than the Primary Drinking Water Standard MCLs, but the site is subject to a legally enforceable RCRA corrective action program until MCLs are met. The MCLs were designated as the groundwater protection standards based on protection of human health. Discontinuing the CAP after meeting the MCLs, may allow some groundwater that is currently being captured by the CAP to discharge to surface water. Section 2.2.5 provides a discussion of the potential impact to surface water from discharge of OU-1 groundwater.

Two process water wells and two monitor wells that are screened in the Miocene Aquifer were also sampled for the RI. Table 1-7 summarizes the results and also provides background sampling results from McIntosh City Water Wells 1 and 2, which are also screened in the Miocene Aquifer, but away from the Olin site. Water Well 1 is about 2 miles to the northwest and Water Well 2 is about 5 miles southwest of the site. For comparison, Table 1-7 also lists the Primary Drinking Water Standard MCLs for the detected constituents that have established standards.

Chlorobenzene, 1,2-dichlorobenzene, and 1,4-dichlorobenzene were reported in the groundwater samples from one of the process water wells screened in the Miocene Aquifer. The detected concentrations in this well were less than the MCLs. The continuous operation of the process water wells should preclude off-site migration of these contaminants.

A total of 122 residential wells (active, inactive and closed) were identified within a 3-mile radius of the Olin facility; 34 of these wells were drinking water wells that could be sampled. See Appendix D for well locations and results. Samples from the drinking water wells identified in the domestic well survey were analyzed for the following constituents: total mercury, total organic carbon (TOC), total suspended solids (TSS), and chloride. In addition, the wells were analyzed for TCL volatile organic constituents. Mercury was reported in only 1 of these 34 drinking water wells and volatile constituents were reported in 11 wells. Most of the reported concentrations of volatile constituents

were clearly unrelated to the Olin facility. All reported concentrations were below the respective MCLs.

1.3.2 Operable Unit 2

The site characterization activities for OU-2 focused on the sediments and surface water and an assessment of the potential effects on biota. Samples were obtained from the basin (surface water, sediment grab and sediment core), the floodplain (sediment grab) and the ditches (surface water, sediment grab and sediment core). The sampled ditches included the wastewater ditch that currently conveys stormwater and wastewater, the current discharge ditch to the Tombigbee River, and the former discharge ditch to the basin. Wastewater no longer flows in the former discharge ditch.

The biota assessment was conducted as part of the baseline risk assessment and is summarized in Section 1.6. It included fish sampling, a macroinvertebrate study, and a vegetative stress survey.

1.3.2.1 Potential Contaminant Sources

The sediments deposited in the basin and the ditches are the source of contaminants in OU-2. The sediments could be considered a secondary rather than a primary source, since contamination was transported there years ago by wastewater and storm water discharges. The lithologic descriptions of the cores indicate that as much as five feet of sediment has been deposited in the wastewater ditch since plant operations began. The geologic cross section created from the cores in the basin area (Figure 1-11) showed a silty clay/clayey silt unit that thins to the east away from the former discharge ditch. The thicker portions of this unit are interpreted to be sediments carried down the wastewater ditch and deposited in this area. Plant operations probably increased the quantity of these sediments and their potential to act as secondary sources to other media. The effects on other media were evaluated from the surface water sampling, the biota sampling and the evaluation of OU-2 groundwater.

1.3.2.2 OU-2 Sediments

The sediment sampling in OU-2 was conducted in three phases. A total of 15 core sediment samples and 112 grab, surficial (upper 6 inches) sediment samples were collected from within the basin and ditches in OU-2 during Phase I. Core samples were collected at five additional locations (three in the basin and two in the wastewater ditch) during Phase II. The Phase I and II sampling was designed to characterize the constituents in the sediment and define the horizontal and vertical extent of contamination. A review of the data showed that the Phase I and II sampling did not completely delineate the horizontal and vertical extent, and additional sampling was conducted during Phase III. The Phase III sampling consisted of collecting grab surface samples (0 to 0.5 feet) from the floodplain area beyond the limits of the basin, collecting a surficial sediment sample from the Tombigbee River at the outlet to the discharge ditch, and collecting additional core samples to a greater depth at the OD15 location. Background sediment samples were also collected during Phase III and analyzed for TAL constituents for comparison to the Phase I data.

Table 1-8 summarizes the results of the Phase I sediment sampling. Mercury and the chlorinated benzenes are the predominant constituents related to the Olin facility that were detected in the sediments. Therefore, mercury and hexachlorobenzene were used to define the horizontal extent of contamination. The most frequently detected organic constituents, however, were those related to DDT and its by-products (4,4'-DDD, 4,4'-DDT, and 4,4'-DDE). Olin has never manufactured or handled any of the DDT constituents.

The distributions of hexachlorobenzene and mercury in the basin and ditches are summarized in Figures 1-16 and 1-17, respectively. Hexachlorobenzene in the sediments is generally limited to the southern one-third of the basin, with isolated detected values in the northeastern corner of the basin and the small pond to the north of the basin. On the floodplain, hexachlorobenzene was detected only in the area adjacent to the former discharge ditch. Mercury concentrations higher than 10 mg/kg are generally confined to the basin and localized parts of the two ponded areas to the north. A distinct pattern of decreasing mercury concentrations with distance from the water bodies supports the finding that the boundary of the submerged areas at nonflood

conditions defines the extent of mercury. Mercury concentrations in the grab sediment samples from the wastewater ditch were generally lower than those from the basin. Hexachlorobenzene was detected at higher concentrations in the wastewater ditch than in the basin.

Figure 1-18 illustrates the vertical distribution of constituents in the OU-2 basin sediments. The vertical distribution is related to the sediment type and depositional history. The stratigraphy in the basin consists of silty clay/clayey silt (interpreted to be deposits of sediment carried down the wastewater ditch) underlain by the Tombigbee River floodplain deposits. Samples from the floodplain showed nondetectable or low concentrations of both mercury and hexachlorobenzene. Consequently, the contact between the upper silt unit and the floodplain deposits is interpreted to define the vertical extent of contamination in the basin. The vertical extent of constituents in the wastewater ditch is defined as the contact between the upper unconsolidated sediments (i.e., ditch sediment deposits) and the underlying stiff Quaternary clay, as illustrated in Figure 1-18.

1.3.2.3 OU-2 Surface Water

A total of 12 surface water samples were collected during the RI site characterization. Nine samples were collected at five locations in the basin. Samples were collected at two discrete depths at four of these locations. In addition, one sample was obtained from each of the three ditches (the current wastewater ditch, the current discharge ditch to the Tombigbee River, and the former discharge ditch to the basin). The samples were analyzed for mercury (total and dissolved), the selected list of other TAL constituents (total and dissolved), TCL volatile organics, TCL semivolatile organics, TCL pesticides/PCBs, dissolved oxygen (DO), pH, total organic carbon (TOC), total suspended solids (TSS), and total dissolved solids (TDS).

Only two organic constituents were detected in the surface water samples: chloroform in one sample at 3.0 μg/l and alpha-BHC (at less than 0.25 μg/l) in two samples. Eight inorganic constituents were detected in the total (unfiltered) analyses. The following compares the maximum detected concentrations to the Federal Water Quality Criteria:

Chemicals	Maximum* Concentration Detected (µg/l)	Number of* Samples Out of 12 Where Analyte Was Detected	Average** (µg/l)	Federal Water Quality Criteria (µg/l)			
				Freshwater Aquatic Life		Human Health-Ingestion Organisms Only	
				Acute [a]	Chronic [c]	No Risk Level	10^{-5} Cancer Risk in Lifetime
Alpha-BHC	0.22	2	0.05	NA	NA	NA	0.31
Arsenic	12.2	2	2.83	NA	NA	NA	0.175
Cadmium	2.2	2	1.19	1.8-8.6[b][e]	0.66-2[d][e]	NA	NA
Chromium[f]	11.1J	8	4.97	16[b]	11[d]	NA	NA
Cyanide	36.9	7	14.96	22[b]	5.2[d]	NA	NA
Lead	3.8J	4	2.04	34-200[b][e]	1.3-7.7[d][e]	NA	NA
Mercury	2.8	12	1.37	2.4[b]	0.012[d]	0.146	NA
Nickel	45.9	7	13.27	790-2500[b][e]	88-280[d][e]	100	NA
Zinc	444J	11	131.33	65-210[b][e]	59-190[d][e]	NA	NA
Chloroform	3J	1	4.83	28900	1240	NA	157

NOTES:

- * Total (unfiltered) analyses only
- ** Non-detections were taken as one-half the detection limit to calculate the average.
- NA Not available
- J Estimated concentrations
- U Not detected at or above the detection limit shown.
- (a) Instantaneous maximum, not to be exceeded at any time. Applies to all acute aquatic life criteria, except for those noted with (b).
- (b) One hour average, not to be exceeded more than once every 3 years on the average.
- (c) Twenty-four hour average. Applies to all chronic aquatic life criteria, except for those noted with (d).
- (d) Four day average, not to be exceeded more than once every 3 years on the average.
- (e) By formula dependent on water hardness. Source: Shields, E. J. Pollution Controls, Engineer's Handbook. Federal Quality Criteria, p. 65-70.
- (f) The water quality criteria is for hexavalent chromium. The surface water samples were for total chromium.

Additional discussion of the Federal Water Quality Criteria is presented in Section 2.2.

1.4 FATE AND TRANSPORT

1.4.1 Operable Unit 1

The primary routes of migration in OU-1 are percolation through the subsoils (with potential leaching of contaminants from the soils to the percolate), infiltration to the groundwater, and horizontal groundwater contaminant migration in the Alluvial Aquifer.

Mercury-containing dense brine seeped from the weak brine pond during its operation and sank to the top of the Miocene clay. Lateral migration of this mercury-containing dense brine along the base of the Alluvial Aquifer is also a potential pathway. Section 1.4.1.1 summarizes the fate and transport of constituents from the soils to the groundwater and presents quantitative evaluations of whether SWMUs/AOCs are continuing sources of groundwater contamination. The fate and transport analysis of constituents in the groundwater is summarized in Section 1.4.1.2.

1.4.1.1 Fate and Transport in Soils

This section presents an evaluation of the potential for contaminant migration through the soils to the Alluvial Aquifer from the SWMUs/AOCs that were sampled during Phase III. The criteria to judge whether the effects on groundwater are significant is the MCL, i.e., whether contaminant migration from a SWMU/AOC would cause otherwise uncontaminated groundwater to exceed MCLs at the SWMU boundary. The analysis was conservatively conducted and in most cases it was assumed that the source concentration was the maximum concentration detected in the soils. Where site-specific leachate (TCLP) test data were available, the maximum concentration from the TCLP extract was assumed to be the leachate concentration at the source. Based on this analysis, potential soil action levels (PSALs) were developed for the SWMUs/AOCs that were identified as potential continuing sources of groundwater contamination. The development of PSALs is described in Section 2.2.3.

Old Plant (CPC) Landfill

As discussed in Section 1.3.1.1, the old plant (CPC) landfill was evaluated as a possible continuing source of mercury and organics. No inorganics other than mercury were found in the soils at concentrations significant enough to indicate a need to further evaluate the old plant (CPC) landfill as a possible continuing source of those inorganics. Cadmium, chromium and lead concentrations in groundwater of the Alluvial Aquifer indicate that acidic water released in this area may have leached cadmium, chromium, and lead from the soil into the groundwater, but the data indicate that this is not continuing.

One of four soil borings (BOP1) completed through the landfill encountered a loose, low-strength silt/clay zone from 12 to 21 feet. The pH of this silt/clay was 2.6 and the clay structure may have been affected by the acid neutralization activities that took place in the western portion of the landfill prior to 1972. Low pH conditions were not present in the overlying landfill materials. The area at BOP1 appears to be a possible localized pathway for migration of organic constituents downward in the Alluvial Aquifer. Mercury was not detected in the residual fill/waste material at BOP1.

Mercury was detected in only one of the five samples of the clay that separates the landfill from the Alluvial Aquifer. The mercury concentration of that clay sample was 0.62 mg/kg. Mercury was not detected in any of the eight samples of soil that were collected below the landfill from the sand above the Alluvial Aquifer. These data indicate that the landfill is probably not a continuing source of mercury to the Alluvial Aquifer. However, since mercury is a primary contaminant in OU-1 groundwater, further evaluation was conducted to assess whether the landfill could affect mercury concentrations in the groundwater of the Alluvial Aquifer.

Groundwater would be considered affected by the landfill if percolation through the soil and infiltration to the groundwater caused mercury concentrations in the Alluvial Aquifer to exceed the Safe Drinking Water Act maximum contaminant level (MCL) of 2.0 μg/l. The soil sampling data indicate that this is probably not occurring. However, an analysis was performed to evaluate whether mercury generated from the soils would cause otherwise uncontaminated groundwater at the landfill boundary to exceed the MCL. This approach is referred to as the Summers model (Summers and others, 1988). The Summers analysis is very conservative because it does not consider attenuation in the unsaturated zone and therefore reflects worst case. The landfill occupies an area of about 300 x 400 feet. Although only one of five soil samples of the clay underlying the landfill contained detectable mercury, at 0.62 mg/kg, a conservative assumption that the subsoil in the entire area contains 0.62 mg/kg of mercury was used in this calculation.

Leachate (i.e., TCLP) data are not available for the samples from the old plant (CPC) landfill and therefore the concentration in the downward percolating leachate was estimated with the following equation:

$$C_{LEACH} = \frac{C_{SOIL}}{Ad} \qquad \textbf{(1-1)}$$

where:

C_{LEACH}	=	concentration of percolating leachate
C_{SOIL}	=	soil concentration (mg/kg) = 0.62 mg/kg
Ad	=	the adsorption factor, which was estimated using:

$$Ad = \frac{\theta_w + \rho_b K_d}{(\theta_w \rho_w + \rho_b)} \qquad \textbf{(1-2)}$$

where:

θ_w	=	the volumetric water content (cm^3/cm^3)
ρ_b	=	the bulk density of the soil (g/cm^3)
ρ_w	=	the bulk density of the water (g/cm^3)
K_d	=	the sorption (distribution) coefficient ($g/g/g/cm^3$).

For mercury, the sorption coefficient was estimated using the following relationship between K_d and pH provided in Loux et al. (1990):

$$Log\ K_d = 0.122 \times pH + 1.42 \qquad \textbf{(1-3)}$$

The pH of the sample was 3.6 (from the CLP Form 1[1]), and K_d is therefore estimated as 72.3 g/g/g/cm^3. The volumetric water content (θ_w) was 20 percent (also from the CLP Form 1[1]). The porosity or saturated water content (θ_s) was assumed to be 0.40 (the approximate porosity for silt/sand, from Table 5.1 in Driscoll, 1986), and the bulk density of soil (weight of dry soil divided by the field or net volume of soil) was calculated from the relationship:

$$\rho_b = \rho_s (1-\theta_s) \tag{1-4}$$

where:

ρ_b	=	bulk density of soil (g/cm^3)
ρ_s	=	particle mass density (g/cm^3)
θ_s	=	porosity or the saturated water content

The particle mass density (ρ_s) was estimated to be 2.65 g/cm^3 (Freeze and Cherry, 1979) and the estimated bulk density of the soil (ρ_b) is 1.60 g/cm^3.

Using the above input parameters, Ad is calculated as 64 g/g/g/cm^3.

The estimated concentration in the leachate is:

$$C_{LEACHATE} = \frac{C_{SOIL}}{Ad} = \frac{0.62\ mg/kg}{64\ g/g/g/cm^3} \tag{1-5}$$

Based on this analysis, the concentration in the leachate is estimated as 0.0097 mg/l = 9.7 μg/l.

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[1] CLP Form 1s are in Volume N of the draft RI report.

The annual percolation rate through 6 inches of topsoil and 2 feet of clay was calculated from the HELP model, Version 2.0 (U. S. EPA, 1992) to simulate percolation through the landfill cap. The HELP model calculations are presented in Appendix E. As contaminants enter the Alluvial Aquifer, they will mix with the water flowing through the aquifer. The contaminants penetrate the aquifer and spread vertically beneath the source area because of the combined effects of vertical dispersion and vertical velocity of the recharge. Vertical spreading and mixing was simulated using a mass balance near-field mixing algorithm that is analogous to the approach used by U. S. EPA in the EPA's Composite Model for Landfill (U. S. EPA, 1990). This well-publicized and publicly scrutinized algorithm (noticed in the Federal Register) estimates the penetration depth (H) by adding the thickness of the plume due to the effects of vertical dispersion and vertical recharge rate:

$$H = (2\alpha_v L_b)^{\frac{1}{2}} + B\left(1 - \exp\left[\frac{-L_b I}{V B}\right]\right) \qquad \textbf{(1-6)}$$

where:

H	=	contaminant penetration depth (ft)
α_v	=	the vertical dispersivity in the Alluvial Aquifer (ft)
L_b	=	the horizontal length of the plume at the bottom of the unsaturated zone (ft)
B	=	the thickness of the Alluvial Aquifer (ft)
I	=	the vertical recharge rate (ft/day)
V	=	the Darcy velocity in the Alluvial Aquifer (ft/day)

Note that L_b is the horizontal length parallel to the flow direction and is equal to the characteristic length of the source. If the computed value of H is equal to or larger than the thickness of the aquifer, then H is assumed to be equal to the thickness. Equation 1-6 was used to calculate the vertical penetration depth with the following input parameters:

Vertical Dispersivity. The vertical dispersivity, α_V, in the Alluvial Aquifer was estimated as one-tenth the longitudinal dispersivity, α_L. Based on a relationship provided by Walton (1988), the longitudinal dispersivity was estimated as one-tenth the travel (transport) distance, L_b, as follows:

$$\alpha_L = 0.1\ L_b \tag{1-7}$$

$$\alpha_V = 0.1\ \alpha_L \tag{1-8}$$

Based on this analysis and assuming a longitudinal travel distance of 400 feet (the length of old plant (CPC) landfill in the groundwater flow direction), the longitudinal dispersivity for the old plant (CPC) landfill area was estimated as 40 feet. The vertical dispersivity was therefore estimated as 4.0 feet.

Horizontal Length of the Source. The horizontal length of the source, Lb, was estimated as the length of the source in the groundwater flow direction, which is 400 feet for the old plant (CPC) landfill.

Aquifer Thickness. The aquifer thickness, B, was estimated as 50 feet.

Vertical Recharge Rate. The estimated infiltration rate, I, from the HELP model (U.S. EPA, 1992) is 2.3 in/yr or 0.00053 ft/day (Appendix E).

Darcy Velocity. The Darcy velocity, V, in the aquifer was calculated from the following equation:

$$V = K\ i \tag{1-9}$$

where:

K	=	hydraulic conductivity of the Alluvial Aquifer (ft/day)
i	=	hydraulic gradient (dimensionless)

The Darcy velocity for the old plant (CPC) landfill was estimated as 0.75 ft/day.

Hydraulic Conductivity. Historical data were used to estimate the hydraulic conductivity, K. Available hydraulic conductivity data include single-well response test results from four monitor wells located in the area, MP4, MP7, MP9 and E4 (see Table 1-9) and data from one pump test of corrective action well CA3. The single-well response tests were generally reported as minimum values due to the rapid recovery of the wells during testing. The average hydraulic conductivity value from these four tests was 24.5 ft/day. The hydraulic conductivity value from the pump test was estimated as 578 ft/day. Since pump tests generally yield more reliable estimates of hydraulic conductivity, the average of 24.5 ft/day and 578 ft/day, which is 300 ft/day, was used as the estimate for the hydraulic conductivity.

Hydraulic Gradient. The hydraulic gradients, i, were estimated from the September 1991 potentiometric maps presented in the RI report (WCC, 1993). These estimates were obtained by calculating the gradient at several locations in both the upper and lower zones of the aquifer. For the old plant (CPC) landfill, the gradient was estimated as 0.0025 to the east. Appendix E presents the hydraulic gradient calculations.

The vertical contaminant penetration depth, H, calculated from Equation 1-6 and the input parameters listed above exceeded the thickness of the aquifer; therefore, the penetration depth was assumed to be the aquifer thickness (i.e., 50 feet).

The horizontal flow rate across the 300-foot width of the old plant (CPC) landfill and the calculated 50-foot penetration depth was calculated from Darcy's Law as follows:

$$Q_h = K\ i\ A_1 \qquad (1\text{-}10)$$

where:

K	=	300 ft/day, estimated above
i	=	0.0025, estimated above
A_1	=	300 feet x 50 feet

therefore:

Q_h	=	11,250 ft^3/day or 4,106,000 ft^3/yr

The vertical flow rate (Q_v) to the Alluvial Aquifer across the surface area of the old plant (CPC) landfill was calculated as follows:

$$Q_v = I\ A_2 \qquad (1\text{-}11)$$

where:

I	=	0.00053 ft/day, from the HELP model calculations (Appendix E)
A_2	=	300 feet x 400 feet, the map area of the old plant (CPC) landfill

therefore:

$$Q_v = 64\ ft^3/day$$

The calculated ratio of the horizontal to vertical flow rates (Q_h/Q_v) is 178. The relationship Q_h/Q_v is the concentration reduction factor (CRF), which can also be expressed as:

$$CRF = \frac{Q_h}{Q_v} = \frac{C_{LEACH}}{C_{AA}} \qquad (1\text{-}12)$$

where:

CRF	=	concentration reduction factor (dimensionless)
C_{LEACH}	=	concentration of the percolating leachate (μg/l)
C_{AA}	=	resulting concentration at the Alluvial Aquifer after mixing (μg/l)

which indicates that if the concentration in the downward percolating water (C_{LEACH}) is 9.7 μg/l, the concentration in the Alluvial Aquifer after mixing (C_{AA}) would be 0.06 μg/l. Since the Safe Drinking Water Act maximum contaminant level (MCL) for mercury is 2.0 μg/l, the analysis indicates that the soils in the old plant (CPC) landfill would not leach mercury at a rate that would cause the groundwater concentrations to exceed the MCL at landfill boundary.

As stated in Section 1.3.1.2, 406 mg/kg of mercury was detected in a sample from the residual fill/waste material. The above analysis was conducted using the maximum mercury concentration from the clay rather than the results of this fill/waste sample because the vertical distribution of constituents indicate that the mercury does not leach from the fill/waste. The underlying clay and sand samples from this same boring with 406 mg/kg showed mercury below the detection limit. Therefore, mercury concentrations from the clay were believed to more accurately reflect site condition. Nevertheless, PSALs (including mercury) were developed for the old plant (CPC) landfill as described in Section 2.2.3 because the landfill was identified as a potential continuing source of organics to the groundwater.

Organics were detected in the clay underlying the landfill and in the sand overlying the Alluvial Aquifer. The organic potential constituents of concern for OU-1 groundwater which were detected were:

- Clay underlying the landfill
  - chlorobenzene in five of five samples at 0.007J[1] to 7.3 mg/kg
  - benzene in three of five samples at 0.009J to 3.3 mg/kg
  - chloroform in three of five samples at 0.004J to 0.16 mg/kg
  - 1,4-dichlorobenzene in two of five samples at 2.2 and 74 mg/kg
  - 1,2-dichlorobenzene in two of five samples at 1.8 and 57 mg/kg
  - 1,3-dichlorobenzene in one of five samples at 5.0 mg/kg
  - 1,2,4-trichlorobenzene in one of five samples at 0.71J mg/kg
  - 1,2,4,5-tetrachlorobenzene in one of five samples at 0.22J mg/kg
  - alpha-BHC in three of five samples at 0.022 to 0.52J
  - delta-BHC in one of five samples at 0.075 mg/kg

- Sand overlying the Alluvial Aquifer
  - chlorobenzene in four of eight samples at 0.001J to 46 mg/kg
  - benzene in one of eight samples at 2.3 mg/kg
  - chloroform in two of eight samples at 0.004J to 0.033 mg/kg
  - 1,4-dichlorobenzene in three of eight samples at 8.5 to 150 mg/kg
  - 1,2-dichlorobenzene in three of eight samples at 6.4 to 130 mg/kg
  - 1,3-dichlorobenzene in three of eight samples at 0.15J to 11 mg/kg
  - 1,2,4-trichlorobenzene in three of eight samples at 0.79 to 4.6 mg/kg
  - 1,2,4,5-tetrachlorobenzene in three of eight samples at 0.67 to 4.1 mg/kg

[1] J = Estimated concentration below the quantitation limit.

- alpha-BHC in five of eight samples at 0.0023J to 0.66J
- delta-BHC in three of eight samples at 0.0055 to 0.093J

The data indicate that the landfill was probably a source of organics to the Alluvial Aquifer in the past. The vertical distribution (see Figure 1-13) of constituents in three of the soil borings (BOP2, BOP3 and BOP4) showed distinct decreases in constituent concentrations with increasing depth. At BOP2 and BOP3, the constituent concentrations in the clay beneath the landfill and in the underlying sand above the water table are near or below detection limits, indicating that vertical migration is not affecting the groundwater of the Alluvial Aquifer in this area. Concentrations of organic constituents at BOP4, located in the western portion of the landfill, indicate migration of constituents through the clay and into the upper portion of the unsaturated underlying sand, but not to the deeper portions of this sand. The data for BOP1, located in the western portion of the landfill, indicate that organic constituents have migrated through the clay and the unsaturated portion of the underlying sand. Consequently, migration of organic constituents to the Alluvial Aquifer at BOP1 is probable. Overall, the data indicate that migration of organic constituents into the Alluvial Aquifer from the soil is most likely in the western portion of the landfill where acid neutralization took place prior to 1972. The organic concentrations in the fill/waste matrix at BOP1 were similar to concentrations detected at the other three borings. The vertical migration that occurred at this area is the result of the diminished attenuation properties of the underlying clay zone due to the effects of the acid. Any remedial action for the landfill should focus on the loose saturated silt/clay zone and the underlying sands. The data indicate that vertical migration of constituents into the Alluvial Aquifer is not probable in other portions of the old plant landfill. Based on the analytical results described above, the old plant (CPC) landfill was identified as a potential source of organics to the groundwater and PSALs were developed as described in Section 2.2.3.

Former CPC Plant Area

Chloroform is the only OU-1 groundwater potential constituent of concern that was found in soil samples from the boring (BCP2) located at the south boundary of the old plant area. Chloroform was found at an estimated concentration below the quantitation

limit of 0.002 mg/kg in the shallow soil and at an estimated concentration below the quantitation limit of 0.008 mg/kg in the lower portion of the shallow clay. Chloroform was not found in the soil sample from the unsaturated sand overlying the Alluvial Aquifer. The data do not indicate that migration of the OU-1 groundwater potential constituents of concern into the Alluvial Aquifer is occurring at this location. The identification and quantitation of chloroform at concentrations below the quantitation limit is suspect. However, the data were evaluated to demonstrate that even if chloroform was actually present in the soil at the reported concentration, it would not affect the groundwater above the EPA standard. The MCL is the EPA standard that is used to evaluate whether there is any effect. The MCL for total halogenated methanes in drinking water (i.e., chloroform, chlorodibromomethane, bromoform and bromodichloromethane) is 100 μg/l. Chloroform is the only one of these compounds reported for this sample, and for the purpose of this evaluation, 100 μg/l is considered the MCL for chloroform. The moisture content of the sample of the sand was 21 percent. Making the very conservative assumption that all of the 0.008 mg/kg reported in the soil sample is present in the pore water, the pore water concentration would be only 38 μg/l, much lower than the MCL. Leachate generated by infiltration through these soils should have much lower concentrations than the calculated 38 μg/l because of adsorption to the soil and dilution from downward percolating water. Based on this analysis, the chloroform concentration reported in the soils does not affect groundwater above the MCL.

OU-1 groundwater potential constituents of concern were detected in soil samples from boring (BCP1) at the west boundary of the old plant area. Concentrations of some constituents (chlorobenzene, chloroform, di-tri-penta and tetra-chlorinated benzenes, alpha-BHC and delta-BHC) were reported in the shallowest of the three samples of the unsaturated sand of the Alluvial Aquifer, but, except for 1,2,4,5-tetrachlorobenzene and pentachlorobenzene, they were not reported in the deeper soil samples. An analysis similar to that conducted for chloroform would show that there is a potential for semivolatile organic constituents to migrate to the sands above the Alluvial Aquifer in the vicinity of boring BOP1. Within these sands, however, there is a distinct decrease in concentrations with depth, indicating that any pore water that reached the Alluvial Aquifer would contain very low (if detectable) concentrations of organics. Because the data indicated a potential for the area west of the former CPC plant to be a continuing

source of groundwater contamination, potential soil action levels were developed as described in Section 2.2.3.

Old Plant Landfill Drainage Ditch

Since the old plant landfill drainage ditch soils are not in a defined area and leachate data (TCLP) are not available, a quantifiable fate and transport analysis to assess potential impact on groundwater was not performed. However, the potential is judged to be low based on the concentrations. Only mercury, at a concentration of 10 mg/kg, and hexachlorobenzene, at a concentration of 6 mg/kg, were found in any significant concentration. Hexachlorobenzene is not found in groundwater at the site because of its low solubility. Other sources of mercury are obviously so much more significant that this pales by comparison as a source. Nonetheless, the drainage ditch is in close proximity to the old plant (CPC) landfill, and for the purpose of this FS, the ditch soils will be considered with the landfill soils. A quantitative evaluation of the potential for migration to groundwater was performed for the old plant (CPC) landfill and potential soil action levels were developed.

Lime Ponds

The two closed lime ponds were sampled and analyzed to evaluate whether they are a continuing source of mercury to the groundwater of the Alluvial Aquifer. The analyses indicate that the lime wastes contain little mercury. TCLP tests of the lime wastes did not result in mercury leachate concentrations higher than 10 μg/l.

Groundwater would be considered affected by the closed lime ponds if leachate from the closed ponds infiltrated into the Alluvial Aquifer and caused mercury concentrations in otherwise uncontaminated groundwater to exceed the MCL of 2 μg/l at the SWMU boundary. The chemical analyses of the samples from the closed lime ponds indicate that this is probably not occurring. However, a quantitative analysis was performed to evaluate whether the leachate from the soils could affect the Alluvial Aquifer.

The Summers model was used to assess the concentration of mercury in the groundwater of the Alluvial Aquifer that could result from infiltration of leachate from

the closed lime ponds. The very conservative assumption that the infiltrating water for each lime pond has a mercury concentration equal to that of the highest mercury TCLP result (10 μg/l) was used in the calculation. This is conservative because 1) the highest TCLP result is used for the entire area of both ponds, 2) the TCLP test utilizes acidic conditions which would be expected to leach more mercury than would actually occur in the alkaline conditions of the closed lime ponds, and 3) the concentration of mercury in the leachate would be attenuated as it moves through the 25 to 30 feet of soil between the base of the former lime ponds and the water table. The area of the lime ponds is estimated at 170 feet x 300 feet for the lime pond to the east (Lime Pond 1) and 100 feet x 180 feet for the lime pond to the west (Lime Pond 2). The annual percolation rate through each lime pond was calculated from the HELP model, Version 2.0 (U. S. EPA, 1992). The HELP model calculations are presented in Appendix E.

Equation 1-6 was used to calculate the vertical penetration depth with the following input parameters:

Vertical Dispersivity. The vertical dispersivity in the Alluvial Aquifer was estimated using Equations 1-7 and 1-8. Assuming a longitudinal travel distance of 170 feet and 100 feet (the approximate length of Lime Ponds 1 and 2 in the groundwater flow direction, respectively), the longitudinal dispersivity for the lime ponds was estimated as 17 feet and 10 feet. The vertical dispersivity was therefore estimated as 1.7 and 1.0 feet for Lime Ponds 1 and 2, respectively.

Horizontal Length of the Source. The horizontal length of the source was estimated as the length of the source in the groundwater flow direction, which is 170 feet for Lime Pond 1 and 100 feet for Lime Pond 2.

Aquifer Thickness. The aquifer thickness was estimated as 50 feet.

Vertical Recharge Rate. The estimated infiltration rate from the HELP model is 3.3 in/yr (0.00075 ft/day) for Lime Pond 1 and 5.3 in/yr (0.0012 ft/day) for Lime Pond 2.

Darcy Velocity. The Darcy velocity in the aquifer was calculated from Equation 1-9 as 0.71 ft/day and 1.12 ft/day for Lime Ponds 1 and 2, respectively.

Hydraulic Conductivity. The horizontal hydraulic conductivity, K, was estimated using historical data. Available hydraulic conductivity data include single-well response test results from five monitor wells located in the area (MP7, MP9, MP11, WP6A and WP3; see Table 1-9 and the pump test data from CA3. The single-well response tests were generally reported as minimum values because of the rapid recovery of the wells during testing. The average K value from these five tests was 14 ft/day. The K value from the pump test was estimated as 578 ft/day. Since pump tests generally yield more reliable estimates of hydraulic conductivity, the average of 14 ft/day and 578 ft/day, which is 296 ft/day, was used as the estimate for the hydraulic conductivity.

Hydraulic Gradient. The hydraulic gradients were estimated from the September 1991 potentiometric maps presented in the RI report (WCC, 1993). These estimates were obtained by calculating the gradients in both the upper and lower zones of the aquifer. The estimated gradients based on these maps are 0.0024 and 0.0038 for Lime Ponds 1 and 2, respectively. Appendix E presents the hydraulic gradient calculations.

Using the parameters listed above, the vertical penetration depths of 24 feet for Lime Pond 1 and 14 feet for Lime Pond 2 were calculated from Equation 1-6.

The horizontal flow rate (Q_h) in the Alluvial Aquifer across the cross-sectional area beneath each lime pond and the corresponding penetration depth was calculated from Equation 1-10, where:

K	=	296 ft/day for both ponds
A_1	=	24 x 300 ft^2 (Lime Pond 1) and 14 x 180 ft^2 (Lime Pond 2)
i	=	0.002 for both ponds (since the calculated penetration depths were 24 and 14 feet, only gradients in the upper zone of the Alluvial Aquifer were considered)

therefore:

Q_h = 4,262 ft^3/day (Lime Pond 1) and 1,492 ft^3/day (Lime Pond 2)

The vertical flow rate (Q_v) to the Alluvial Aquifer across the surface area of each lime pond was calculated from Equation 1-11, where:

I = 0.00075 ft/day (Lime Pond 1) and 0.0012 ft/day (Lime Pond 2)

A_2 = 170 x 300 ft^2 (Lime Pond 1) and 100 x 180 ft^2 (Lime Pond 2)

therefore:

Q_v = 38.25 ft^3/day (Lime Pond 1) and 21.6 ft^3/day (Lime Pond 2)

The ratios of the horizontal to vertical flow rates (Q_h/Q_v) based on these calculations are 111 and 69 for Lime Ponds 1 and 2, respectively. These ratios were used to calculate the resulting contribution to concentrations in the Alluvial Aquifer from Equation 1-12. The calculated concentration in the Alluvial Aquifer (CAA) is 0.090 μg/l for Lime Pond 1 and 0.145 μg/l for Lime Pond 2, assuming a leachate concentration (C_{LEACH}) of 10 μg/l. This conservative analysis indicates that mercury from the former lime ponds would not affect the Alluvial Aquifer above the MCL at the lime pond boundaries.

Strong Brine Pond

The closed strong brine pond was sampled and analyzed to evaluate whether the subsoil at the closed brine pond is a continuing source of mercury to the groundwater of the Alluvial Aquifer.

TCLP analyses of two subsoil samples reported mercury leachate concentrations of 5 and 30 μg/l at depths of 8 to 10 feet. These concentrations indicate that the subsoils are probably not a continuing source of mercury to the groundwater of the Alluvial Aquifer, since the depth to groundwater is about 30 feet.

Groundwater would be considered affected by the closed strong brine pond if leachate from the subsoil infiltrated into the Alluvial Aquifer and caused mercury concentrations in otherwise uncontaminated groundwater to exceed the MCL of 2 μg/l of the SWMU boundary. The TCLP analyses of the subsoil samples indicate that this is probably not occurring. However, an analysis was performed to evaluate whether the leachate from the subsoil could affect the Alluvial Aquifer.

The Summers model calculation was completed to assess what concentration of mercury in the groundwater of the Alluvial Aquifer could result from infiltration of water through the subsoil. The very conservative assumption that the infiltrating water has a mercury concentration equal to that of the highest mercury TCLP result (30 μg/l) was used in the calculation. This is conservative since the higher TCLP result is used and because the concentration of mercury in the leachate would be attenuated as it moved through the approximate 20 feet of soil between the base of the former pond and the water table. The area of the former strong brine pond is about 340 x 340 feet. The annual percolation rate was calculated from the HELP model, Version 2.0 (U. S. EPA, 1992). The HELP model calculations are presented in Appendix E.

Equation 1-6 was used to calculate the vertical penetration depth with the following input parameters:

Vertical Dispersivity. The vertical dispersivity in the Alluvial Aquifer was estimated using Equations 1-7 and 1-8. Assuming a longitudinal travel distance of 340 feet (the approximate length of the strong brine pond in the groundwater flow direction) the longitudinal dispersivity, αv, for the strong brine pond was estimated as 34 feet. The vertical dispersivity, αv, was therefore estimated as 3.4 feet.

Horizontal Length of the Source. The horizontal length of the source was estimated as the length of the source in the groundwater flow direction, which is approximately 340 feet for the strong brine pond.

Aquifer Thickness. The aquifer thickness was estimated as 50 feet.

Vertical Recharge Rate. The estimated infiltration rate from the HELP model is 3.3 in/yr or 0.00075 ft/day.

Darcy Velocity. The Darcy velocity in the aquifer was calculated from Equation 1-9 as 0.54 ft/day.

Hydraulic Conductivity. The horizontal hydraulic conductivity, K, was estimated using historical data. Available hydraulic conductivity data include single-well response test results from three monitor wells located in the area (MP7, MP9 and MP11; see Table 1-9) and the pump test data from CA3. The single-well response tests were generally reported as minimum values due to the rapid recovery of the wells during testing. The average hydraulic conductivity value from these three tests was 26 ft/day. The hydraulic conductivity value from the pump test was estimated as 578 ft/day. Since pump tests generally yield more reliable estimates of hydraulic conductivity, the average of 26 ft/day and 578 ft/day, which is 302 ft/day, was used as the estimate for the hydraulic conductivity.

Hydraulic Gradient. The hydraulic gradients were estimated from the September 1991 potentiometric maps presented in the RI report (WCC, 1993). These estimates were obtained by calculating the gradients in both the upper and lower zones of the aquifer. For the strong brine pond, the gradient was estimated as 0.0018 to the west-northwest (Appendix E).

A vertical penetration depth of 49 feet, which is close to the saturated thickness of the aquifer, was calculated from Equation 1-6 and the input parameters listed.

The horizontal flow rate in the Alluvial Aquifer across the 340-foot width and the 49-foot saturated thickness of the aquifer was calculated from Darcy's Law (Equation 1-10):

$$Q_h = K\ i\ A_1$$

where:

K	=	302 ft/day, estimated above
i	=	0.0018, estimated above
A_1	=	340 x 49 ft^2

therefore:

Q_h	=	9,100 ft^3/day or 3,321,000 ft^3/yr

The vertical flow rate (Q_v) to the Alluvial Aquifer across the surface area of the strong brine pond was calculated from Equation 1-11, $Q_v = IA_2$, where:

I	=	0.00075 ft/day
A_2	=	340 x 340 ft^2

therefore:

Q_v	=	87 ft^3/day

The ratios of the horizontal to vertical flow rates based on these calculations is 104. This ratio was used to calculate the concentrations in the Alluvial Aquifer from Equation 1-12.

For a leachate concentration (C_{LEACH}) of 30 μg/l, the Alluvial Aquifer concentration (C_{AA}) is 0.29 μg/l (Equation 1-12). This conservative analysis indicates that mercury in water percolating through the soil beneath the closed strong brine pond would not affect the Alluvial Aquifer above the MCL at the SWMU boundary.

Former Mercury Cell Plant

Six samples were collected from the soils from beneath the former mercury cell plant area and these samples were analyzed for total and TCLP mercury. Mercury was not detected in the TCLP leachate in five of the samples. A concentration of 40 μg/l was detected in the TCLP leachate from the other sample.

Groundwater would be considered affected by the former mercury cell plant if leachate infiltrated into the Alluvial Aquifer and caused mercury concentrations in otherwise uncontaminated groundwater to exceed the MCL of 2 μg/l at the mercury cell plant boundary. The analyses of the soil samples from beneath the former plant indicates that this is probably not occurring, particularly considering that the soils are covered with concrete, Durbigum® and asphalt, which limit infiltration.

A Summers model analysis was used to evaluate the potential migration from the mercury cell plant. The assumption that the infiltrating water would have a concentration of 40 μg/l was used in the analysis, which is a very conservative assumption considering that mercury was not detected in the TCLP leachate from five of the six samples from the area. The infiltration rate was assumed to be the same as for the strong brine pond, 3.3 inches per year, which was calculated based on infiltration through 6 feet of silty clay. As discussed above, this is also a very conservative assumption because the soils in the former mercury cell plant are covered with concrete, Durbigum® and asphalt, and the actual infiltration rate would be much less.

Equation 1-6 was used to calculate the vertical penetration depth with the following input parameters:

> Vertical Dispersivity. The vertical dispersivity in the Alluvial Aquifer was estimated using Equations 1-7 and 1-8. Assuming a longitudinal travel distance of 260 feet (the length of the former mercury cell plant in the groundwater flow direction) the longitudinal dispersivity for the mercury cell plant area was estimated as 26 feet. The vertical dispersivity was therefore estimated as 2.6 feet.

Horizontal Length of the Source. The horizontal length of the source was estimated as the length of the source in the groundwater flow direction, which is 260 feet for the former mercury cell plant.

Aquifer Thickness. The aquifer thickness was estimated as 50 feet.

Vertical Recharge Rate. The infiltration rate was estimated as 3.3 in/yr or 0.00075 ft/day, as discussed above.

Darcy Velocity. The Darcy velocity in the aquifer was calculated from Equation 1-9 as 0.53 ft/day.

Hydraulic Conductivity. The horizontal hydraulic conductivity, K, was estimated using historical data. Available hydraulic conductivity data include single-well response test results from three monitor wells located in the area (MP9, MP11 and WP3; see Table 1-9) and the pump test data from CA3. The single-well response tests were generally reported as minimum values because of the rapid recovery of the wells during testing. The average K value from these three tests was 7.0 ft/day. The K value from the pump test was estimated as 578 ft/day. Since pump tests generally yield more reliable estimates of hydraulic conductivity, the average of 7.0 ft/day and 578 ft/day, which is 292 ft/day, was used as the estimate for the hydraulic conductivity.

Hydraulic Gradient. The hydraulic gradients were estimated from the September 1991 potentiometric maps presented in the RI report (WCC, 1993). These estimates were obtained by calculating the gradients in both the upper and lower zones of the aquifer. For the mercury cell plant, the average gradient was estimated as 0.0018 to the southwest (Appendix E).

A vertical penetration depth of 37 feet, which is close to the saturated thickness of the aquifer, was calculated from Equation 1-6 and the input parameters listed.

The horizontal flow rate in the Alluvial Aquifer across the 370-foot width and the 37-foot saturated thickness of the aquifer was calculated from Darcy's Law (Equation 1-10), $Q_h = KiA_1$, where:

$K = 292$ ft/day
$A_1 = 370 \times 37$ ft^2
$i = 0.0018$

therefore:

$Q_h = 7{,}195$ ft^3/day or 2,626,175 ft^3/yr

The vertical flow rate to the Alluvial Aquifer across the 260 x 370-foot area was calculated from Equation 1-11, $Q_v = IA_2$, where:

$I = 0.00075$ ft/day
$A_2 = 260 \times 370$ ft^2

therefore:

$Q_v = 72.15$ ft^3/day

The ratio of the horizontal to vertical flow rates (Q_h/Q_v) based on these calculations is 100. This ratio was used to calculate the concentrations in the Alluvial Aquifer from Equation 1-12.

For a leachate concentration (C_{LEACH}) of 40 μg/l, the resulting Alluvial Aquifer groundwater concentration (C_{AA}) is 0.40 μg/l. This very conservative analysis indicates that mercury in water percolating through the soil beneath the mercury cell plant would not affect the Alluvial Aquifer, particularly since the hypothetical infiltration rate and the estimated mercury leachate concentrations used in this analysis are probably much greater than would actually occur.

Sanitary Landfills

Groundwater would be considered affected by the sanitary landfills if leachate infiltrated into the Alluvial Aquifer and caused constituent concentrations in otherwise uncontaminated groundwater to exceed their corresponding MCLs of the landfill boundary. The groundwater constituents used for this analysis are listed on the table below. This table does not include the metals that were detected at concentrations within a range commonly found for naturally occurring soils (arsenic, chromium, copper, and nickel), and it does not include the tentatively identified compounds detected which do not have MCLs (pentachlorobenzene, pentachloronitrobenzene and tetrachlorobenzene isomers). Mercury is not included in this table because the all of the TCLP mercury concentrations were reported as not detected, and therefore the sanitary landfill soils are not considered a source of mercury to the groundwater.

SUMMARY OF GROUNDWATER CONSTITUENTS DETECTED IN THE SANITARY LANDFILL SOILS

	Maximum Concentration (mg/kg)	Sample ID Where Detected	Moisture of Sample (%)	Koc[1] ($g/g/g/cm^3$)
Chlorobenzene	5.7	BSL212	20	188
1,2-Dichlorobenzene	2.4	BSL312	19	861
1,3-Dichlorobenzene	1	BSL107	18	646
1,4-Dichlorobenzene	1.8	BSL312	19	431
1,2,4-Trichlorobenzene	7.4	BSL312	19	4869
Lead	62.5	BSL312	19	--

NOTE: [1] The Koc for each chemical constituent was estimated as the mean of values listed in Montgomery and Welkom (1990), Jeng et al. (1992), and the U.S. EPA Soil Transport and Fate Database (U.S. EPA, 1991). The highest and lowest values listed were excluded from the calculation of the mean.

The annual percolation rate was calculated from the HELP model, Version 2.0 (U.S. EPA, 1992). The upper 8 feet of soil was modeled as an uncompacted percolated layer with fair grass cover. The HELP model calculations are presented in Appendix E. Based on these calculations, the downward percolating rate averaged over a 5-year period is 5.3 in/yr. This percolation rate is considered conservative because it only

accounts for water losses for percolation through the upper 8 feet of soil and does not consider the caps over the landfills. Percolation would have to occur through additional clay material and through the unsaturated portion of the Quaternary sands before infiltration to groundwater would occur. The concentrations of constituents in the downward percolating leachate were calculated from Equation 1-1, $C_{LEACH} = C_{SOIL}/Ad$, where:

C_{LEACH}	=	concentration that would be generated from the parameters of concern.
C_{SOIL}	=	concentration in the soils, conservatively assumed to be the maximum concentration detected.
Ad	=	the Adsorption factor, which was estimated using Equation 1-2:

$$Ad = \frac{\theta_w + \rho_b K_d}{(\theta_w \rho_w + \rho_b)}$$

where:

θ_w	=	the volumetric water content (cm^3/cm^3)
ρ_b	=	the bulk density of the soil (g/cm^3)
ρ_w	=	the bulk density of water (g/cm^3)
K_d	=	the distribution coefficient ($g/g/g/cm^3$)

<u>The distribution coefficient:</u> The distribution coefficient (K_d) was calculated using one of the following two methods: For the organic constituents, the distribution coefficient was calculated by using the expression:

$$K_d = K_{oc} f_{oc} \qquad \textbf{(1-13)}$$

where:

K_{oc}	=	the normalized, chemical-specific organic carbon partition coefficient ($g/g/g/cm^3$), provided in the table above
f_{oc}	=	the fractional organic carbon content of the soil (unitless), estimated as 1%, the same value used by the U.S. EPA for a similar analysis at the Ciba Geigy site to the north (BCM Engineers, 1992).

For lead, the relationship between K_d and pH provided by Loux et al. (1990) was used:

$$Log\ K_d\ of\ lead = 0.0768 \times pH + 1.55 \qquad \textbf{(1-14)}$$

The pH of BSL312, the sample that contained the highest concentrations of lead, was 8.8, and K_d was therefore estimated as 168 $g/g/g/cm^3$ for lead.

<u>The volumetric water content</u> (θ_w) for each soil sample (obtained from the CLP Form 1 report) is listed on the table above.

<u>The bulk density of soil</u> (weight of dry soil divided by the field or net volume of soil) was calculated from Equation 1-4, $\rho_b = \rho_s (1-\theta_s)$, where:

ρ_b	=	bulk density of soil (g/cm^3)
ρ_s	=	particle mass density (g/cm^3), estimated as 2.65 g/cm^3 (Freeze and Cherry, 1979)
θ_s	=	porosity or the saturated water content (cm^3/cm^3), estimated as 0.40 from (the approximate porosity for silt/sand, from Table 5.1 in Driscoll, 1986).

From Equation 1-4, the bulk density of the soil is calculated as 1.60 g/cm^3.

Using the above input parameters and Equations 1-1 and 1-2, the adsorption factors (Ad) were calculated and the results are summarized in the following table:

ADSORPTION FACTOR (AD) AND LEACHATE CONCENTRATION			
	C_{SOIL} (mg/kg)	Ad	C_{LEACH} (μg/l)
Chlorobenzene	5.7	1.78	3200
1,2-Dichlorobenzene	2.4	7.80	308
1,3-Dichlorobenzene	1.0	5.90	169
1,4-Dichlorobenzene	1.8	3.96	455
1,2,4-Trichlorobenzene	7.4	43.60	170
Lead	62.5	150.17	416

Initially, as a very conservative assumption, it was assumed that leachate would infiltrate the Alluvial Aquifer at the concentrations (C_{LEACH}) listed above (i.e., it is conservatively assumed that there is no attenuation from the unsaturated zone above the Alluvial Aquifer). As contaminants enter the Alluvial Aquifer, they will mix with the water flowing through the aquifer. The contaminants will penetrate the aquifer and spread vertically beneath the source area because of the combined effects of vertical dispersion and vertical velocity of the recharge. Vertical spreading and mixing was simulated using Equation 1-6,

$$H = (2\alpha_v L_b)^{\frac{1}{2}} + B\left(1 - \exp\left[\frac{-L_b I}{V B}\right]\right) \qquad \textbf{(1-6)}$$

where:

H	=	contaminant penetration depth (ft)
α_v	=	the vertical dispersivity in the Alluvial Aquifer (ft)
L_b	=	the horizontal length of the plume at the bottom of the unsaturated zone (ft)
B	=	the thickness of the Alluvial Aquifer (ft)

I = the vertical recharge rate (ft/day)
V = the Darcy velocity in the Alluvial Aquifer (ft/day)

Vertical Dispersivity. Based on a relationship provided by Walton (1988), the vertical dispersivity (α_V) in the Alluvial Aquifer was estimated as one-tenth of the longitudinal dispersivity (α_L), while the longitudinal dispersivity was estimated as one-tenth of the travel (transport) distance (L_b) using Equations 1-7 and 1-8.

Based on this analysis and using a longitudinal travel distance of 1,000 feet (the estimated length of the source in the groundwater flow direction) the longitudinal dispersivity was estimated as 100 feet. The vertical dispersivity was therefore estimated as 10 feet.

Horizontal Length of the Source. The horizontal length of the source was estimated as 1,000 feet.

Aquifer Thickness. The aquifer saturated thickness was estimated as 50 feet.

Vertical Recharge Rate. The estimated infiltration rate from the HELP model is 5.34 in/yr (Appendix E).

Darcy Velocity. The Darcy velocity in the aquifer was calculated from the Equation 1-9, V = Ki, where:

K = hydraulic conductivity of the Alluvial Aquifer (ft/day)

i = hydraulic gradient (dimensionless)

Hydraulic Conductivity. Because of the close location of CA3 to the sanitary landfills, the hydraulic conductivity value from the pump test of corrective action well CA3 (578 ft/day) is used.

Hydraulic Gradient. The hydraulic gradient was estimated using the potentiometric map of the upper zone Alluvial Aquifer (Figure 1-8). Four measurements were taken at locations near the sanitary landfills, and the average hydraulic gradient was calculated as 0.000577.

Therefore, the calculated vertical penetration depth, H, based on Equation 1-6 is 138 feet. This penetration depth exceeds the thickness of the aquifer; therefore, the vertical penetration depth was assumed to be the aquifer thickness (i.e., 50 feet).

Next, the horizontal flow rate across the approximately 625-foot width and the 50-foot depth was calculated from Darcy's law using Equation 1-10.

Using the same values for hydraulic conductivity (K = 578 ft/day) and hydraulic gradient (i = 0.000577) as above and the area described above (625 x 50 ft^2), the horizontal flow rate (Q_h) is estimated as 10,422 ft^3/day.

The vertical flow rate is calculated from the Equation 1-11, $Q_v = IA_2$, where the vertical infiltration rate (I) is estimated from the HELP model (Appendix E) as 5.34 in/year, and the map area of the sanitary landfills (A_2) is estimated as 510,000 ft^2. Therefore, the vertical flow rate (Q_V) is calculated as 622 ft^3/day.

The ratio of the horizontal to vertical flow rates (Q_h/Q_v) is calculated from Equation 1-12 to be 17, which indicates that if the concentration in the downward percolating water is C_{LEACH} from the table above, the concentration in the Alluvial Aquifer after mixing (C_{AA}) would be $C_{LEACH}/17$. The four semivolatile parameters (the dichlorobenzenes and trichlorobenzene) show that concentrations would be below the Safe Drinking Water Act maximum contaminant levels (MCLs), and thus the analysis indicates that the soils in the sanitary landfills will not affect groundwater above the MCL for these parameters, as summarized below:

Constituent	C_{LEACH}[1]	$C_{LEACH}/17$	MCL
1,2-Dichlorobenzene	308	18.12	600
1,3-Dichlorobenzene	169	9.94	600
1,4-Dichlorobenzene	455	26.76	75
1,2,4-Trichlorobenzene	170	10.00	70

NOTES: [1] From Equation 1-1.

For chlorobenzene and lead, the analysis was taken one step further and the attenuation due to transport through the unsaturated soil was calculated using the PESTAN (Pesticide Analytical) model. PESTAN is a computer code for estimating the transport of constituents through soil to the groundwater. It was used to estimate the attenuation of chlorobenzene and lead due to vertical migration through the unsaturated zone. A description of this program and a discussion of its input parameters are presented in the Potential Soil Action Levels report (Appendix F). The input parameters for this analysis are listed as follows:

Solubility: The solubility of chlorobenzene is 471.7 mg/l, as listed in Appendix F, Table 3-5 (the Potential Soil Action Level Report). Since the solubility of lead is dependent upon the type of lead compound that is present, the concentration of the leachate calculated above (C_{LEACH} = 0.416 mg/l) was used instead of the solubility.

Recharge: From HELP model (Appendix E), the vertical infiltration was estimated as 5.34 in/year.

Sorption constant: The sorption or distribution constant (K_d) for chlorobenzene was calculated as 1.88 g/g/g/cm^3 from Equation 1-13 and for lead as 168 g/g/g/cm^3 from Equation 1-14.

Solid phase decay rate and liquid phase decay rate: No decay (i.e., no biodegradation) was assumed for this analysis.

Bulk density: Bulk density was calculated from Equation 1-4 as 1.72, assuming a particle mass density (ρ_s) of 2.65 g/cm^3 (Freeze and Cherry, 1979) and a porosity of 0.35 for transport through the sands (Table 5.1 in Driscoll, 1986).

Porosity: A porosity of 0.35 for transport through the sands is assumed (Table 5.1 in Driscoll, 1986).

Characteristic curve coefficient and saturated hydraulic conductivity: The PESTAN Version 4.0 program documentation (CSMS, 1992) presents tables for these two input parameters which are dependent on the soil type. The values listed for sand were used for the dimensionless characteristic curve coefficient (4) and the saturated hydraulic conductivity (63 cm/hr).

Dispersion coefficient: The dispersion coefficient was estimated using the following relationship:

$$D = \frac{I \times \alpha_V}{\theta_{vol}} \qquad \textbf{(1-15)}$$

where the infiltration (I) was estimated from the HELP model (Appendix E) as 5.34 in/yr or 0.0015 cm/hr, the vertical dispersivity (α_V) is estimated as one-tenth of the travel distance (Walton, 1988) or 88.4 cm, and θ_{VOL} is the volumetric water content calculated by the PESTAN program as 0.133. The dispersion coefficient, D, is therefore estimated as 0.997 cm^2/hr.

Minimum x-value: A value of 0 cm was entered.

Maximum x-value: The travel distance is 884 cm.

Waste application rate: Using a volume of soil with a surface area of 100,000 m^2 (= 1 ha) and a thickness of 8 feet (2.44 m) for the source, with a density of 1.72 g/cm^3, and the maximum concentration of chlorobenzene and lead

detected in the soils, the waste application rate is calculated as 239 kg/ha for chlorobenzene and 2,623 kg/ha for lead.

The output files from the PESTAN model are presented in Appendix E. The model indicates that the concentration of chlorobenzene reaches its peak after 208 years at 734 μg/l, and lead after 19,925 years at 7 μg/l. After dividing these results by the CRF of 17, to account for mixing with the Alluvial Aquifer, the calculated values are lower than their respective MCLs. The following table summarizes the fate and transport analysis for the sanitary landfills:

SUMMARY OF CONTAMINANT FATE AND TRANSPORT ANALYSIS FOR CONSTITUENTS DETECTED IN THE SANITARY LANDFILLS

	MCL (μg/l)	C_{AA}[1]/CRF (μg/l)	C_{LEACH}[2] (μg/l)
Chlorobenzene	100	43.18	734
1,2-Dichlorobenzene	600	18.12	308
1,3-Dichlorobenzene	600	9.94	169
1,4-Dichlorobenzene	75	26.76	455
1,2,4-Trichlorobenzene	70	10.00	170
Lead	15	5.12	87

NOTES:

1 C_{AA} is the concentration of the Alluvial Aquifer after mixing.

2 The concentration of the leachate (C_{LEACH}) listed is the concentration obtained from the PESTAN model for chlorobenzene and lead. For all other parameters, the concentration listed was obtained from Equation 1-1.

Based on this analysis, constituents percolating in infiltrating water through the soils in the sanitary landfill should not affect the Alluvial Aquifer above the MCL at the landfill boundary.

Well Sand Residue Area

The well sand material was sampled to determine the mercury content and assess the leachability of any detected mercury. Samples were collected at ten randomly selected

areas and depths within the well sand mounds; the 10 individual samples were ground and composited into one sample for analysis (mercury and TCLP mercury). The total mercury concentration in the well sand composite sample was 20.1 mg/kg. As would be expected considering the cemented nature of the material, mercury was not detected in the leachate from the TCLP analysis. Since mercury in the well sand is not leachable, the well sand is not considered a source of groundwater contamination.

1.4.1.2 Fate and Transport in Groundwater

There are five RCRA corrective action wells that have been operating since September 1987, effectively controlling migration from any known past or current sources. The groundwater flow direction throughout the horizontal extent of contamination in OU-1 is inward towards the corrective action wells. Continued operation of the corrective action wells should prevent future lateral migration of the constituents; that is, they will not migrate beyond their present extent and will be gradually reduced in extent.

Horizontal migration of mercury-containing dense brine would be influenced not only by the structure of the top of the Miocene clay, but also by horizontal groundwater flow. There is a structural low to the southwest of the weak brine pond and an east-west trending structural low to the southeast of the weak brine pond. The distribution of chlorides and mercury indicates that dense brine migrated along these structural pathways. Figure 1-19 illustrates the interpreted distribution of dense brine that contains mercury. Any further lateral migration of the dense brine would be to the east toward corrective action wells CA5 and CA4. If the brine migrates laterally, concentrations and density would decrease, thus decreasing the tendency of the brine to migrate along structural pathways.

The potential for vertical migration of dense brine through the Miocene confining unit to the Miocene Aquifer was quantitatively evaluated using the linear form of Darcy's law, adjusting for the difference in density between the brine and the fresh water. The analysis is presented in Appendix A. Boring logs from wells that penetrate the upper Miocene confining unit indicate that this unit is laterally continuous beneath the Alluvial Aquifer and is approximately 80 to 100 feet thick. Laboratory permeability tests indicate that the vertical permeability of the upper clay is extremely low, with vertical

hydraulic conductivities (K) of less than 1 x 10^{-5} feet per day (less than 1 x 10^{-8} cm/sec) (S&ME, 1982). (See Section 1.2.1.2). The Darcy's Law calculation indicates that the time required for brine to migrate vertically through the approximately 80-foot thick clay layer is about 3,400 years. The calculation did not account for horizontal velocity, lateral dispersion, adsorption and retardation. Based on the quantitative analysis and considering these other mechanisms, vertical migration of the dense brine is not considered a contaminant migration pathway.

As discussed in Section 1.3.1.3, organic constituents at concentrations below the MCL were detected in the Miocene Aquifer. If the constituents are from an on-site source, the most probable pathway is down the casing or annulus of a Miocene process water well that is not currently pumping. Olin currently pumps two process water wells that are screened in the Miocene Aquifer, at rates of about 1,000 gpm each. An evaluation of the drawdown produced by this pumping indicates that lateral migration of constituents within the Miocene Aquifer should be radially inwards towards these active water supply wells. If the contamination is from an on-site source, constituents are not expected to be present in the Miocene Aquifer beyond the lateral hydraulic control of these active water supply wells. Sufficient data does not exist to evaluate whether the detected constituents result from migration within the Miocene Aquifer from off-site sources.

1.4.2 Operable Unit 2

Physical entrainment and transport of the sediments and their associated adsorbed constituents are considered the most important transport mechanisms in OU-2. The primary constituents in the sediment that are subject to surface water transport mechanisms are mercury, the semivolatile chlorinated benzenes, and the DDT residues. Processes influencing the aquatic fate of these compounds include sorption, volatilization, biodegradation, photolysis, hydrolysis, bioaccumulation and biotransformation. An investigation is currently underway to evaluate hydrodynamic transport in the basin. Preliminary results from this investigation indicate that the basin is generally a depositional area, with minimal potential for sediment transport.

Considering the limited vertical extent of constituents in OU-2 sediments/soils and the fate and transport properties of the constituents that are present in the sediments, the groundwater migration pathway in OU-2 is not considered to be significant.

1.5 SUMMARY OF HUMAN HEALTH BASELINE RISK ASSESSMENT

Table 1-10 summarizes the media-specific chemicals of potential concern that were developed for the baseline risk assessment. The potential exposure of adult and adolescent resident/trespasser receptors, adult and child hypothetical future residents in OU-1, and site industrial workers to the chemicals of potential concern and the risks associated with these exposures were evaluated in the baseline risk assessment.

Exposure pathways for offsite residential receptors include (1) residential exposure to water from domestic wells screened in the Alluvial Aquifer (ingestion, dermal contact and inhalation of volatile constituents), (2) ingestion of fish from OU-2, (3) potential contact with OU-2 surface water (dermal and inhalation of volatile constituents) and sediments (dermal and ingestion), and (4) potential contact with soils from OU-1 (particulate inhalation) and OU-2 (dermal, particulate inhalation and incidental ingestion). The adolescent resident may potentially be at greater risk due to behavior patterns or sensitivity to chemical constituents. Trespassers are also included in the off-site adult and adolescent residential receptor scenarios to account for those residents who may trespass and be exposed to OU-2 media.

Exposure pathways for the hypothetical future residential receptors include those for the current resident/trespasser with the addition of ingestion and dermal contact to OU-1 surface soils.

Exposure pathways for site industrial workers include the quarterly sampling of groundwater from monitor wells and corrective action wells. Therefore, exposure to site constituents in groundwater via dermal and inhalation pathways could occur. Industrial worker exposure to OU-1 surface soils (dermal, ingestion and particulate inhalation) was also evaluated.

Adult and Adolescent Resident/Trespasser. Twelve potential exposure pathways were quantitatively evaluated in regard to excess lifetime cancer risks and noncarcinogenic hazard indexes for the adult and adolescent off-site residents who trespass on Olin property (OU-2) and ingest fish from the basin. To be conservative, exposure to domestic well water was also evaluated for these same receptors.

The total RME excess lifetime cancer risk and hazard index for the adult receptor are 8.4×10^{-5} and 0.48, respectively. RME excess lifetime cancer risk and hazard index for adolescent residents are 5.8×10^{-5} and 0.49, respectively. The fish ingestion pathway was the dominant exposure route for these receptors in regard to total excess lifetime cancer risk and noncarcinogenic hazard from site constituents, comprising over 90 percent of the excess cancer risk and noncarcinogenic hazard. The chemicals of potential concern primarily responsible for the excess lifetime cancer risks were the DDT residues (i.e., 4,4'-DDT, 4,4'-DDD, and 4,4'-DDE) and hexachlorobenzene. Mercury contributed approximately 76 percent of the total noncarcinogenic hazard index for adult and children resident/trespassers.

Industrial Worker. Five complete and quantifiable exposure pathways were identified for the site industrial worker who is involved in sampling monitoring wells in OU-1. The total RME excess lifetime cancer risk and noncarcinogenic hazard index for this receptor are 1.7×10^{-6} and 0.041, respectively. Dermal exposure to OU-1 groundwater incurred while sampling monitoring wells contributed the highest risk numbers for this receptor (i.e., 10^{-6} range). The calculated risks are conservative because the dermal exposure pathway to OU-1 groundwater assumed no dermal protection (i.e., gloves) for the workers.

All total excess lifetime cancer risks and noncarcinogenic hazard indexes for adult/child resident/trespassers and site industrial workers were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risks and 1.0 hazard index).

Hypothetical Future OU-1 Resident. Fourteen exposure pathways were quantitatively evaluated in regard to excess lifetime cancer risks and noncarcinogenic hazard indexes for the hypothetical adult and child future on-site resident in OU-1. The total calculated RME excess lifetime cancer risk and hazard index for the hypothetical future

adult receptor are 5.4 x 10^{-3} and 25.8, respectively. The calculated RME excess lifetime cancer risk and hazard index for hypothetical future child residents are 6.7 x 10^{-3} and 48.9, respectively. Ingestion of on-site groundwater was the dominant exposure route contributing to total excess risk from site constituents, comprising over 95 percent of the cancer risk and 80 percent of the hazard index. Olin asserts that the hypothetical future resident is a unlikely receptor, considering that the facility is industrial and that the potential for parts of the site to become residential is virtually nonexistent.

Summary - Human Health Risk Assessment

The total excess lifetime cancer risks and hazard indexes for the current and likely future receptors were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risks and 1.0 hazard index). Exposure to a hypothetical future resident in OU-1 (child and adult) was also evaluated; the maximum estimated cancer risk and hazard index were 6.7 x 10^{-3} and 48.9 for the hypothetical future resident. Olin believes that the hypothetical future resident is an unlikely receptor, considering that the facility is industrial and that the potential for portions of the site to become residential is virtually nonexistent.

1.6 SUMMARY OF ECOLOGICAL ASSESSMENT

The overall objective of the ecological assessment was to evaluate the current and potential future ecological effects of the site's potential constituents of concern. The first phase of the assessment consisted of defining the chemicals of potential concern (based on ecological considerations); characterizing the ecosystem; and assessing whether any effects have occurred. Potential effects that were identified were further evaluated in the second phase, which included an exposure assessment, toxicity assessment and risk characterization.

Characterization of the ecosystem was conducted with data obtained during the RI and from a review of scientific literature and previous investigations at the facility. Studies conducted during the RI included a vegetative stress survey, a benthic macroinvertebrate study and fish sampling.

Vegetative Stress Survey. Major goals of the vegetative stress survey for OU-2 were to characterize the principal macrophytic plant communities and to identify indications of possible vegetative stress, with particular focus on possible correlations with the distribution of contaminants or other stress factors in OU-2. For these purposes, quantitative vegetation sampling and a detailed ground survey for endangered and threatened plant species were performed in September 1991.

Generally, the vegetation, aquatic, and terrestrial populations in OU-2 were characterized as healthy. The survey did not identify any impacts to individual plants or communities that could be attributed to site constituents. Diverse and abundant flora were generally documented throughout OU-2. The limited areas where anthropogenic or unexplained stresses occurred showed no relationship to the distribution of site constituents.

Benthic Macroinvertebrate Study. Sampling of benthic macroinvertebrates was conducted in two phases. In November of 1991, samples were collected from 22 stations in OU-2, primarily in the largest and hydrographically lowermost permanent water body (the basin). Results of this sampling indicated the need for a reference site (which was initially planned, but a suitable site near the basin could not be found), which led to a second phase of sampling in early September 1992. At that time, three stations were sampled in Hatchetigbee Lake, a Tombigbee River floodplain oxbow lake about 45 miles upriver from the basin, as well as three physically similar stations from the original grid in OU-2. Hatchetigbee Lake was sampled to provide indications of background, or reference, conditions.

Results of benthic sampling suggested that the basin may not support as diverse a macroinvertebrate community as might generally be expected in similar systems. The only definite correlation between benthic composition and contaminant distribution with water depth. The benthic macroinvertebrate communities in samples from Hatchetigbee Lake appeared slightly more diverse and abundant than those of the basin. Mercury could be a contributing factor to the differences observed. Chaetal aberrations were observed in some oligochaetes from the basin and not in those from the reference area. The literature indicates that these aberrations can be caused by the presence of heavy metals such as mercury; however, it is not known whether the condition of the chaetae

is actually associated with any harm to the animals and relevant to overall ecology of the basin.

Fish Studies. Sampling of fish in the basin was performed on November 4 through 8, 1991. The main objective of the sampling was to obtain tissues for contaminant analyses from a species at the top of the aquatic food chain (largemouth bass), as well as from a bottom-dwelling, bottom-feeding species (bullheads or catfish). During efforts to collect the target species, observations were recorded on the numbers and sizes of all other fish collected. The purpose of these observations was to provide information on basin fish communities under nonflood conditions.

Twenty specimens each of two fish species (largemouth bass and channel catfish) were collected for chemical analyses. Ten whole body samples and 10 filet samples were obtained from each species. The 40 fish samples were analyzed for mercury, chlorobenzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, 1,2,4-trichlorobenzene, pentachlorobenzene, hexachlorobenzene, pentachloronitrobenzene, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and percent lipids. Table 1-11 summarizes the fish sample analyses. Mercury and DDT residue (DDT_R) concentrations in the fish samples exceeded FDA action levels in some fish samples.

The concentrations of site constituents in the sediment and surface water might suggest possible effects to individual fish. However, no evidence was noted of such effects during the sampling performed for this RI. The favorable comparisons of condition factors (K_T) for several OU-2 species with regional averages suggest that effects on fish, if any, are not significant.

Terrestrial/Amphibians Receptors. There were no obvious indications (either direct or indirect) that amphibian, reptile, bird, or mammal populations of OU-2 differ significantly (if at all) from those of similar areas off-site. The findings of the vegetation studies reinforce this observation, since they provide no indication that terrestrial habitats in OU-2 are structurally or functionally dissimilar to others in the vicinity. None of the species actually observed (directly or by "sign") were unexpected; nor did any appear conspicuously abundant, as might be indicative of a stress limiting the numbers of competitors.

A group of higher vertebrate species known or expected to occur in OU-2 was selected as indicator species to evaluate the dietary exposure and potential risks associated with exposures to mercury, hexachlorobenzene, and DDT/metabolites via ingestion. Four bird species and three mammal species were selected for the analysis. The evaluation consisted of relating known or estimated exposures to levels known or anticipated to be harmful, sometimes referred to as reference toxicity values (RTVs). Various aspects of animal behavior and physiology of the respective indicator species affect their exposures to the site constituents. Results of this dietary exposure analysis of the selected bird and mammal receptors are summarized in Table 1-12. With the exception of the estimated exposure of raccoons to DDT_R, all of the PDE values are one or more orders of magnitude below levels described as adequately protective of sensitive wildlife species. Newell and others (1987) suggested that a safe dietary concentration of DDT_R for sensitive mammals would be 0.5 mg/kg, and the highest estimated exposure concentration for OU-2 (raccoon) is 0.15 mg/kg. In view of the dietary exposure calculations in Table 1-12, it is improbable that any terrestrial or amphibious higher vertebrate populations in OU-2 are adversely affected by exposures to site constituents via the ingestion pathway. The estimated exposures, as noted, are well below levels deemed protective of fairly sensitive species. The receptors chosen for the dietary exposure analysis are considered to be representative of (and hence credible surrogates for) most if not all of the other avian and mammalian species likely to occur in OU-2. Since the ingestion pathway is generally considered the most important for exposures of higher vertebrates to bioaccumulative chemicals, the risks associated with other pathways (e.g., dermal contact with water or soil) in OU-2 are judged to be inconsequential.

Federally Listed Threatened or Endangered Species. The only federally listed threatened or endangered species known to occur in OU-2 is the American alligator. Based on the dietary exposure calculations for terrestrial/amphibious receptors, the ecological assessment concluded that alligators are unlikely to be affected by site constituents.

Wetlands. OU-2 comprises three basic ecological components—permanent water bodies (e.g., the basin, or lake, ponds and interconnecting channels), wetlands, and uplands. Nearly 60 percent of OU-2 is wetland. Wetlands are particularly valuable and sensitive

environments, serving as habitat for a great diversity of organisms. Additional functional values of wetlands include flood control, water purification, and groundwater replenishment. Olin is aware of the special value and sensitivity of wetlands and notes that in the evaluation of alternatives, it will be necessary to address all of the state and federal regulations and policies established for the protection of these resources. A formal jurisdictional determination ("delineation") was not performed as part of the RI, but it is clear from the vegetation and hydrology that most of OU-2 is riparian wetland. Soils east of the bluff described in Section 1.2.1 are of the Urbo and Una Series, which are recognized by the U. S. Department of Agriculture, Soil Conservation Service as hydric (Kenneth W. Johnson, USDA/SCS, Grove Hill, AL; pers. comm.). Therefore, all three criteria for formal wetland status are met in the portion of OU-2 between the margins of the permanent water bodies and the base of the bluff. The potential for site constituents to adversely affect the wetland is considered negligible.

Summary - Ecological Assessment

The vegetation and animal populations (aquatic and terrestrial) in the basin were characterized as healthy. The basin may not support as diverse a macroinvertebrate community as might generally be expected in similar systems; however, it was not apparent to what extent (if any) this is due to site constituents. Constituent concentrations in the sediment and surface water might suggest possible effects to individual fish, but no evidence of such effects was noted during the RI activities. Results of the dietary exposure analysis of the selected bird and mammal receptors indicated that the site constituents of concern pose little if any risk to terrestrial vertebrates. The ecological assessment concluded that American alligator, which was the only federally listed threatened or endangered species known to occur in OU-2, is unlikely to be affected by site constituents. The potential for site constituents to adversely affect the wetlands is also considered negligible.

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TABLES

TABLE 1-1

SUMMARY OF SWMUs AND AOCs RECOMMENDED IN THE RFA FOR ADDITIONAL WORK

RFA SWMU/AOC		RFA Recommendation	OLIN Response	Comments
SWMU 4	Lime Ponds (2)	Confirmatory sampling	Sampling conducted during OU-1 Phase III activities.	
SWMU 11	Old Plant (CPC) Landfill	RFI	Sampling conducted during OU-1 Phase III activities.	
SWMU 12	Sanitary Landfills (2)	Confirmatory sampling	Sampling conducted during OU-1 Phase III activities.	
SWMU 13	Asphalt/Concrete Disposal Area	Determination of whether material exhibits hazardous characteristics	No determination required	Area is not for waste disposal. It is used for stockpiling construction rubble for fill.
SWMU 15	Pump and Treat System	RFI	Addressed as part of the RI/FS	
SWMU 20	Used Oil Tank and Unloading Area	Confirmatory sampling	Removal of visibly stained soils and cleaning of visibly stained surfaces.	At the time of the VSI the EPA Contractor observed staining on concrete wall and adjacent soils.
SWMU 29	Hydrazine Wastewater Unloading Area	Confirmatory sampling	Cleaning of visibly stained surfaces.	At the time of the VSI the EPA Contractor observed staining on surfaces.
SWMU 35	Old Plant Landfill Drainage Ditch	Confirmatory sampling	Sampling conducted during OU-1 Phase III activities.	
SWMU 36	Former Hex-lined Drainage Ditches	Confirmatory sampling, contingent on results of AOC A and AOC F sampling	Agree	Hexachlorobenzene is also believed to be present in CPC Plant area. Any sampling of the hex-lined ditches will be developed based on results of the CPC Plant investigation.

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TABLE 1-1 (Continued)

SUMMARY OF SWMUs AND AOCs RECOMMENDED IN THE RFA FOR ADDITIONAL WORK

RFA SWMU/AOC		RFA Recommendation	OLIN Response	Comments
SWMU 37	Coal Storage Area Drainage	Confirmatory sampling	Will provide results of past sampling required for NPDES Permit	
SWMU 38	Basin	RFI	Addressed as part of the RI/FS	
SWMU 40	Barge Caustic Soda Spill Site	Confirmatory sampling or documentation	Will provide documentation of cleanup. Olin believes no further sampling will be required	
SWMU 44	Plugged Brine Injection Wells	Confirmatory sampling or documentation	No sampling required	The physical characteristics of the salt domes prevent any migration of fluids out of the domes. The injection wells are continuously maintained under pressure and the pressure is checked routinely as part of plant operations and as required by UIC permit. Sampling is not warranted or practical.
SWMU 45	Caustic Spill Site	Confirmatory sampling or documentation	Will provide documentation of cleanup. Olin believes no further sampling will be required	
SWMU 46	Diaphragm Cell Trenches and Sump	Confirmatory sampling	No sampling required	The RFA Report cited drums that may be leaking in the area. Olin determined that the drums contain an asphalt material, which is very insoluble and the drums are located within a curbed concrete area with collection trenches routed to NPDES outfall.

TABLE 1-1 (Continued)

SUMMARY OF SWMUs AND AOCs RECOMMENDED IN THE RFA FOR ADDITIONAL WORK

RFA SWMU/AOC		RFA Recommendation	OLIN Response	Comments
SWMU 47	Original Lime Slurry Pit	Confirmatory sampling	Will use data from sampling other two lime ponds to determine if sampling is required	
SWMU 48	River Road Groundwater Area	RFI	Address as part of the RI/FS	
AOC A	CPC Plant	RFI	Details of investigation are outlined in revised SAP	
AOC B	Mercury Cell Plant	Confirmatory sampling	Sampling conducted during OU-1 Phase III activities.	
AOC C	Bilbo Creek	Confirmatory sampling	No sampling required; will provide results of storm water permit sampling	No pathway exists from plant facilities to Bilbo Creek; runoff from Olin property that drains to Bilbo Creek was recently sampled for Olin's storm water permit. The results showed that runoff concentrations are within acceptable limits.
AOC D	Well Sand Residue Area	Confirmatory sampling	Sampling conducted during OU-1 Phase III activities.	
AOC E	Former Underground Storage Tanks	Confirmatory sampling or documentation	Will provide documentation	
AOC F	Strong Brine Pond	Confirmatory sampling	Sampling conducted during OU-1 Phase III activities.	

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TABLE 1-2

TCL AND SELECTED TAL CONSTITUENT RESULTS FOR OLD PLANT (CPC) LANDFILL FILL/WASTE MATERIAL OU-1, PHASE III SAMPLING[1,2] (Concentrations in mg/kg)

Parameter	BOP1	BOP2	BOP3	BOP4
TCL VOLATILE ORGANICS				
Chlorobenzene	6.3	0.004J	0.057	9.7
Chloroform	--	0.009J	--	--
TCL SEMIVOLATILE ORGANICS				
1,2,4,5-Tetrachlorobenzene	0.26J	0.15J	16	32
1,2,4-Trichlorobenzene	0.75	--	20	6.4
1,2-Dichlorobenzene	2.9	--	110	2.1J
1,3-Dichlorobenzene	0.16J	--	6.6	1.9J
1,4-Dichlorobenzene	2.7	--	120	17
Fluoranthene	--	--	--	0.42J
Hexachlorobenzene	19	13	110	170
Naphthalene	--	--	--	2.6J
Phenanthrene	--	--	--	0.41J
Pyrene	--	--	--	0.44J
TCL PESTICIDE/PCB ORGANICS				
4,4'-DDE	--	0.034J	0.1	0.023J
4,4'-DDT	--	0.025J	--	--
Alpha-BHC	0.022J	0.86JX	0.089JX	--
Aroclor - 1260	--	--	--	0.94N
Beta-BHC	--	0.23	0.051J	--
Delta-BHC	--	--	0.025J	--
Endosulfan I	--	--	0.026J	--
Endosulfan II	--	0.0055J	--	--
Endosulfan Sulfate	--	--	0.031J	--
Gamma-BHC	--	0.12	--	--
Gamma-Chlordane	--	--	--	0.012
Heptachlor	--	--	0.023J	--
TAL INORGANICS				
Arsenic	2.9	0.85R	0.85R	0.96R
Chromium	31.6	--	19.9J	31.4J
Copper	8.3	--	19.8	77.1
Lead	8.3J	3.46J	6.3J	7.2J
Mercury	--	57.1	21.7	406
Nickel	7.9	--	--	--
Zinc	40.3J	--	69.6J	168J

NOTES:

1 Only compounds detected are listed.
2 Samples collected August 15 to August 20, 1992.
J The associated numerical value was an estimated quantity.
R The presence or absence of the analyte could not be verified from the existing data.
X Observed as semivolatile TIC.
N There was presumptive evidence to make a tentative identification.
-- Compound not reported in this sample.

TABLE 1-3

SUMMARY OF TCL AND SELECTED TAL CONSTITUENT RESULTS FOR OLD PLANT (CPC) LANDFILL AREA CLAY AND SAND SAMPLES OU-1 PHASE III SAMPLING[1]

Parameter	Loose Silt/Clay	Clay					Sand							
	BOP121 (12-21 ft)	BOP128 (26-28 ft)	BOP219 (18-19 ft)	BOP221 (20-21 ft)	BOP325 (24-25 ft)	BOP420 (18-20 ft)	BOP140 (38-40 ft)	BOP148 (46-48 ft)	BOP230 (28-30 ft)	BOP240/DUP (38-40 ft)	BOP340 (38-40 ft)	BOP342 (40-42 ft)	BOP422 (20-22 ft)	BOP440 (38-40 ft)
TCL VOLATILE ORGANICS														
1,1,1-Trichloroethane	–	–	–	–	–	–	–	–	–	–	–	–	0.53J	–
Acetone	–	–	0.38J	0.41J	–	–	–	–	–	–	–	–	–	–
Benzene	2.4	3.3	0.009J	0.051	–	–	–	2.3	–	–	–	–	–	–
Chlorobenzene	60	7.3	0.029	0.12	0.007J	1.8	32	36	–	0.001J/0.002J	–	–	46	–
Chloroform	0.37J	–	0.054	0.16	0.004J	–	–	–	–	0.033/0.031	0.004J	–	–	–
Tetrachloroethene	0.2J	–	–	–	–	–	–	–	–	–	–	–	–	–
TCL SEMIVOLATILE ORGANICS														
1,2,4,5-Tetrachlorobenzene	30	–	–	–	–	0.22J	4.1	0.67	–	–	–	–	0.8J	–
1,2,4-Trichlorobenzene	30	–	–	–	–	0.71J	4.6	0.79	–	–	–	–	1.6J	–
1,2-Dichlorobenzene	120	1.8	–	–	–	57	7.5	6.4	–	–	–	–	130	–
1,3-Dichlorobenzene	7.1	–	–	–	–	5	0.15J	0.28J	–	–	–	–	11	–
1,4-Dichlorobenzene	120	2.2	–	–	–	74	15	8.5	–	–	–	–	150	–
2-Chlorophenol	–	–	–	–	–	0.44J	–	–	–	–	–	–	–	–
Hexachlorobenzene	140	–	–	–	–	0.4J	1.2	0.24J	–	–	–	–	0.88J	–
Phenol	3.1J	–	2.9	–	–	3.7	–	–	5.2	–	–	–	–	11

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TABLE 1-3 (Continued)

SUMMARY OF TCL AND SELECTED TAL CONSTITUENT RESULTS FOR OLD PLANT (CPC) LANDFILL AREA CLAY AND SAND SAMPLES OU-1 PHASE III SAMPLING[1]

Parameter	Loose Silt/Clay	Clay					Sand							
	BOP121 (12-21 ft)	BOP128 (26-28 ft)	BOP219 (18-19 ft)	BOP221 (20-21 ft)	BOP325 (24-25 ft)	BOP420 (18-20 ft)	BOP140 (38-40 ft)	BOP148 (46-48 ft)	BOP230 (28-30 ft)	BOP240/DUP (38-40 ft)	BOP340 (38-40 ft)	BOP342 (40-42 ft)	BOP422 (20-22 ft)	BOP440 (38-40 ft)
TCL PESTICIDE/PCB ORGANICS														
4,4'-DDD	0.54J													
4,4'-DDE	–	–	–	–	–	–	0.059J	0.015J	–	–	–	–	0.005J	–
4,4'-DDT	0.07	–	–	–	–	0.0058J	–	–	–	–	–	–	–	–
Alpha-BHC	0.68X	–	0.022	0.025	–	0.52J	0.27	0.067	0.0023J	–	–	–	0.66J	0.01J
Alpha-Chlordane	–	–	–	–	–	–	–	–	–	–	–	–	0.0026J	–
Beta-BHC	–	–	–	0.007J	–	0.083J	–	–	–	–	–	–	0.1J	0.0035J
Delta-BHC	–	–	–	–	–	0.075J	0.023	0.0055	–	–	–	–	0.093J	–
Dieldrin	–	–	–	–	–	0.006J	0.0063J	–	–	–	–	–	–	–
Endosulfan II	0.054J	–	–	–	–	–	–	–	–	–	–	–	–	–
Gamma-BHC	–	–	0.0092J	0.0093J	–	0.11J	–	–	–	–	–	–	0.14J	0.002
Heptachlor	–	–	–	–	–	0.0023J	–	–	–	–	–	–	–	–
Methoxychlor	–	–	–	–	–	–	0.04	–	–	–	–	–	–	–
TAL INORGANICS														
Arsenic	0.99R	3	4.7R	0.93R	0.97R	0.98R	–	–	0.76R	0.93R/0.92R	0.86R	0.87R	1.5J	4.9R
Chromium	13.1J	16	15.9J	34J	20.6J	32.7J	–	–	2.6J	–	4.9J	4.1J	29.5J	–
Copper	–	6.9	5.7	6.4	13.1	8	–	–	–	–	–	–	8.1	–
Cyanide	–	–	–	4.2	–	–	–	–	–	–	–	–	–	–
Lead	1.6J	9.4J	8.9J	–	8.3J	54.3J	–	–	–	–	–	–	3.8J	–

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TABLE 1-3 (Continued)

SUMMARY OF TCL AND SELECTED TAL CONSTITUENT RESULTS FOR OLD PLANT (CPC) LANDFILL AREA CLAY AND SAND SAMPLES OU-1 PHASE III SAMPLING[1]

Parameter	Loose Silt/Clay	Clay					Sand							
	BOP121 (12-21 ft)	BOP128 (26-28 ft)	BOP219 (18-19 ft)	BOP221 (20-21 ft)	BOP325 (24-25 ft)	BOP420 (18-20 ft)	BOP140 (38-40 ft)	BOP148 (46-48 ft)	BOP230 (28-30 ft)	BOP240/DUP (38-40 ft)	BOP340 (38-40 ft)	BOP342 (40-42 ft)	BOP422 (20-22 ft)	BOP440 (38-40 ft)
Mercury	0.42	–	–	0.62	–	–	–	–	–	–	–	–	–	–
Thallium	–	–	–	–	–	–	0.4J	–	–	–	–	–	–	–
Zinc	51.7J	28.4J	20.9J	20.1J	35.6J	27.5J	9.5J	–	–	–	–	–	125J	–

NOTES:

1 Only compounds that were detected are listed.
J Estimated concentration below the quantitation limit.
R The presence or absence of the analyte could not be verified from the existing data.
X Observed as a semivolatile TIC.
– Not detected.

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TABLE 1-4

TCL AND SELECTED TAL CONSTITUENT RESULTS FOR FORMER CPC PLANT AREA OU-1 PHASE III SAMPLING[1,2,3]

(Concentrations in mg/kg)

Parameter	BCP1 Clay 2-4 ft	BCP1 Clay 8-10 ft	BCP1 Sand 12-14 ft	BCP1 Sand 30-32 ft	BCP1 Dup[4] Sand 30-32 ft	BCP2 Clay 2-4 ft	BCP2 Clay 8-10 ft	BCP2 Sand 14-16 ft
TCL VOLATILE ORGANICS								
Benzene	0.003J	--	--	--	--	--	--	--
Carbon Disulfide	--	0.019	--	--	--	--	--	--
Chlorobenzene	0.54	0.086	0.4	--	--	--	--	--
Chloroform	--	0.007J	0.005J	--	--	0.002J	0.008J	--
Tetrachloroethene	--	--	0.001J	--	--	--	--	--
TCL SEMIVOLATILE ORGANICS								
1,2,4,5-Tetrachlorobenzene	0.74	750	9.9	0.055J	0.055J	--	--	--
1,2,4-Trichlorobenzene	1.3	700	8.5	--	--	--	--	--
1,2-Dichlorobenzene	--	30	3.5	--	--	--	--	--
1,3-Dichlorobenzene	--	2.5J	0.22J	--	--	--	--	--
1,4-Dichlorobenzene	--	24	2.2	--	--	--	--	--
Hexachlorobenzene	0.2J	75	8	1.5	0.3J	0.13J	--	--

TABLE 1-4 (Continued)

TCL AND SELECTED TAL CONSTITUENT RESULTS FOR
FORMER CPC PLANT AREA
OU-1 PHASE III SAMPLING[1,2,3]
(Concentrations in mg/kg)

Parameter	BCP1 Clay 2-4 ft	BCP1 Clay 8-10 ft	BCP1 Sand 12-14 ft	BCP1 Sand 30-32 ft	BCP1 Dup[4] Sand 30-32 ft	BCP2 Clay 2-4 ft	BCP2 Clay 8-10 ft	BCP2 Sand 14-16 ft
TCL PESTICIDE/PCB ORGANICS								
4,4'-DDD	--	0.017J	--	--	--	--	--	--
4,4'-DDT	--	0.051J	--	--	--	--	--	--
Alpha-BHC	0.017J	0.12	0.031J	--	--	--	--	--
Beta-BHC	--	0.016J	--	--	--	--	--	--
Delta-BHC	--	--	0.0056J	--	--	--	--	--
Endosulfan I	--	0.0028J	--	--	--	--	--	--
Gamma-BHC	--	--	0.0031J	--	--	--	--	--
INORGANICS								
Arsenic	3.5	2.72	--	--	--	1.7J	--	1 J
Chromium	45.6	23.4	--	--	--	33.1	8.9	8.5
Copper	10.5	9.7	--	--	--	5.2	--	--
Lead	13.8J	9.7J	3.4J	--	--	9.5J	12.5J	7.8J
Selenium	--	--	--	--	0.75J	--	--	--
Zinc	24.3J	19.3J	--	--	--	22.7J	17.4J	45.6J

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TABLE 1-4 (Continued)

TCL AND SELECTED TAL CONSTITUENT RESULTS FOR FORMER CPC PLANT AREA OU-1 PHASE III SAMPLING[1,2,3] (Concentrations in mg/kg)

NOTES:

1 Samples collected from August 11, 1992 to August 14, 1992.
2 Only compounds detected are listed. No compounds were detected in BCP2 in the sand sample from 18 to 20 feet.
3 All depths from ground surface.
4 Duplicate sample of BCP1.
J The associated numerical value was an estimated quantity.
-- Compound not detected in this sample.

TABLE 1-5

TCL AND SELECTED TAL CONSTITUENT RESULTS FOR SANITARY LANDFILL SAMPLES OU-1 PHASE III SAMPLING[1,2] (Concentrations in mg/kg)

Parameter	BSL1	BSL2	BSL3
TCL VOLATILE ORGANICS			
Chlorobenzene	0.1	5.7	0.037
Ethylbenzene	--	--	0.002J
TCL SEMIVOLATILE ORGANICS			
1,2,4,5-Tetrachlorobenzene	2.9	0.61	6.6
1,2,4-Trichlorobenzene	0.43	0.56	7.4
1,2-Dichlorobenzene	--	--	2.4
1,3-Dichlorobenzene	1	0.37J	0.4J
1,4-Dichlorobenzene	0.67	1.2	1.8
2-Methylnaphthalene	--	--	0.23J
Acenaphthene	--	0.056J	0.79J
Anthracene	--	--	0.88J
Benzo(A)Anthracene	0.056J	--	1.1J
Benzo(A)Pyrene	0.043J	--	0.74J
Benzo(B)Fluoranthene	0.048J	--	0.81J
Benzo(G,H,I)Perylene	--	--	0.45J
Benzo(K)Fluoranthene	0.058J	--	1J
Bis(2-Ethylhexyl)Phthalate	0.77	--	--
Carbazole	--	--	0.55J
Chrysene	0.065J	--	1.3J
Dibenzofuran	--	--	0.45J
Fluoranthene	0.12J	--	4
Fluorene	--	0.041J	0.9J
Hexachlorobenzene	44	9.5	26
Indeno(1,2,3-CD)Pyrene	--	--	0.43J
Naphthalene	--	--	0.69J
Phenanthrene	0.093J	0.16J	4.6
Pyrene	0.13J	--	3.1
TCL PESTICIDE/PCB ORGANICS			
Aroclor - 1254	0.14NJ	--	0.47NJ
Endrin Aldehyde	--	0.0067J	--
INORGANICS			
Arsenic	2.8	3.3	4.1
Chromium	21.3	23.3	36.4
Copper	7.2	14.5	17.1
Lead	16.2J	12.5J	62.5J
Mercury	7.8	10.6	27.1
Nickel	--	4.2	7.4
Selenium	2.2J	--	--
Zinc	30.5J	45.9J	54.7J

NOTES:

1 Only compounds detected are listed.
2 Samples collected on August 19 and August 20, 1992.
J The associated numerical value was an estimated quantity.
N There was presumptive evidence to make a tentative identification.
-- Compound not detected in this sample.

TABLE 1-6

SUMMARY OF TCL AND SELECTED TAL CONSTITUENTS DETECTED IN THE ALLUVIAL AQUIFER GROUNDWATER SAMPLES[1]
(Concentrations in μg/l)

	Analyte	Maximum Concentration Reported[2]	Number of Wells Out of 29 Where Analyte Was Detected	Background Well WP9A Concentration[2]	Drinking Water Standard MCL[3]
TCL Volatile Organics	1,1,1-Trichloroethane	5J	1	10U	200
	1,1-Dichloroethane	3J	1	10U	NS
	1,1-Dichloroethene	5J	1	10U	7.0
	2-Butanone	200J	5	10U	NS
	Benzene	350	6	10U	5.0
	Bromodichloromethane	65	7	10U	100[4]
	Bromoform	31	3	10U	100[4]
	Carbon Tetrachloride	8J	1	10U	5.0
	Chlorobenzene	2,500	14	10U	100
	Chloroform	1,200	17	10U	100[4]
	Dibromochloromethane	40	5	10U	100[4]
TCL Semivolatile Organics	1,2,4-Trichlorobenzene	220	11	10U	70[8]
	1,2-Dichlorobenzene	4,000	13	10U	600
	1,3-Dichlorobenzene	270	8	10U	600
	1,4-Dichlorobenzene	4,100	13	10U	75
	2,4-Dichlorophenol	59	3	10U	NS
	2-Chloropenol	80	3	10U	NS
	Phenol	3J	1	10U	NS

TABLE 1-6 (Continued)

SUMMARY OF TCL AND SELECTED TAL CONSTITUENTS DETECTED IN THE ALLUVIAL AQUIFER GROUNDWATER SAMPLES[1] (Concentrations in $\mu g/l$)

	Analyte	Maximum Concentration Reported[2]	Number of Wells Out of 29 Where Analyte Was Detected	Background Well WP9A Concentration[2]	Drinking Water Standard MCL[3]
TCL Pesticides/PCBs	Alpha-BHC	5.6	14	0.05U	NS
	Beta-BHC	2.2	12	0.05U	NS
	Delta-BHC	0.57	7	0.05U	NS
	Gamma-BHC (Chlordane)	1.0	9	0.05U	0.2
	Gamma-Chlordane	0.2	1	0.05U	NS
Inorganic Constituents	Antimony	2120J	1	32U	6.0[8]
	Arsenic	32.7J	6	6J	50[5]
	Beryllium	115J	18	2.6U	4.0[8]
	Cadmium	95	4	3.2U	5.0
	Chromium	719	17	144	100 (Total)
	Copper	3430J	5	48.6U	1300[7]
	Lead	252	24	17J	15[7]
	Mercury	146	18	0.41	2.0
	Nickel	1310	12	57.4U	100
	Selenium	31.90J	1	3.6U	50
	Silver	40.20	4	2U	NS
	Zinc	3060J	24	299J	5000[9]
	Cyanide	350J	6	130J[6]	200

TABLE 1-6 (Continued)

SUMMARY OF TCL AND SELECTED TAL CONSTITUENTS DETECTED IN THE ALLUVIAL AQUIFER GROUNDWATER SAMPLES[1] (Concentrations in μg/l)

NOTES:

1	Wells sampled in September 1991.
2	Maximum concentration reported for total inorganic results only.
3	Reference: Drinking Water Regulations and Health Advisories, Office of Water, U.S. EPA, Washington, D.C., November 1992.
4	The MCL is 100 μg/l for the sum of bromoform, chloroform, bromodichloromethane, and dibromochloromethane.
5	Under review.
6	Missing raw data and sample-specific CLP quantitation limit. Concentrations and detection limits are estimated.
7	EPA action level.
8	Standard becomes effective January 17, 1994.
9	Secondary maximum contaminant level.
NS	A final MCL has not been established for this parameter.
TT	Treatment technology-based standard.
J	Concentration is estimated.
U	Not detected at or above the detection limit shown.

TABLE 1-7

TCL AND SELECTED TAL CONSTITUENTS DETECTED IN THE MIOCENE AQUIFER GROUNDWATER SAMPLES[1]
(Concentrations in μg/l)

TCL Organics	DH1	DH3	WW8	WW12	WW12 Duplicate	McIntosh Well Number 1[2]	McIntosh Well Number 2[3]	Primary Drinking Water Standard MCL[4]
Chlorobenzene	6J	-	3J	99	88	NA	<50	100
1,2-Dichlorobenzene	6J	-	-	50	44	NA	<50	600
1,3-Dichlorobenzene	-	-	-	3J	2J	NA	<50	600
1,4-Dichlorobenzene	8J	-	-	68	59	NA	<50	75
Arsenic	-	3.7J[5,6]	-	-	-	<20	<10	50
Beryllium	-	-	54J[6]	51J[6]	-	NA	NA	4[10]
Chromium	11.9	12.5	-	-	-	<10	<10	100 (Total)
Lead	10.7J[6]	20.3J[6]	6J[7]	-	-	<5.0	<5.0	15[11]
Zinc	211J[8]	188J[8]	-	1240J[5]	1290J[6]	<10	<10	5000[12]
Cyanide	-	150J[9]	-	-	-	NA	NA	200[10]

NOTES:

1. Only detected compounds are shown. The TAL results are from the total analyses. Samples collected in September 1991, unless otherwise indicated.
2. Savannah Laboratories Analytical Report Log No. 13824-1 dated December 6, 1990.
3. Savannah Laboratories Analytical Report Log No. 21399-1 dated May 28, 1991.
4. Primary Drinking Water Standard Maximum Contaminant Level. Reference: Drinking Water Regulations and Health Advisories. U.S. EPA Office of Water, November 1992.
5. Reported value is less than the sample-specific CRDL and the identification and quantitation are questionable.
6. Matrix spike recovery outside control limits; concentration is estimated.
7. Graphite furnace post digestion spike recovery outside control limits. Concentration is estimated.
8. ICP serial dilution percent difference outside control limits. Concentration is estimated.

TABLE 1-7 (Continued)

TCL AND SELECTED TAL CONSTITUENTS DETECTED IN THE MIOCENE AQUIFER GROUNDWATER SAMPLES[1]
(Concentrations in μg/l)

NOTES: (Continued)

[9] Missing raw data and sample-specific quantitation limit. Concentrations and detection limits are estimated.
[10] Standard becomes effective January 17, 1994.
[11] EPA action level.
[12] Secondary maximum contaminant level.
- Compound not detected.
TT Treatment technology-based standard.
NS A final MCL has not been established for this parameter.
J (Without footnote) Estimated concentration below the quantitation limit.

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TABLE 1-8

SUMMARY OF PHASE I TCL AND SELECTED TAL CONSTITUENT RESULTS[1] OU-2 SURFICIAL GRAB AND CORE SAMPLES

Analyte	Number of Grab Samples Out of 21 Where Analyte Was Detected	Maximum Concentration Detected in Grab Sample (mg/kg)	Number of Core Samples Out of 6 Where Analyte Was Detected	Maximum Concentration Detected in Core Samples (mg/kg)
TCL Volatile Organics				
Benzene	0	-	3	0.18
Chlorobenzene	20	1.0	5	5.8
TCL Semivolatile Organics				
1,2,4-Trichlorobenzene	1	1.1	0	-
1,2-Dichlorobenzene	1	0.24J	0	-
1,3-Dichlorobenzene	4	0.95	0	-
1,4-Dichlorobenzene	5	0.63	1	0.49J
Hexachlorobenzene	10	810	1	2.80
TCL Pesticides/PCB				
4,4'-DDD	19	1.8	4	0.13
4,4'-DDE	20	1.4	4	0.71
4,4'-DDT	18	4.0	0	-
Aldrin	1	0.028	0	-
Alpha-BHC	2	0.014	0	-
Beta-BHC	4	0.018	0	-
Delta-BHC	2	0.17	0	-
Endosulfan I	1	0.11	0	-
Endosulfan II	1	0.052	0	-
Gamma-BHC	1	0.029	0	-
Heptachlor Epoxide	2	0.017	1	0.019

TABLE 1-8 (Continued)

SUMMARY OF PHASE I TCL AND SELECTED TAL CONSTITUENT RESULTS[1] OU-2 SURFICIAL GRAB AND CORE SAMPLES

Analyte	Number of Grab Samples Out of 21 Where Analyte Was Detected	Maximum Concentration Detected in Grab Sample (mg/kg)	Number of Core Samples Out of 6 Where Analyte Was Detected	Maximum Concentration Detected in Core Samples (mg/kg)
Inorganics				
Antimony	4	24.6J	0	-
Arsenic	21	16.1J	6	4.6J
Beryllium	1	3.7	0	-
Chromium	21	52.1	6	69.4
Copper	20	57.5J	6	16.6
Cyanide	6	1.5	0	-
Lead	21	44.2J	6	26.4J
Mercury	108[2]	290	13[3]	157J
Zinc	21	227J	6	86.4

NOTES:

J The associated numerical value was an estimated quantity.
- Analyte not detected at or above the sample quantitation or detection limit.
1 Collected in August 1991.
2 A total of 112 grab samples were analyzed for mercury.
3 A total of 15 core samples were analyzed for mercury.

TABLE 1-9

SUMMARY OF FIELD BOREHOLE PERMEABILITY TESTS[1, 2]

Well Number	Elevation of Top/Bottom of Screen (feet msl)	Screened Interval	Estimated Radial Hydraulic Conductivity (K)		Remarks
			ft/day	cm/sec	
MP4	4.23/-0.77	Alluvial aquifer, upper zone	+7	2.4×10^{-3}	Test 8/18/82 One gallon, two tests. Readings (5) good.
MP6	6.85/1.85	Alluvial aquifer, upper zone			One gallon, K too high measure. Back to SWL in 30 seconds.
MP7	2.05/-2.95	Alluvial aquifer, upper zone	+34	1.2×10^{-2}	Test 8/18/82. Readings (13) good. One gallon.
MP9	-1.21/-6.21	Alluvial aquifer, upper zone	+17	6×10^{-3}	One gallon, two tests. Readings (4) good.
MP11	7.83/2.83	Alluvial aquifer, upper zone	+1.0	1.8×10^{-4}	Test 8/18/82. One gallon. Readings (10) good.
MP13	-37.96/-47.96	Alluvial aquifer, lower zone			Test 8/18/82. One gallon. Only two readings. K too high to measure.
MP1	2.14/-2.86	Alluvial aquifer, upper zone			Test 8/19/82. Five gallons. K too high for any readings.
WP3	-34.22/-44.22	Alluvial aquifer, lower zone	+3	1.0×10^{-3}	Test 8/19/82. Five gallons. Readings (9) good.
WP4	-11.47/-20.47	Alluvial aquifer, lower zone	+4	1.3×10^{-3}	Test 8/19/82. Five gallons. Readings (4) good.
WP5	6.44/1.44	Alluvial aquifer, upper zone			Test 8/19/82. Five gallons. Only two readings. K too high for more readings.
WP6A	-5.09/-15.09	Alluvial aquifer, lower zone	+15	5.1×10^{-3}	Test 8/18/82. Five gallons. K too high to measure. Two tests.

TABLE 1-9 (Continued)

SUMMARY OF FIELD BOREHOLE PERMEABILITY TESTS[1, 2]

Well Number	Elevation of Top/Bottom of Screen (feet msl)	Screened Interval	Estimated Radial Hydraulic Conductivity (K)		Remarks
			ft/day	cm/sec	
WP7A		Alluvial aquifer, lower zone			Test 8/18/82. Five gallons. Drained less than 60 seconds.
WP8	-10.01/-20.01	Alluvial aquifer, lower zone			Test 8/18/82. Five gallons. K too high to measure.
WP10A	-12.70/-22.70	Alluvial aquifer, lower zone			Test 8/18/82. Five gallons. Readings (12) erratic for first three minutes. Mud in well during development.
E1	-27.88/-37.88	Alluvial aquifer, lower zone			Test 8/18/82. Five gallons. First reading 48 seconds. K too high to measure.
E2	2.10/-2.90	Alluvial aquifer, upper zone			Test 8/19/82. Five gallons. K too high to measure during second test.
E4	-7.28/-12.28	Alluvial aquifer, upper zone	+40		Test 8/19/82. Five gallons. Two tests. K too high to measure.

NOTE:

1 Hydraulic conductivity values and remarks from S&ME, 1982.

TABLE 1-10

MEDIA-SPECIFIC CHEMICALS OF POTENTIAL CONCERN HUMAN HEALTH RISK ASSESSMENT

Groundwater (OU-1) Alpha-BHC Antimony Arsenic Benzene Beryllium Bromobenzene Bromodichloromethane Cadmium Carbon Tetrachloride Chlorobenzene Chloroform Chromium (VI) Copper Cyanide Delta-BHC 1,2-Dichlorobenzene 1,3-Dichlorobenzene 1,4-Dichlorobenzene 1,2,4-Trichlorobenzene Lead Nickel Mercury Pentachlorobenzene Pentachloronitrobenzene Tetrachlorobenzene isomers	**Surface Water (OU-2)** Alpha-BHC Arsenic Cadmium Chromium (VI) Cyanide Lead Mercury Nickel Zinc
Surface Soil (OU-2) Hexachlorobenzene Mercury	**Fish (OU-2)** 4,4'-DDD 4,4'-DDE 4,4'-DDT Hexachlorobenzene Mercury
Domestic Well Water (Off-Site) Chlorobenzene Chloroform Mercury 1,1,2,2-Tetrachloroethane Tetrachloroethene	**Sediment (OU-2)** Arsenic Benzene Chromium (VI) Hexachlorobenzene Lead Mercury
Surface Soil (OU-1) Hexachlorobenzene Mercury	**Surface Soil Particulates (OU-1)** Hexachlorobenzene Mercury
Surface Soil Particulates (OU-2) Hexachlorobenzene Mercury	**Surface Water VOCs (OU-2)** Mercury
Groundwater VOCs (OU-1) Benzene Carbon Tetrachloride Chlorobenzene Chloroform Mercury	**Domestic Well Water VOCs (Off-Site)** Chlorobenzene Chloroform Mercury 1,1,2,2-Tetrachloroethane Tetrachloroethene

TABLE 1-11

SUMMARY OF FISH ANALYSES[1] IN OPERABLE UNIT 2

(All Concentrations in mg/kg)

Field Sample ID	Mercury	4,4'-DDD	4,4'-DDE	4,4'-DDT	Chlorobenzene	Hexachlorobenzene	Pentachlorobenzene
CC-E4-27-WB	U	11	17	1JN	U	1.8JN	U
CC-G1-42-WB	0.33	4.5	5	0.27JN	U	1.2	U
CC-G1-43-WB	0.6	3.3	5.7	0.16JN	U	0.84	U
CC-G1-44-WB	0.32	2.1	4.2	U	U	0.64JN	U
CC-G3-09-WB	0.49	0.96	3.1	U	U	0.22JN	U
CC-G3-11-WB	0.41	0.91	3	U	U	0.32JN	U
CC-G3-13-WB	0.42	0.49JN	2.5	U	U	0.16JN	U
CC-G3-15-WB	0.46	0.62JN	2.3	U	U	0.41JN	U
CC-G3-17-WB	0.44	1.9	4.1	0.093JN	U	0.41JN	U
CC-G3-19-WB	0.45	2.2	2.6	0.067JN	U	0.73	U
CC-G1-41-FI	0.62	0.41JN	0.67JN	U	U	U	U
CC-G2-38-FI	0.57	1.2	2.2	0.17JN	U	0.31JN	U
CC-G2-39-FI	0.63	2.6	3.8	0.24JN	U	U	U
CC-G2-40-FI	0.57	1.5	2.3	0.2JN	U	0.25JN	U
CC-G3-10-FI	0.29	0.69	1.3	U	U	0.22JN	U
CC-G3-12-FI	0.28	3	5.9	0.36J	U	0.58JN	U
CC-G3-14-FI	0.67	1	2.1	U	U	0.25JN	U
CC-G3-16-FI	0.39	0.33JN	0.85JN	U	U	0.18JN	U
CC-G3-18-FI	0.52	0.64JN	1.4JN	U	U	0.2JN	U
CC-G3-20-FI	0.61	0.59JN	1.6JN	U	U	U	U
LB-E1-02-WB	0.7	5.8	8.8	0.87	U	1	0.07JN
LB-E1-03-WB	0.84	8	12	0.66JN	0.00486JN	0.96JN	U
LB-E3-21-WB	0.91	8.5	13	1.2JN	U	0.8JN	U
LB-E3-23-WB	0.77	22	24	0.89JN	U	1.2JN	U
LB-E3-25-WB	0.47	8.9	12	0.34JN	U	1.4	U
LB-E5-28-WB	0.79	8	12	0.44JN	U	1.0JN	U
LB-E5-30-WB	0.76	11	16	0.5JN	U	2.5JN	U
LB-E5-32-WB	0.7	5.2	8.8	0.2JN	U	1.6	U
LB-E6-34-WB	0.76	3	5.9	0.36JN	U	0.58JN	U
LB-G1-37-WB	1.2	2.8	4.2	U	U	0.23JN	U
LB-E2-05-FI	1.5	2.6	3.9	0.43J	U	0.18JN	U
LB-E2-06-FI	1.8	1.2	2	0.16JN	U	0.12JN	U
LB-E3-22-FI	1.4	0.81	1.7	U	U	0.13JN	U
LB-E3-24-FI	2.2	1.3	2.6	0.082JN	U	0.14JN	U
LB-E4-26-FI	1.7	1.7	3.2	0.2JN	U	0.12JN	U
LB-E5-29-FI	1.7	3.1	4.9	0.47JN	U	0.19JN	U
LB-E5-31-FI	1.8	3.8	5.8	0.36JN	U	0.2JN	U
LB-E6-33-FI	0.9	0.54JN	1.1	U	U	0.15JN	U
LB-E6-35-FI	1.5	0.84	2	U	U	0.13JN	U
LB-E6-36-FI	0.99	0.42JN	0.98	U	U	U	U

NOTES:

[1] Samples collected November 4-8, 1991.
CC Channel Catfish
LB Largemouth Bass
WB Whole Body
FI Fillet
J Estimated concentration
N Presumptive Evidence of Compound
U Not detected at or above the quantitation limit; quantitation limit varies with sample.

TABLE 1-12

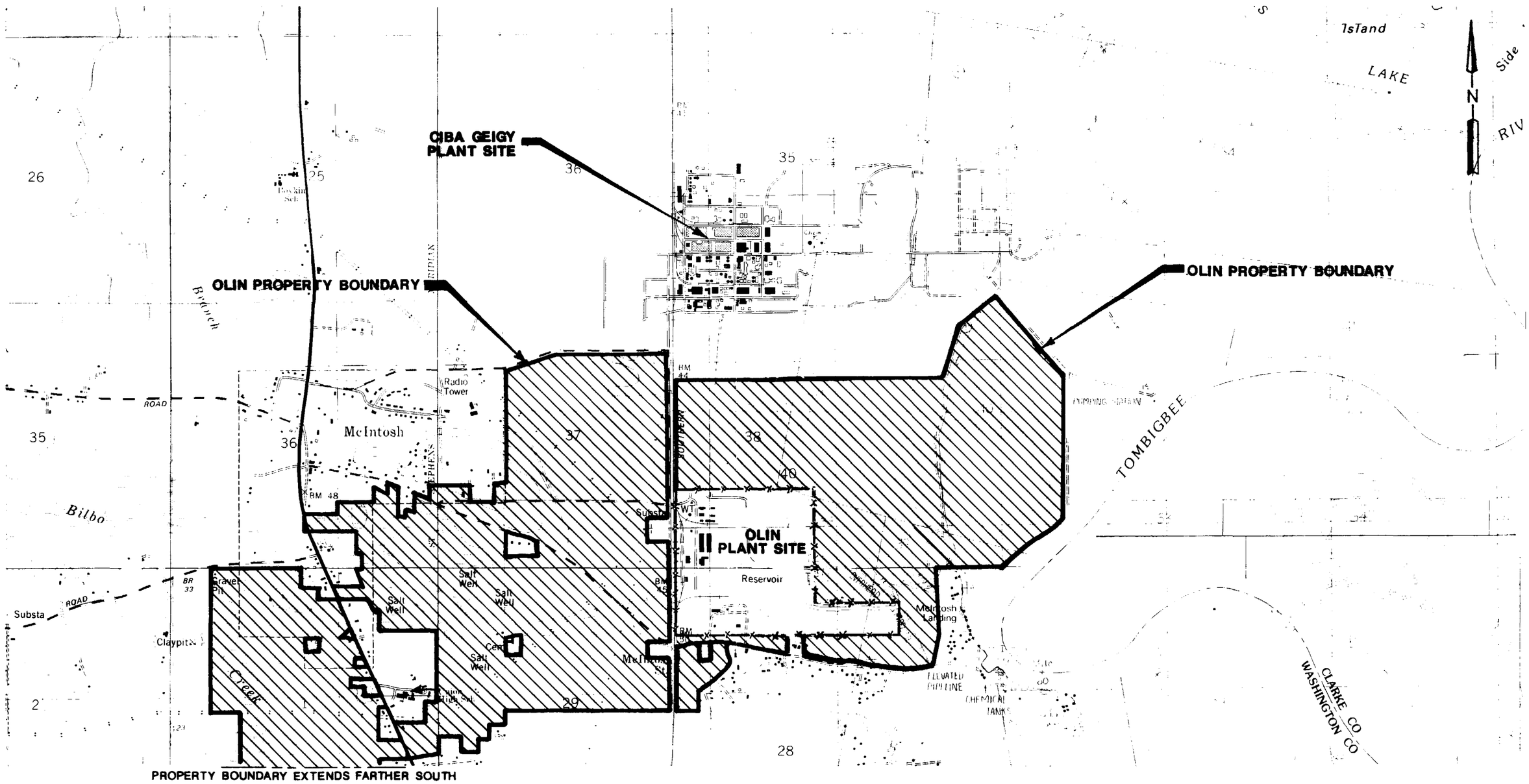
SUMMARY OF ESTIMATED INGESTION PATHWAY EXPOSURES FOR SELECTED ECOLOGICAL RECEPTORS IN OPERABLE UNIT 2

Receptor	Estimated Dose Via Ingestion (mg/kg-bw/day)[1]		
	Total Mercury	Hexachlorobenzene	DDT_R
Great Blue Heron	0.0012	0.0009	0.0058
Mallard	0.0421	0.0276	0.0972
Osprey	0.0006	0.0009	0.0108
Belted Kingfisher	0.0028	0.0029	0.0193
Raccoon	0.0275	0.0255	0.1539
Mink	0.0101	0.0140	0.0866
White-tailed Deer	0.0094	0.0134	0.0339

NOTE:

[1] Refer to RI Report (WCC, 1993) for assumptions used to derive these estimates.

FIGURES



PROPERTY BOUNDARY EXTENDS FARTHER SOUTH

LEGEND

—x— OLIN PLANT SITE FENCE LINE

OLIN PROPERTY BEYOND PLANT SITE

QUADRANGLE LOCATION

0 (FEET) 2000

SCALE

RE: U.S.G.S. 7.5 MINUTE SERIES QUADRANGLE MAP, McINTOSH, ALABAMA, 1984 AND GINHOUSE ISLAND, ALABAMA, 1984.

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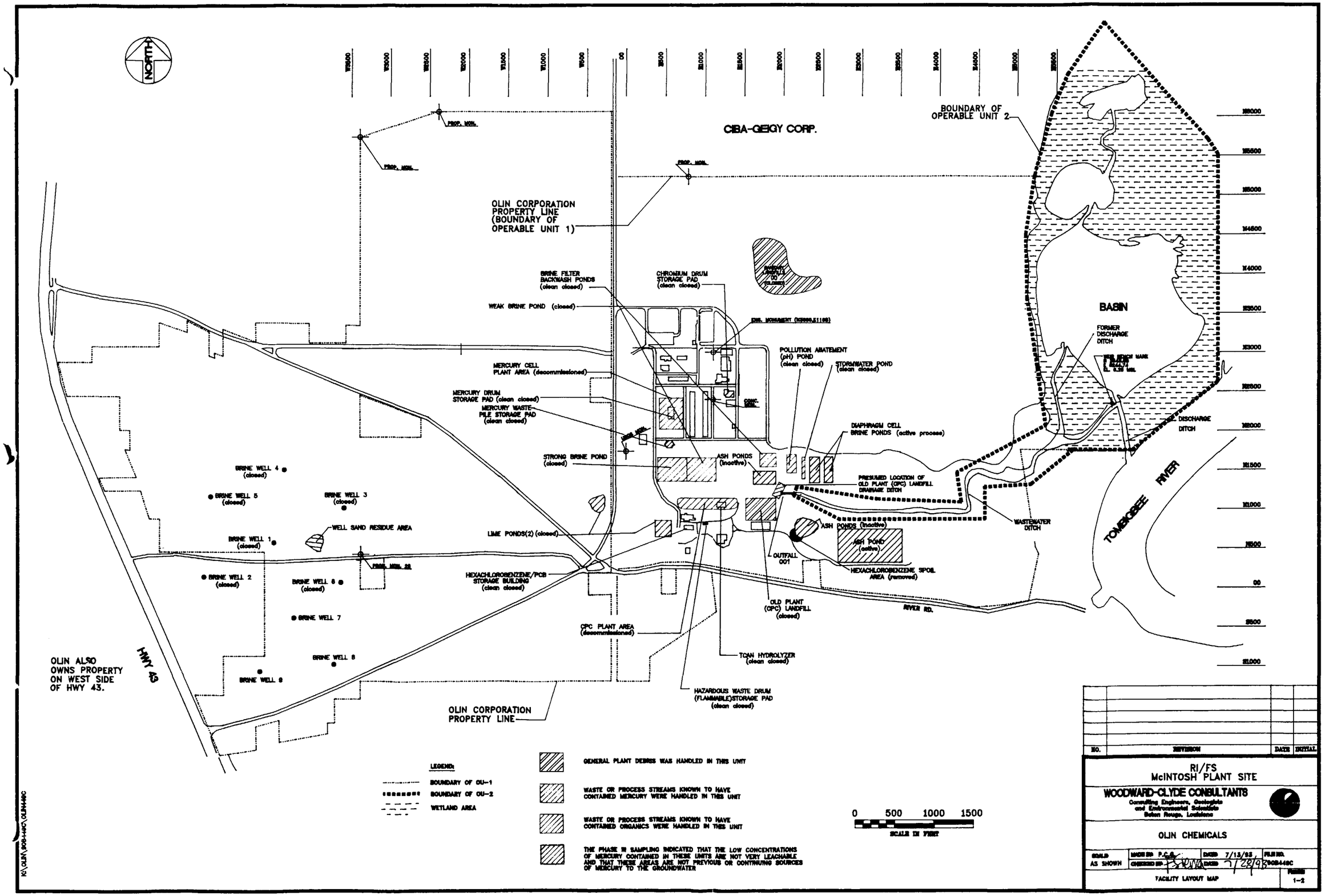
AS SHOWN	CHECKED BY: WAG	DATE: 12/90	90B449C

SITE LOCATION MAP

FIGURE 1-


NORTH
CIBA-GEIGY CORP.
BOUNDARY OF OPERABLE UNIT 2
OLIN CORPORATION PROPERTY LINE (BOUNDARY OF OPERABLE UNIT 1)
BASIN
FORMER DISCHARGE DITCH
BRINE FILTER BACKWASH PONDS (clean closed)
CHROMIUM DRUM STORAGE PAD (clean closed)
WEAK BRINE POND (closed)
POLLUTION ABATEMENT (pH) POND (clean closed)
STORMWATER POND (clean closed)
MERCURY CELL PLANT AREA (decommissioned)
MERCURY DRUM STORAGE PAD (clean closed)
MERCURY WASTE-PILE STORAGE PAD (clean closed)
DIAPHRAGM CELL BRINE PONDS (active process)
STRONG BRINE POND (closed)
ASH PONDS (inactive)
PRESUMED LOCATION OF OLD PLANT (OPC) LANDFILL DRAINAGE DITCH
DISCHARGE DITCH
TOMBIGBEE RIVER
BRINE WELL 4 (closed)
BRINE WELL 5 (closed)
BRINE WELL 3 (closed)
WELL SAND RESIDUE AREA
BRINE WELL 1 (closed)
LIME PONDS(2) (closed)
ASH PONDS (inactive)
ASH POND (active)
WASTEWATER DITCH
OUTFALL 001
HEXACHLOROBENZENE SPOIL AREA (removed)
BRINE WELL 2 (closed)
BRINE WELL 6 (closed)
HEXACHLOROBENZENE/PCB STORAGE BUILDING (clean closed)
OLD PLANT (OPC) LANDFILL (closed)
RIVER RD.
BRINE WELL 7
CPC PLANT AREA (decommissioned)
TCAN HYDROLYZER (clean closed)
BRINE WELL 8
BRINE WELL 9
HWY 43
OLIN ALSO OWNS PROPERTY ON WEST SIDE OF HWY 43.
HAZARDOUS WASTE DRUM (FLAMMABLE)STORAGE PAD (clean closed)
OLIN CORPORATION PROPERTY LINE
LEGEND:
BOUNDARY OF OU-1
BOUNDARY OF OU-2
WETLAND AREA
GENERAL PLANT DEBRIS WAS HANDLED IN THIS UNIT
WASTE OR PROCESS STREAMS KNOWN TO HAVE CONTAINED MERCURY WERE HANDLED IN THIS UNIT
WASTE OR PROCESS STREAMS KNOWN TO HAVE CONTAINED ORGANICS WERE HANDLED IN THIS UNIT
THE PHASE III SAMPLING INDICATED THAT THE LOW CONCENTRATIONS OF MERCURY CONTAINED IN THESE UNITS ARE NOT VERY LEACHABLE AND THAT THESE AREAS ARE NOT PREVIOUS OR CONTINUING SOURCES OF MERCURY TO THE GROUNDWATER
0 500 1000 1500
SCALE IN FEET
NO. REVISION DATE INITIAL
RI/FS
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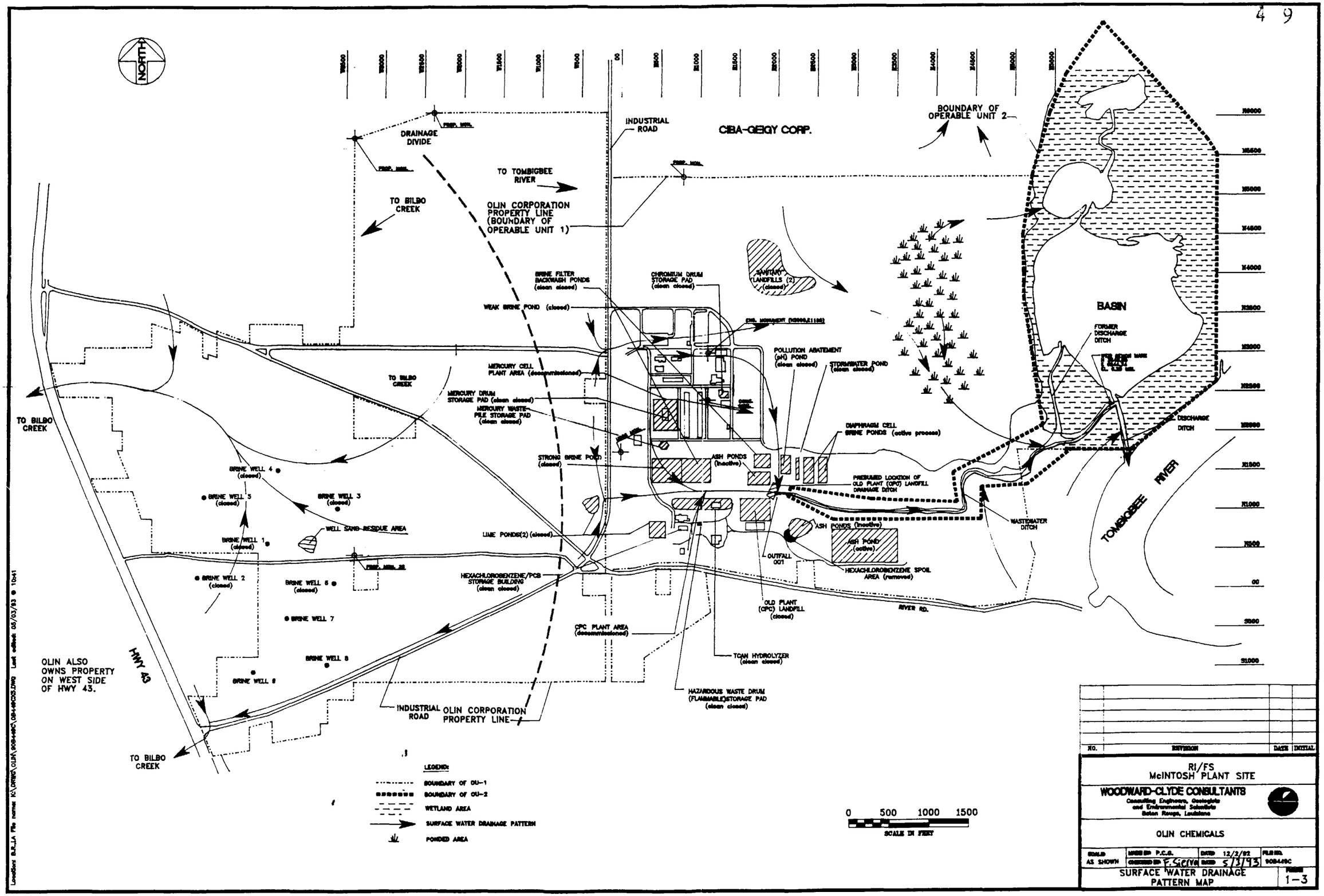
Baton Rouge, Louisiana
OLIN CHEMICALS
SCALE AS SHOWN
MADE BY P.C.B. DATE 7/13/93
CHECKED BY DATE 7/28/93
FILE NO. 90B448C
FACILITY LAYOUT MAP
FIGURE 1-2
K:\OLIN\90B448C\OLIN448C



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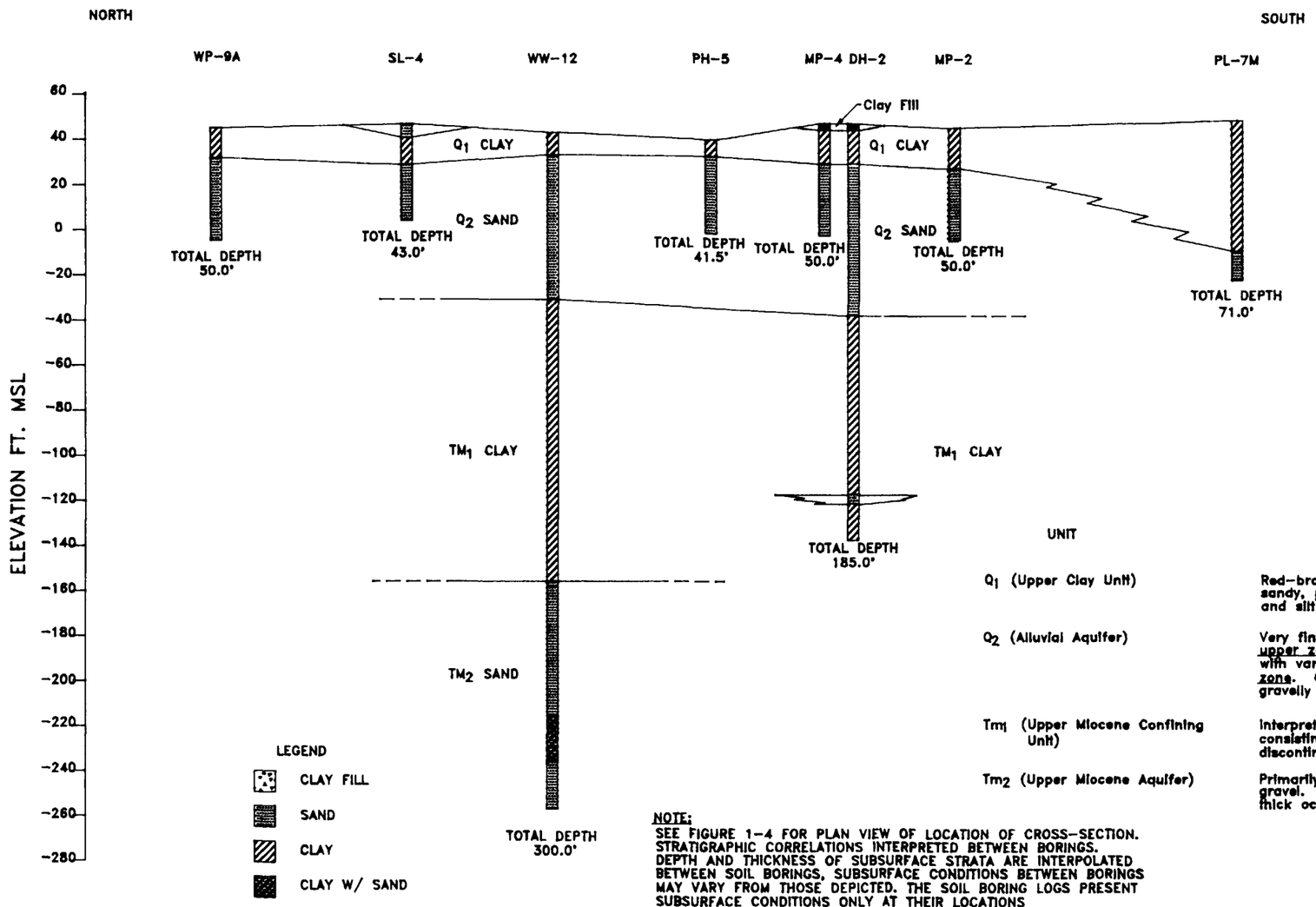
SURFACE WATER DRAINAGE PATTERN MAP

FIGURE 1-3

Leadfiles: BJR_LA File name: K:\DRWG\OLIN\908449C\08-49C13S.DWG Last edited: 05/03/93 @ 10:41

OVERSIZED

DOCUMENT



UNIT	DESCRIPTION
Q_1 (Upper Clay Unit)	Red-brown to yellow-brown and gray silty, sandy, plastic clay with discontinuous sand and silt lenses.
Q_2 (Alluvial Aquifer)	Very fine to fine-grained silty sand in the upper zone and fine to coarse-grained sand with varying amounts of gravel in the lower zone. Contains thin beds of clay or silty, gravelly clay.
Tm_1 (Upper Miocene Confining Unit)	Interpreted to be continuous across the site, consisting predominently of clay with laterally discontinuous sands and silts.
Tm_2 (Upper Miocene Aquifer)	Primarily thick-bedded, coarse sand and gravel. A clayey unit 10 feet to 30 feet thick occurs within this unit.

NOTE:
SEE FIGURE 1-4 FOR PLAN VIEW OF LOCATION OF CROSS-SECTION.
STRATIGRAPHIC CORRELATIONS INTERPRETED BETWEEN BORINGS.
DEPTH AND THICKNESS OF SUBSURFACE STRATA ARE INTERPOLATED BETWEEN SOIL BORINGS, SUBSURFACE CONDITIONS BETWEEN BORINGS MAY VARY FROM THOSE DEPICTED. THE SOIL BORING LOGS PRESENT SUBSURFACE CONDITIONS ONLY AT THEIR LOCATIONS AT THE TIME OF ACQUISITION.

SCALE
300 0 300 600 FEET
VERTICAL SCALE AS SHOWN

DATE	REVISION	DRWN/CHKD

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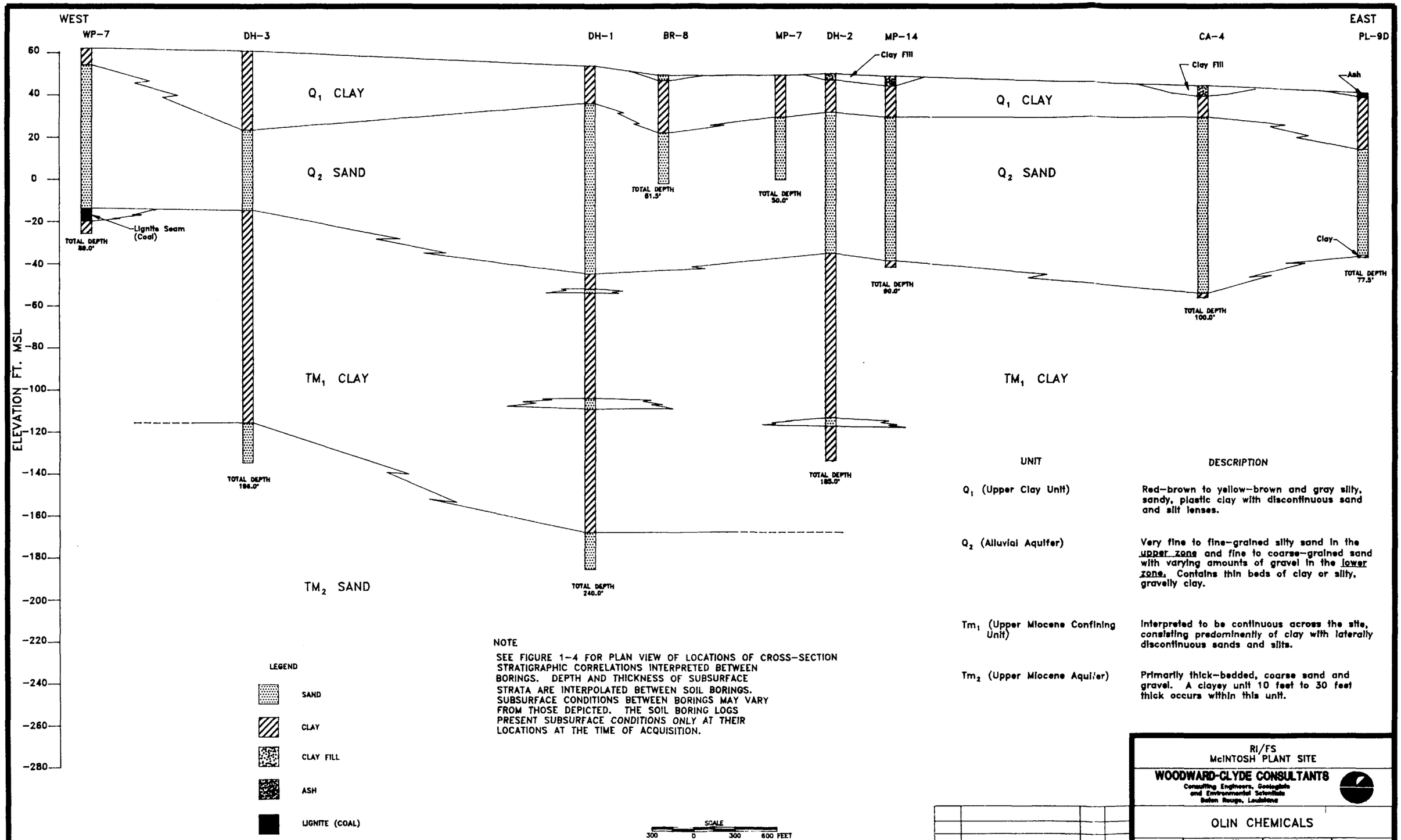
NOTED	CHECKED BY: F. Siewa	DATE: 5/3/93	90B449C

NORTH-SOUTH GEOLOGIC CROSS SECTION
OU-1

FIGURE 1-5

Location: B.R.,LA File name: K:\DRWG\OLIN\0B449C8.DWG Last edited: 04/07/93 @ 14:45



NOTE

SEE FIGURE 1-4 FOR PLAN VIEW OF LOCATIONS OF CROSS-SECTION STRATIGRAPHIC CORRELATIONS INTERPRETED BETWEEN BORINGS. DEPTH AND THICKNESS OF SUBSURFACE STRATA ARE INTERPOLATED BETWEEN SOIL BORINGS. SUBSURFACE CONDITIONS BETWEEN BORINGS MAY VARY FROM THOSE DEPICTED. THE SOIL BORING LOGS PRESENT SUBSURFACE CONDITIONS ONLY AT THEIR LOCATIONS AT THE TIME OF ACQUISITION.

UNIT	DESCRIPTION
Q_1 (Upper Clay Unit)	Red-brown to yellow-brown and gray silty, sandy, plastic clay with discontinuous sand and silt lenses.
Q_2 (Alluvial Aquifer)	Very fine to fine-grained silty sand in the upper zone and fine to coarse-grained sand with varying amounts of gravel in the lower zone. Contains thin beds of clay or silty, gravelly clay.
Tm_1 (Upper Miocene Confining Unit)	Interpreted to be continuous across the site, consisting predominently of clay with laterally discontinuous sands and silts.
Tm_2 (Upper Miocene Aquifer)	Primarily thick-bedded, coarse sand and gravel. A clayey unit 10 feet to 30 feet thick occurs within this unit.

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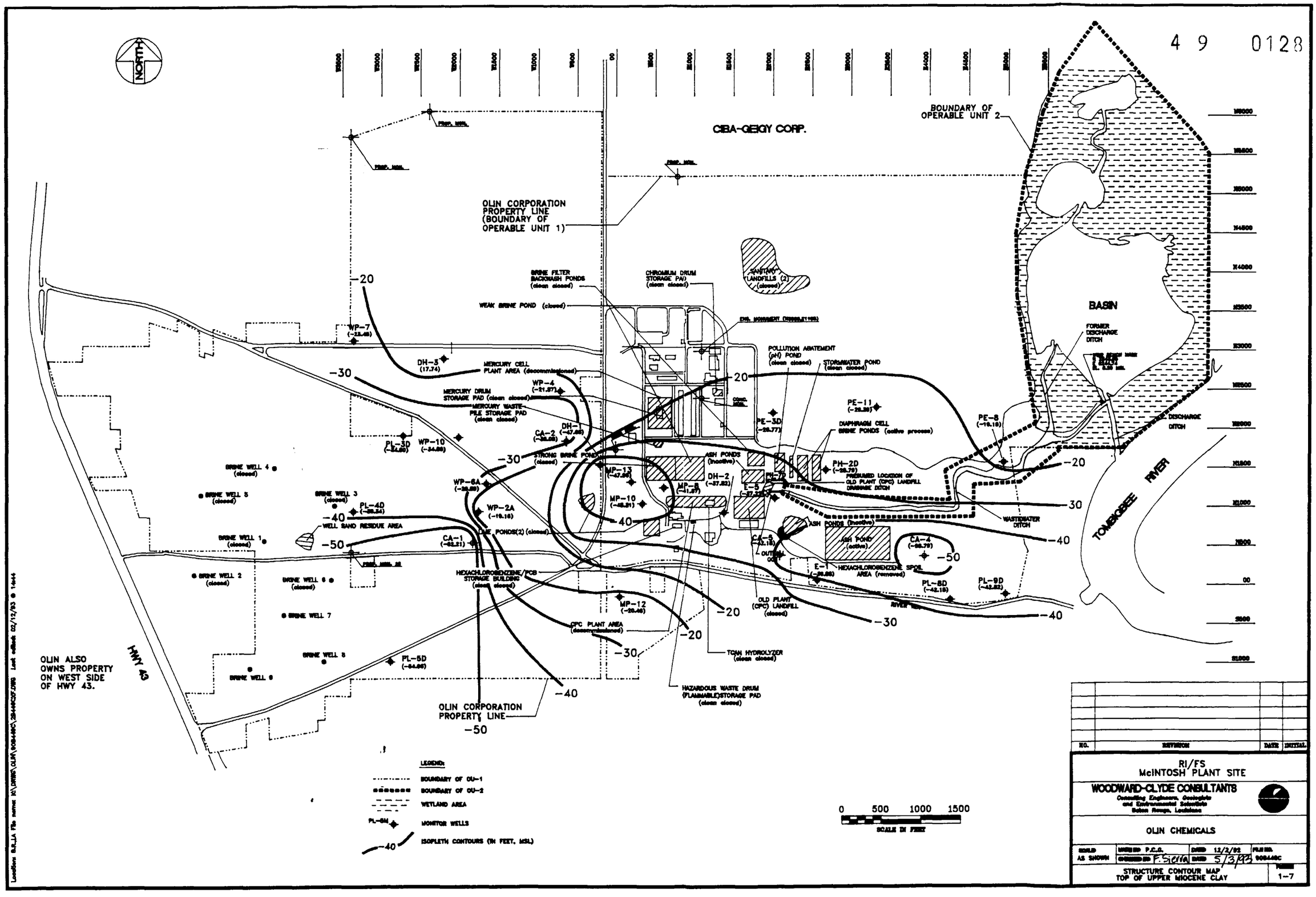
NOTED	CHECKED BY F.Giglio	DATE 5/2/93	

EAST-WEST GEOLOGIC CROSS SECTION
OU-1

FIGURE 1-6

Location: B.R.,LA File name: K:\DRWG\OLIN\0B449C9.DWG Last edited: 05/03/93 @ 14:06



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SCALE	DESIGNED P.C.G.	DATE 12/2/92	FILE NO.
AS SHOWN	CHECKED F. Sicilia	DATE 5/3/93	9084.40C

STRUCTURE CONTOUR MAP
TOP OF UPPER MIOCENE CLAY

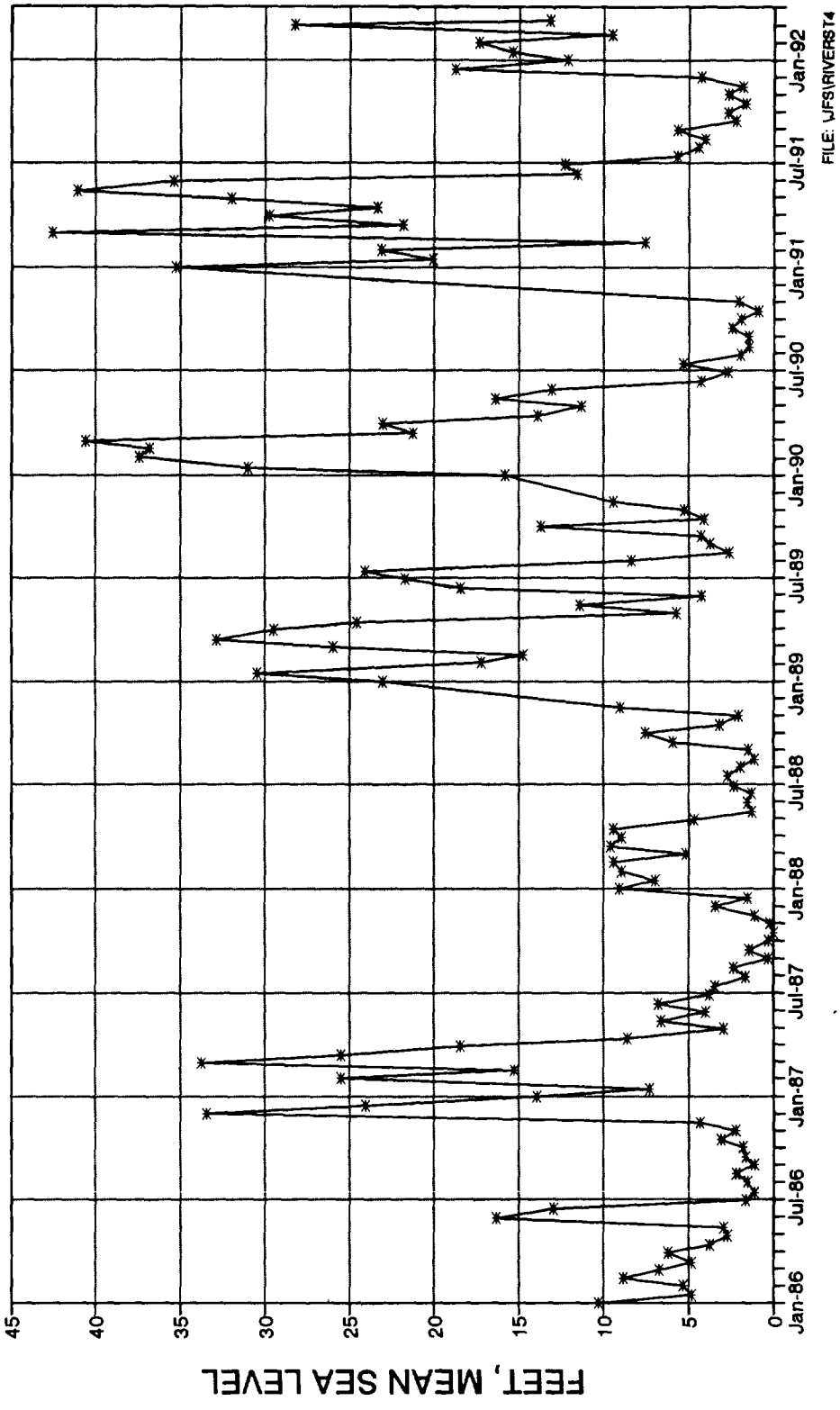
FIGURE 1-7

Location: B:R_LA File name: H:\DWG\OLIN\9084.40C\2844CS7.DWG Last edited: 02/12/93 @ 14:44

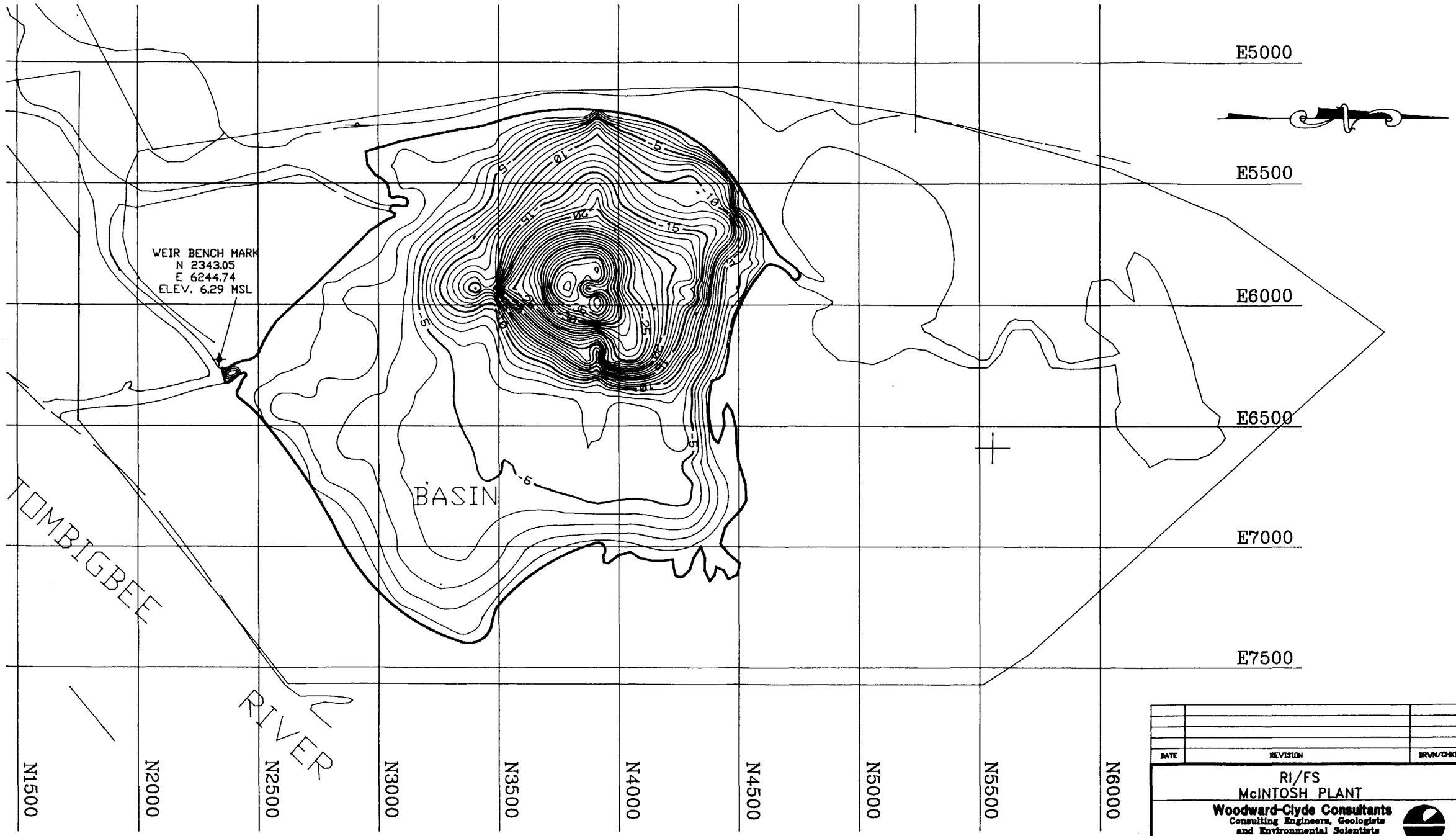
OVERSIZED

DOCUMENT

RIVER STAGE ELEVATIONS



OLIN CHEMICALS	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	RIVER STAGE ELEVATION GRAPH JAN. 1986 thru MARCH 1992	FILE NO. 90B449C FIG. NO. 1-9
	SCALE: NOTED / DRAWN BY: J.T. / DATE: 4/92 / CHKD. BY: M.J.S / DATE: 4-15-92		



SCALE

400 0 400 800 FEET

CONTOUR INTERVAL EVERY ONE FOOT

CONTOUR INTERVALS ON MAP READ AS DEPTH BELOW BASIN WATER LEVEL

A BASIN WATER LEVEL OF 1.56 MSL OBTAINED ON JULY 24, 1991 IS USED AS REFERENCE LEVEL

DATE	REVISION	DRVN/CHKD

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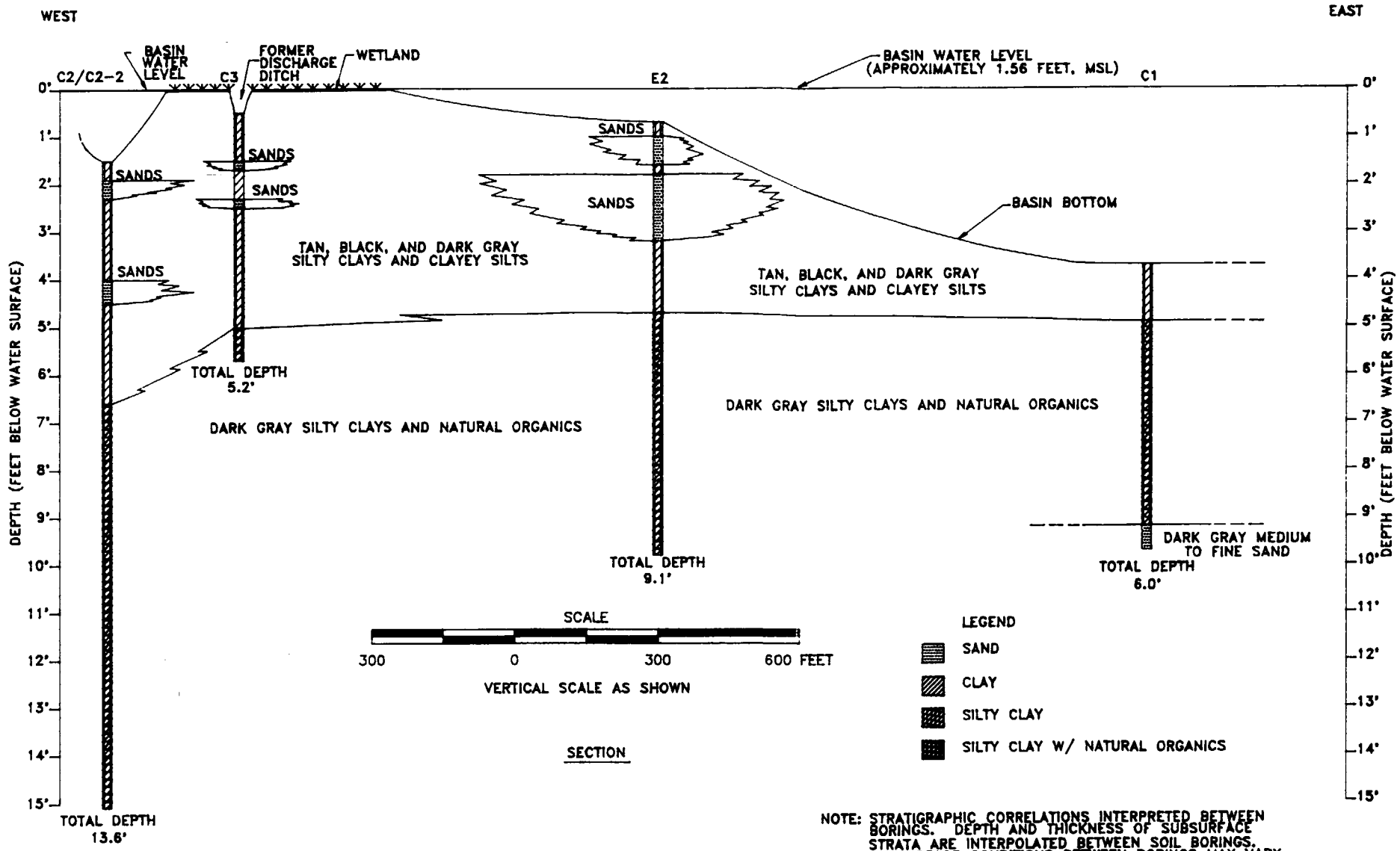
AS SHOWN	CHECKED BY:	DATE:	90B449C

BASIN BATHYMETRIC CONTOUR MAP

FIGURE 1-10

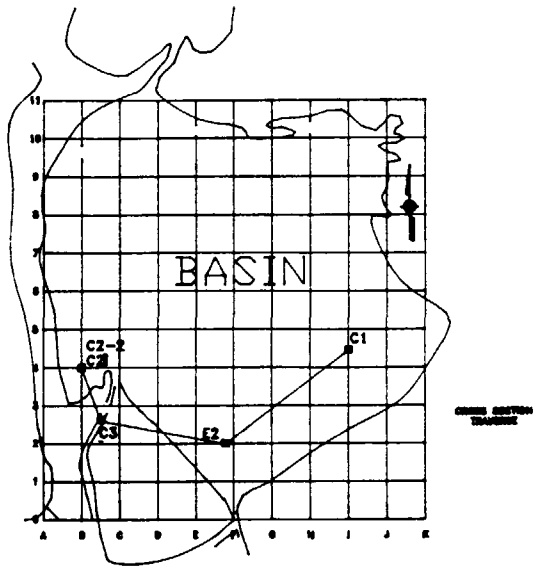
Location: B:R_JA File name: K:\DRWG\OLIN\0B449CFY.DWG Last edited: 07/15/93 ● 11:00



SECTION

NOTE: STRATIGRAPHIC CORRELATIONS INTERPRETED BETWEEN BORINGS. DEPTH AND THICKNESS OF SUBSURFACE STRATA ARE INTERPOLATED BETWEEN SOIL BORINGS. SUBSURFACE CONDITIONS BETWEEN BORINGS MAY VARY FROM THOSE DEPICTED. THE SOIL BORING LOGS PRESENT SUBSURFACE CONDITIONS ONLY AT THE LOCATIONS AND DATES INDICATED. WATER LEVELS AND RELATED DATA MAY VARY WITH TIME.

BASIN WATER LEVEL MEASUREMENT TAKEN ON JULY 24, 1991.



PLAN

DATE	REVISION	DRWN/CHKD

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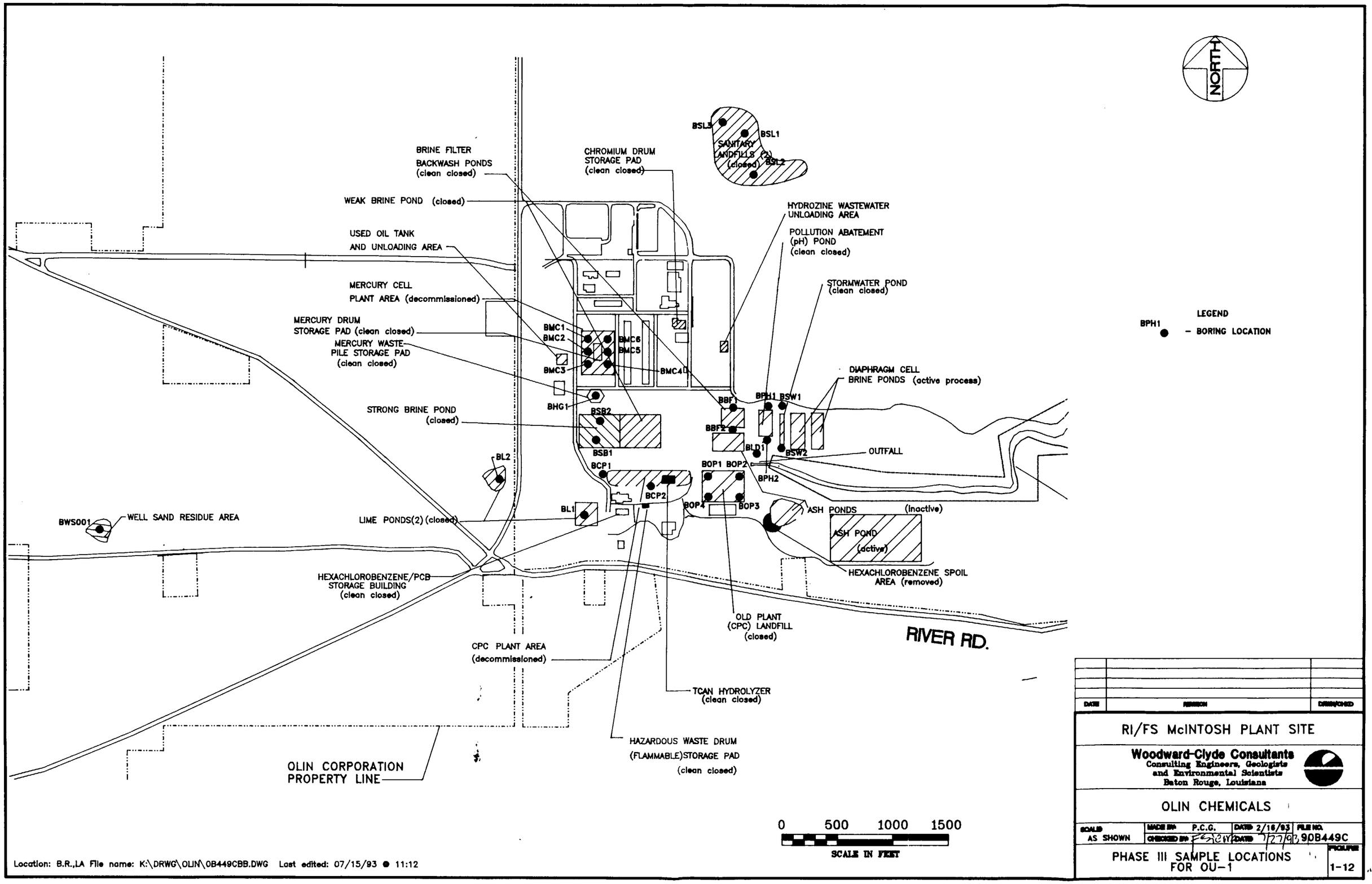
NOTED	CHECKED BY: F. Sicola	DATE: 5/3/93	90B449C

EAST–WEST GEOLOGIC CROSS SECTION
OLIN BASIN

FIGURE 1–11

Location: B.R.,LA File name: K:\DRWG\OLIN\0B449C7.DWG Last edited: 05/03/93 @ 13:25



DATE	REVISION	DRAWN/CHKD

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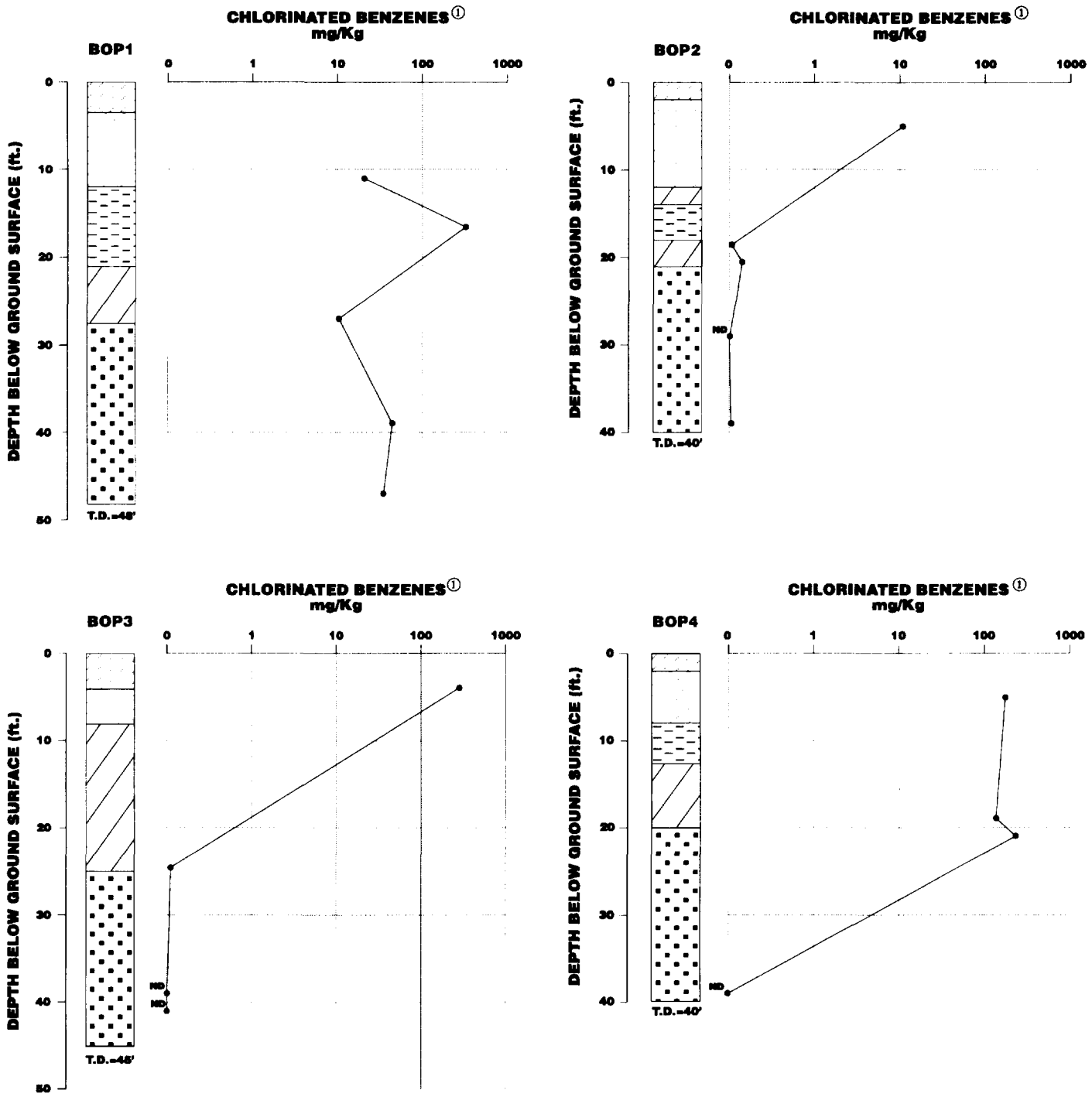
AS SHOWN	P.C.G.	2/18/93	90B449C
	CHECKED BY	DATE	

PHASE III SAMPLE LOCATIONS FOR OU-1

FIGURE 1-12

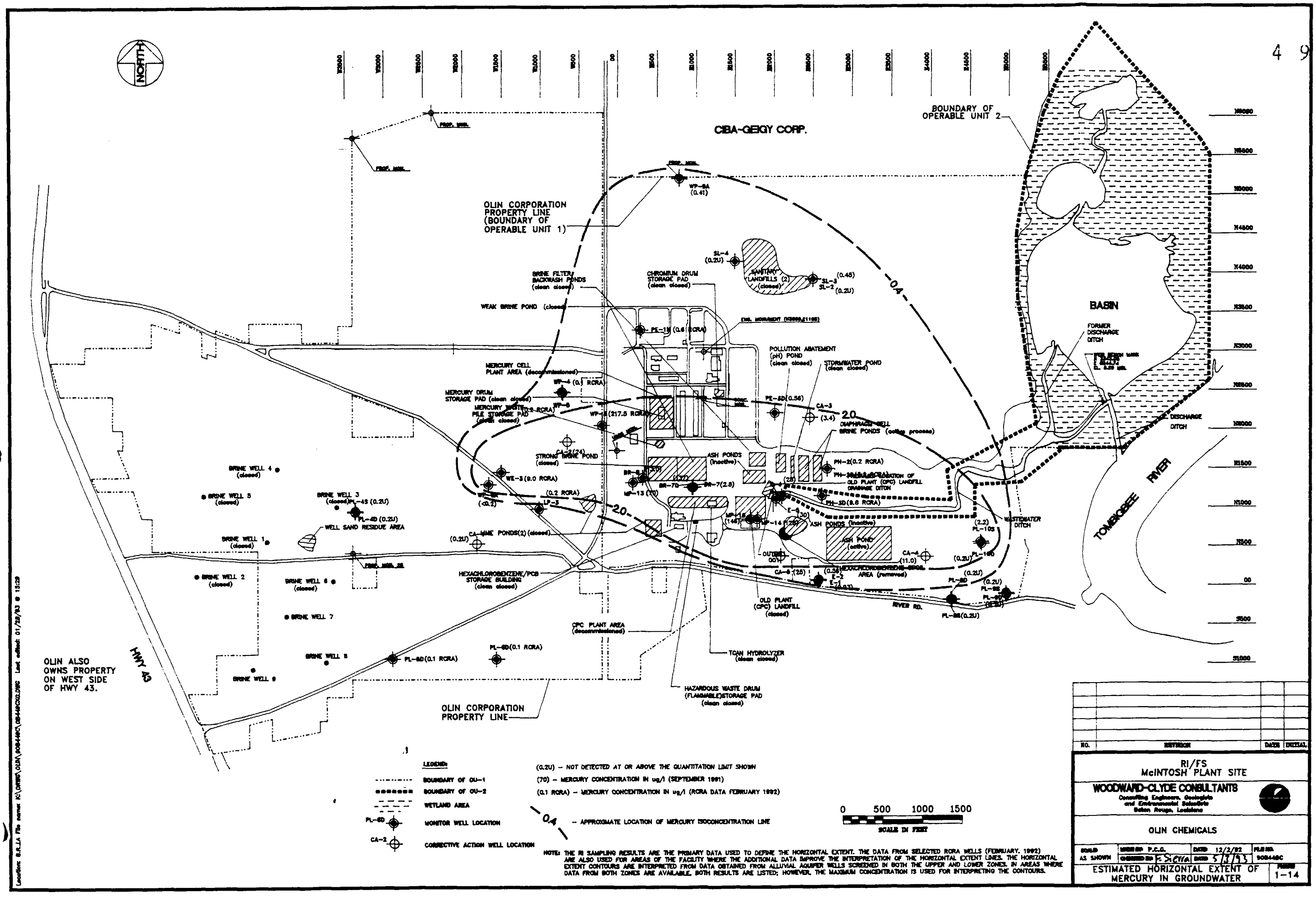


NOTE:

① TARGET COMPOUND LIST CHLORINATED BENZENES
ND = Not Detected

VERTICAL SCALE AS SHOWN

RI/FS McINTOSH PLANT SITE Olin CHEMICALS CHARLESTON, TENNESSEE	**Woodward-Clyde Consultants** Engineering & sciences applied to the earth & its environment		VERTICAL DISTRIBUTION OF CHLORINATED BENZENES IN OLD PLANT (CPC) LANDFILL BORINGS	FILE NO. 90B449C
	SCALE: AS NOTED	DRAWN BY: D.OLSON DATE: 01/27/93 CHKD. BY: W.BEAL DATE: 01/27/93		FIG. NO. 1-13


NORTH
CIBA-GEIGY CORP.
BOUNDARY OF OPERABLE UNIT 2
OLIN CORPORATION PROPERTY LINE (BOUNDARY OF OPERABLE UNIT 1)
BASIN
FORMER DISCHARGE DITCH
DISCHARGE DITCH
TOMBIGBEE RIVER
WASTEWATER DITCH
BRINE FILTER/ BACKWASH PONDS (clean closed)
WEAK BRINE POND (closed)
CHROMIUM DRUM STORAGE PAD (clean closed)
SANITARY LANDFILLS (2) (closed)
MERCURY CELL PLANT AREA (decommissioned)
MERCURY DRUM STORAGE PAD (clean closed)
MERCURY WASTE PILE STORAGE PAD (clean closed)
POLLUTION ABATEMENT (pH) POND (clean closed)
STORMWATER POND (clean closed)
DIAPHRAGM CELL BRINE PONDS (active process)
STRONG BRINE POND (closed)
ASH PONDS (inactive)
ASH POND (active)
OLD PLANT (CPC) LANDFILL DRAINAGE DITCH
WELL SAND RESIDUE AREA
HEXACHLOROBENZENE/PCB STORAGE BUILDING (clean closed)
HEXACHLOROBENZENE-SPOIL AREA (removed)
OLD PLANT (CPC) LANDFILL (closed)
CPC PLANT AREA (decommissioned)
TCAN HYDROLYZER (clean closed)
HAZARDOUS WASTE DRUM (FLAMMABLE) STORAGE PAD (clean closed)
RIVER RD.
HWY 43
OLIN CORPORATION PROPERTY LINE
OLIN ALSO OWNS PROPERTY ON WEST SIDE OF HWY 43.
BRINE WELL 1 (closed)
BRINE WELL 2 (closed)
BRINE WELL 3 (closed)
BRINE WELL 4 (closed)
BRINE WELL 5 (closed)
BRINE WELL 6 (closed)
BRINE WELL 7
BRINE WELL 8
BRINE WELL 9
LEGEND:
BOUNDARY OF OU-1
BOUNDARY OF OU-2
WETLAND AREA
MONITOR WELL LOCATION
CORRECTIVE ACTION WELL LOCATION
(0.2U) – NOT DETECTED AT OR ABOVE THE QUANTITATION LIMIT SHOWN
(70) – MERCURY CONCENTRATION IN ug/l (SEPTEMBER 1991)
(0.1 RCRA) – MERCURY CONCENTRATION IN ug/l (RCRA DATA FEBRUARY 1992)
– APPROXIMATE LOCATION OF MERCURY ISOCONCENTRATION LINE
0 500 1000 1500
SCALE IN FEET
NOTE: THE RI SAMPLING RESULTS ARE THE PRIMARY DATA USED TO DEFINE THE HORIZONTAL EXTENT. THE DATA FROM SELECTED RCRA WELLS (FEBRUARY, 1992) ARE ALSO USED FOR AREAS OF THE FACILITY WHERE THE ADDITIONAL DATA IMPROVE THE INTERPRETATION OF THE HORIZONTAL EXTENT LINES. THE HORIZONTAL EXTENT CONTOURS ARE INTERPRETED FROM DATA OBTAINED FROM ALLUVIAL AQUIFER WELLS SCREENED IN BOTH THE UPPER AND LOWER ZONES. IN AREAS WHERE DATA FROM BOTH ZONES ARE AVAILABLE, BOTH RESULTS ARE LISTED; HOWEVER, THE MAXIMUM CONCENTRATION IS USED FOR INTERPRETING THE CONTOURS.
NO. REVISION DATE INITIAL
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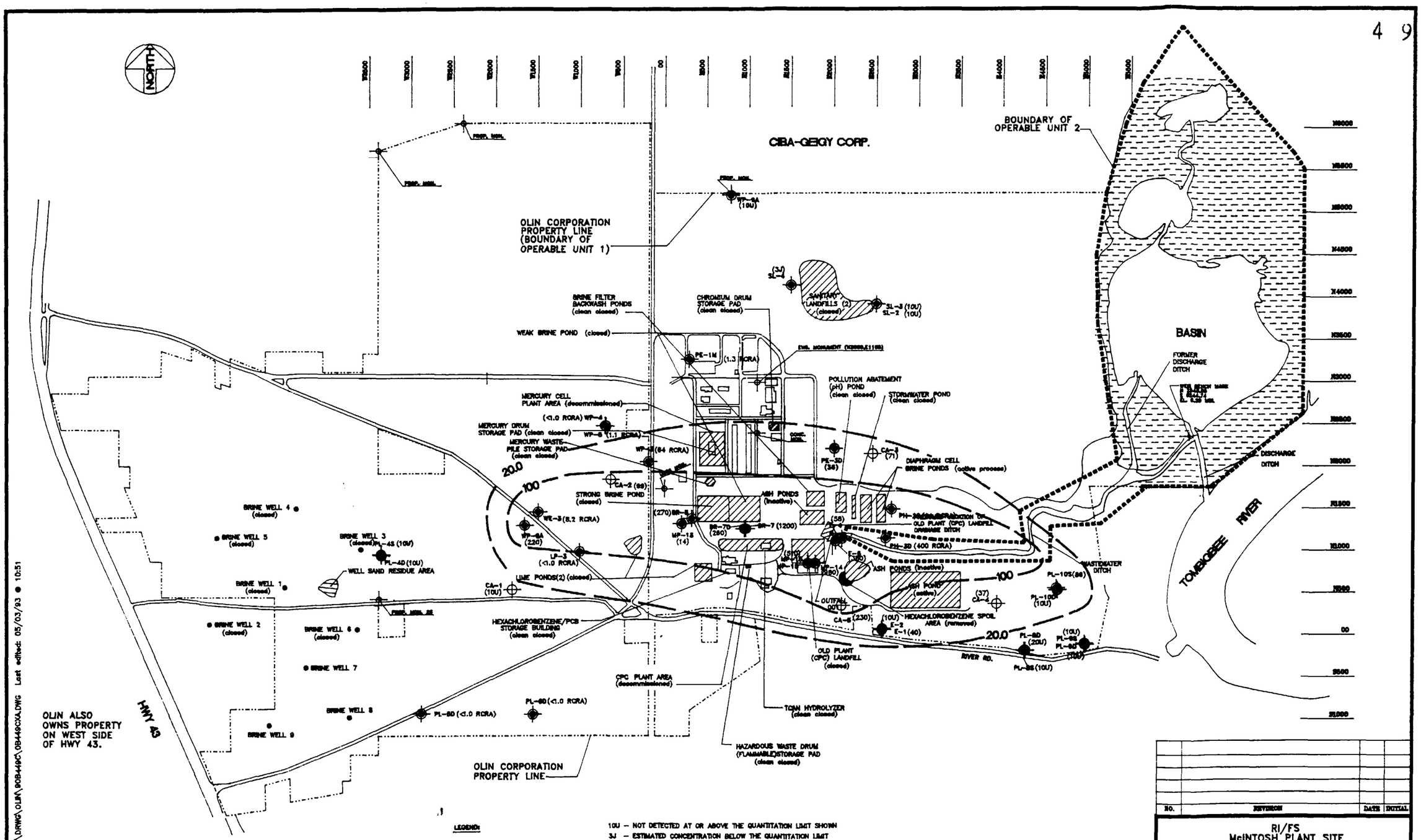
SCALE AS SHOWN
DRAWN BY P.C.G.
DATE 12/2/92
FILE NO. 90B448C
CHECKED BY F. Sicilia
DATE 5/3/93
ESTIMATED HORIZONTAL EXTENT OF MERCURY IN GROUNDWATER
FIGURE 1-14



LEGEND:

- BOUNDARY OF OU-1
- BOUNDARY OF OU-2
- WETLAND AREA
- PL-6D — MONITOR WELL LOCATION
- CA-2 — CORRECTIVE ACTION WELL LOCATION

10U – NOT DETECTED AT OR ABOVE THE QUANTITATION LIMIT SHOWN
3J – ESTIMATED CONCENTRATION BELOW THE QUANTITATION LIMIT
(70) – CHLOROFORM CONCENTRATION IN ug/l (SEPTEMBER 1991)
(0.1 RCRA) – CHLOROFORM CONCENTRATION IN ug/l (RCRA DATA FEBRUARY 1992)

20.0 – APPROXIMATE LOCATION OF CHLOROFORM ISOCONCENTRATION LINE

0 500 1000 1500
SCALE IN FEET

NOTE: THE RI SAMPLING RESULTS ARE THE PRIMARY DATA USED TO DEFINE THE HORIZONTAL EXTENT. THE DATA FROM SELECTED RCRA WELLS (FEBRUARY, 1992) ARE ALSO USED FOR AREAS OF THE FACILITY WHERE THE ADDITIONAL DATA IMPROVE THE INTERPRETATION OF THE HORIZONTAL EXTENT LINES. THE HORIZONTAL EXTENT CONTOURS ARE INTERPRETED FROM DATA OBTAINED FROM ALLUVIAL AQUIFER WELLS SCREENED IN BOTH THE UPPER AND LOWER ZONES. IN AREAS WHERE DATA FROM BOTH ZONES ARE AVAILABLE, BOTH RESULTS ARE LISTED; HOWEVER, THE MAXIMUM CONCENTRATION IS USED FOR INTERPRETING THE CONTOURS.

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OLIN CHEMICALS

SCALE AS SHOWN	DRAWN BY P.C.G.	DATE 12/2/92	FILE NO. 90B449C
	CHECKED BY F. Siena	DATE 5/3/93	

ESTIMATED HORIZONTAL EXTENT OF CHLOROFORM IN GROUNDWATER

FIGURE 1-16

Location: B:R.LA File name: K:\DRWG\OLIN\90B449C\0B449CXA.DWG Last edited: 05/03/93 @ 10:51

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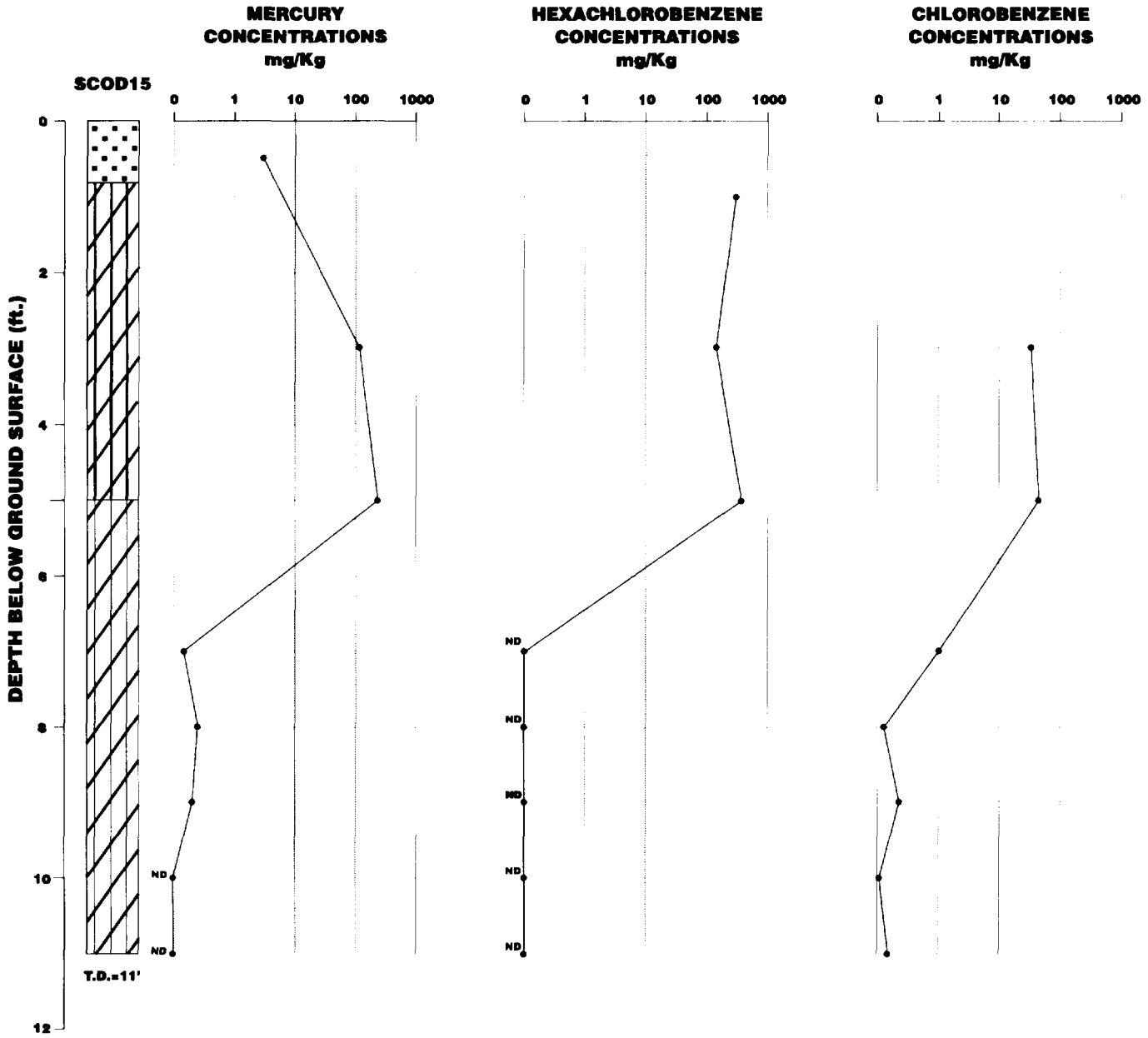
DOCUMENT

OVERSIZED

DOCUMENT



LEGEND

CLAY/SILT (SOFT UNCONSOLIDATED SEDIMENT)

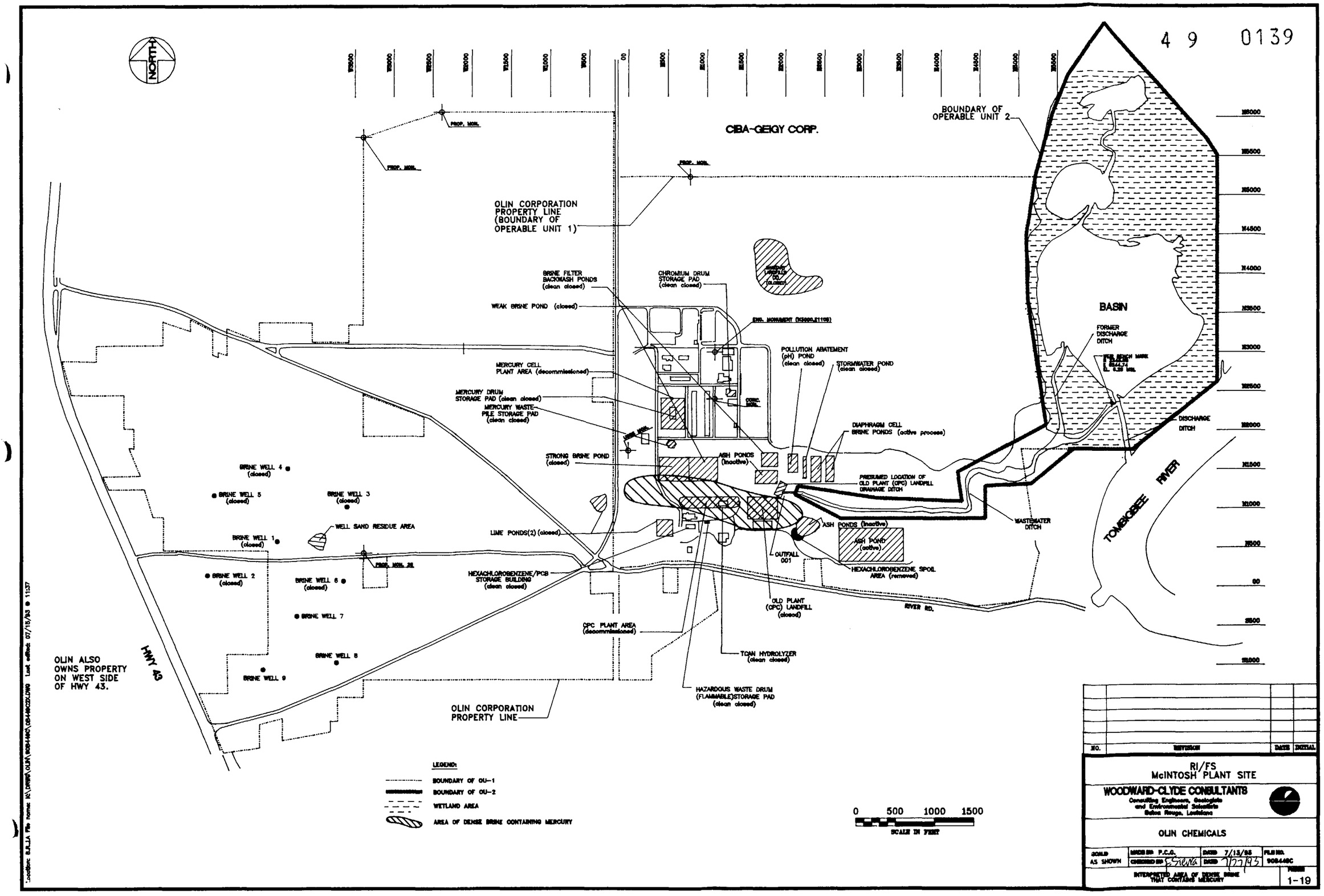
SILTY CLAY

SAND

VERTICAL SCALE AS SHOWN

NOTE:
ND = Not Detected

RI/FS McINTOSH PLANT SITE Olin CHEMICALS CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Engineering & sciences applied to the earth & its environment		MERCURY, HEXACHLOROBENZENE AND CHLOROBENZENE CONCENTRATIONS WITH DEPTH, CORE OD15	FILE NO. 90B449C
	SCALE: AS NOTED	DRAWN BY: D.OLSON DATE: 01/27/93 CHKD. BY: W.BEAL DATE: 01/27/93		FIG. NO. 1-18


NORTH
CIBA-GEIGY CORP.
BOUNDARY OF OPERABLE UNIT 2
OLIN CORPORATION PROPERTY LINE (BOUNDARY OF OPERABLE UNIT 1)
PROP. MON.
BRINE FILTER BACKWASH PONDS (clean closed)
WEAK BRINE POND (closed)
CHROMIUM DRUM STORAGE PAD (clean closed)
MERCURY CELL PLANT AREA (decommissioned)
MERCURY DRUM STORAGE PAD (clean closed)
MERCURY WASTE-PILE STORAGE PAD (clean closed)
STRONG BRINE POND (closed)
POLLUTION ABATEMENT (pH) POND (clean closed)
STORMWATER POND (clean closed)
DIAPHRAGM CELL BRINE PONDS (active process)
ASH PONDS (inactive)
PRESUMED LOCATION OF OLD PLANT (CPC) LANDFILL DRAINAGE DITCH
ASH PONDS (inactive)
ASH POND (active)
OUTFALL 001
HEXACHLOROBENZENE SPOIL AREA (removed)
WASTEWATER DITCH
BASIN
FORMER DISCHARGE DITCH
DISCHARGE DITCH
TOMBIGBEE RIVER
RIVER RD.
OLD PLANT (CPC) LANDFILL (closed)
TCAN HYDROLYZER (clean closed)
HAZARDOUS WASTE DRUM (FLAMMABLE)STORAGE PAD (clean closed)
CPC PLANT AREA (decommissioned)
HEXACHLOROBENZENE/PCB STORAGE BUILDING (clean closed)
LIME PONDS(2) (closed)
WELL SAND RESIDUE AREA
BRINE WELL 1 (closed)
BRINE WELL 2 (closed)
BRINE WELL 3 (closed)
BRINE WELL 4 (closed)
BRINE WELL 5 (closed)
BRINE WELL 6 (closed)
BRINE WELL 7
BRINE WELL 8
BRINE WELL 9
HWY 43
OLIN ALSO OWNS PROPERTY ON WEST SIDE OF HWY 43.
OLIN CORPORATION PROPERTY LINE
LEGEND:
BOUNDARY OF OU-1
BOUNDARY OF OU-2
WETLAND AREA
AREA OF DENSE BRINE CONTAINING MERCURY
0 500 1000 1500
SCALE IN FEET
NO. REVISION DATE INITIAL
RI/FS
McINTOSH PLANT SITE
WOODWARD-CLYDE CONSULTANTS
Consulting Engineers, Geologists and Environmental Scientists
Baton Rouge, Louisiana
OLIN CHEMICALS
SCALE AS SHOWN
MADE BY P.C.G.
DATE 7/13/93
FILE NO. 9084440C
CHECKED BY S. Sierra
DATE 7/27/93
INTERPRETED AREA OF DENSE BRINE THAT CONTAINS MERCURY
FIGURE 1-19

Section 2

2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

As stated in the RI/FS guidance (EPA, 1988a), the alternative development process consists of a series of steps that involve successively more specific definitions of potential remedial alternatives. This section presents the first five steps in this process, which consist of the following:

- Develop remedial action objectives
- Develop general response actions
- Identify volumes and areas of potentially affected media
- Identify and screen remedial technologies and process options
- Evaluate technology process options

2.1 INTRODUCTION

Selecting technologies and assembling alternatives to allow appropriate remedial action decisions begins early in the RI/FS process and is refined as site-specific data are collected. The amended RI/FS work plan (May 1991) identified preliminary remedial action objectives (RAOs) and alternatives. A revised remedial action objectives technical memorandum (RRAOTM) was submitted to EPA on April 30, 1992. The RRAOTM presented a list of RAOs based on the preliminary results of the site characterization work and an evaluation of the potential applicable or relevant and appropriate requirements (ARARs). Potential remedial alternatives were assembled for the remedial technologies, alternatives screening technical memorandum (RTASTM), which was submitted to EPA on October 6, 1992. These were re-evaluated and presented in the draft FS report submitted to EPA on May 5, 1993. EPA reviewed each of the documents noted above and provided Olin with comments. This exchange of information and the additional data collected throughout the process have improved the information base on which to assemble and describe alternatives. Consequently, the selected technologies and assembled alternatives presented in this final FS have been refined from those presented in previous RI/FS submittals.

2.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives are medium-specific or operable-unit-specific goals for protecting human health and the environment. RAOs for protecting human receptors generally specify both a contaminant level and an exposure route because protectiveness may be achieved by either reducing exposure or reducing the contaminant levels. Because RAOs for protecting environmental receptors typically are meant to preserve a resource, they are expressed in terms of the medium of interest and target cleanup levels. The RAOs are defined through hazard calculations based on the risk assessment and by applicable or relevant and appropriate requirements. Table 2-1 summarizes the general RAOs for the site. Development of preliminary remediation goals (PRGs) based on these RAOs is discussed in Sections 2.2.1 through 2.2.4.

2.2.1 Potential Risk-Based Preliminary Remediation Goals

As discussed in Section 1.5, twelve exposure pathways were evaluated for the resident/trespasser receptor, five exposure pathways were evaluated for the site industrial worker/receptor and fourteen exposure pathways were evaluated for the hypothetical OU-1 future resident. Table 2-2 summarizes the estimated cumulative excess lifetime cancer risks and noncarcinogenic hazard indices from the baseline risk assessment. None of the current or likely[1] future exposure pathways indicated cumulative carcinogenic site risk to an individual based on an RME scenario of greater than 10^{-4} or a noncarcinogenic hazard index of greater than 1.0, and therefore, risk-based PRGs were not developed for these exposure pathways. EPA has indicated that "where the cumulative carcinogenic site risk to an individual based on an RME scenario for current and future use is less than 10^{-4}, and the noncarcinogenic hazard quotient (index) is less than one, remedial action is generally not warranted..." (EPA, 1991a).

PRGs were developed for the hypothetical future OU-1 resident exposure pathways that exceeded the 10^{-4} cancer risk or 1.0 noncarcinogenic hazard index (Table 2-3). These PRGs are based on the child receptor (i.e., the most conservative receptor for which to

[1] Olin asserts future residential use is unlikely. See paragraph below for further discussion.

develop PRGs). The PRGs are media concentrations corresponding to the 10^{-4}, 10^{-5} and 10^{-6} cancer risks and 0.1, 1.0 and 10 noncarcinogenic hazard indices. The OU-1 hypothetical future resident scenario was included in the baseline risk assessment to provide risk managers with information about potential risks if this industrial site were to become residential and if residents were to drink on-site groundwater at current concentrations. Olin asserts that the hypothetical future resident is an unlikely receptor considering that the potential for parts of the site to become residential is virtually nonexistent.

The ecological assessment, which is summarized in Section 1.6, indicated that the vegetative, aquatic, and terrestrial populations at the site are healthy. Four bird species and three mammal species known or expected to occur in OU-2 were selected as indicator species to quantitatively evaluate the dietary exposure and potential risks associated with exposures to mercury, hexachlorobenzene, and DDT/metabolites via ingestion. The evaluation consisted of relating known or estimated exposures to levels known or anticipated to be harmful, sometimes referred to as reference toxicity values (RTVs). Results of this dietary exposure analysis of the selected bird and mammal receptors are summarized in Table 1-12. With the exception of the estimated exposure of raccoons to DDT_R, all of the PDE values are one or more orders of magnitude below levels described as adequately protective of sensitive wildlife species. Newell and others (1987) suggested that a safe dietary concentration of DDT_R for sensitive mammals would be 0.5 mg/kg, and the highest estimated exposure concentration for OU-2 (raccoon) is 0.15 mg/kg. In view of the dietary exposure calculations, it is improbable that any terrestrial or amphibious higher vertebrate populations in OU-2 are adversely affected by exposures to site constituents via the ingestion pathway. Since the ingestion pathway is generally considered the most important for exposures of higher vertebrates to bioaccumulative chemicals, the risks associated with other pathways (e.g., dermal contact with water or soil) in OU-2 are judged to be inconsequential. There is some evidence of potential effects of OU-2 sediments in the basin on benthic diversity (less than reference area) and physiology (aberrant chaetae of oligochaetes). These potential effects from sediment contamination must be weighed against the overall good health of the OU-2 ecosystem. This evaluation must be made using ARARs and potential ecological effects, since numerical sediment PRGs (cleanup criteria) are unavailable (see Section 2.2.4).

2.2.2 Potential Applicable or Relevant and Appropriate Requirements

Section 121(d) of CERCLA, as amended by SARA, states that any remedial action selected for a site must attain, at a minimum, a degree of cleanup that ensures protection of human health and the environment. In addition, a level or standard of control under any federal or state environmental law that meets legally enforceable ARARs must be attained for any hazardous substance, contaminant or pollutant remaining on-site at the completion of remedial actions.

The requirements of federal and state laws are identified and applied to remedial actions as ARARs using the approach outlined in the EPA's CERCLA Compliance with Other Laws Manual (EPA, 1988b). Applicable requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that specifically address a hazardous substance, pollutant or contaminant, location, or other circumstance at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that are not directly applicable to a hazardous substance, pollutant or contaminant, location, or other circumstance at a CERCLA site but address problems or situations sufficiently similar to those encountered at the CERCLA site, and whose use is well suited to the particular site. The judgment of the relevance and appropriateness of a requirement action depends on the substances in question or the physical nature of the site.

Section 121(d)(4) of CERCLA identifies six situations under which compliance with ARARs may be waived:

- The remedial action(s) selected is an interim action and is part of an overall, total remedial action which will attain the ARAR upon implementation.

- Compliance with the ARAR will result in a greater risk to human health and the environment than alternative options.

- Compliance with the ARAR is technically impracticable from an engineering perspective.

- An alternative remedial action will attain an equivalent standard of performance through the use of another method or approach.

- The ARAR is a state requirement that the state has not consistently applied (or demonstrated the intent to apply consistently) in similar circumstances.

- For Section 104 Superfund-financed remedial actions, compliance with the ARAR will not provide a balance between protecting human health and the environment and the availability of Superfund money for response at other facilities.

In order to comply with CERCLA requirements, selected remedial actions must attain ARARs unless they can claim a waiver under any of the situations described above. Cleanup levels during the RI/FS process will generally be based on chemical-specific and location-specific ARARs or health-based levels, as described in Section 2.2.1.

In the event that an ARAR does not exist, other pertinent guidelines and standards should be considered. These are commonly referred to as to-be-considered (TBC). Risk-specific doses (RSDs), reference doses (RfDs), health advisories (HAs) and state and federal guidelines and criteria, etc. are example TBCs.

Potential ARARs are divided into three categories: chemical-specific, action-specific and location-specific. Table 2-4 identifies potential ARARs for the site and classifies each ARAR as applicable, relevant and appropriate, or to be considered. Table 2-4 also provides a summary of the requirements and a description of their applicability.

2.2.2.1 Potential Chemical-Specific ARARs

Chemical-specific ARARS are numerical values that define the acceptable concentration of a constituent that must be attained by remedial actions in the affected media at the

site or in discharges from the site. The chemical-specific ARARs were used to develop preliminary remediation goals. The chemical-specific ARARs for groundwater, soil, surface water, air, and fish and game are summarized in this section.

Groundwater

Table 2-5 provides the numerical values associated with the chemical-specific ARARs and TBCs for the groundwater chemicals of potential concern at the site. The maximum concentration for each chemical of potential concern detected in the groundwater during the RI is also listed in Table 2-5.

Safe Drinking Water Act: Based on a review of the EPA guidance (EPA, 1986), the Alluvial and Miocene Aquifers would be classified as Class IIA drinking water sources because the groundwater in the vicinity of the site is currently in use. Maximum contaminant levels (MCLs) and non-zero maximum contaminant level goals (MCLGs) established under the Safe Drinking Water Act are potential ARARs as stated in the National Contingency Plan (NCP) 40 CFR 300.430(e)(2). The NCP also states that alternate concentration limits (ACLs) may be used in accordance with CERCLA Section 121(d)(2)(B)(ii), provided the site-specific situation meets all statutory requirements for ACLs. This includes demonstrating that actual restoration of groundwater to MCLs or MCLGs is impractical. ACLs are potential ARARs for the Olin site.

Resource Conservation and Recovery Act: As stated previously, Olin is currently operating a groundwater corrective action program under RCRA. The groundwater cleanup standards listed in Olin's post-closure RCRA permit (which are based on MCLs) are considered ARARs for restoration of groundwater at the site.

Alabama Primary Drinking Water Standards: ADEM has established drinking water standards for public water systems in Alabama. These standards, which are generally consistent with EPA standards, are potential ARARs.

To Be Considered: EPA health advisories published by the Office of Drinking Water are not enforceable contaminant limits and are potential TBCs for the site.

Soils

The environmental protection RAO for soils as listed in Table 2-1 is to prevent migration of contaminants that would result in groundwater contamination in excess of groundwater remediation goals. Therefore, the chemical-specific ARARs for groundwater (e.g., MCLs and RCRA cleanup levels) are potential ARARs for determination of soil remediation levels. Potential soil action levels (PSALs) were developed based on the groundwater MCLs as described in Section 2.2.3. Although the preliminary remediation goals are based on potential impact to groundwater, for any soils that are excavated (i.e., placement occurs) and classified as 40 CFR Part 261 hazardous waste, the Land Disposal Restriction (LDR) treatment standards (40 CFR Part 268) must be considered.

Surface Water

Clean Water Act: The NCP (40 CFR 300.430(e)(2)) states that water quality criteria established under Sections 303 or 304 of the Clean Water Act shall be attained for remedial actions where relevant and appropriate under the circumstances of the release. For surface water in the basin and the former discharge ditch, the federal water quality criteria and the Alabama water quality standards are potential ARARS. Table 2-6 provides the numerical values associated with the potential chemical-specific ARARs for surface water. These ARARs are listed for both the human health and ecological chemicals of potential concern. The maximum concentration for each chemical of potential concern detected in the RI surface water samples from the basin and the former discharge ditch is also listed in Table 2-6.

For surface water discharges through the existing wastewater ditch, the National Pollutant Discharge Elimination System (NPDES) permit limitations are potential chemical- and action-specific ARARs. Olin's discharge permit limits were developed based on the Alabama water quality standards for the receiving water (the Tombigbee River). Under Alabama's water quality standards, the Tombigbee River adjacent to the site has fish and wildlife as the designated water use classification.

Sediments

EPA has been in the process of developing sediment quality criteria since the mid-1980s. However, these have not yet been promulgated and hence are to be used as guidance only. The EPA sediment guidelines are to be used in conjunction with federal water quality criteria to protect aquatic environments and their uses. Without legally promulgated criteria, CERCLA guidance suggests that consideration be given to other guidelines or that site-specific cleanup criteria be developed. Section 2.2.4 presents a discussion of the guidelines available and how they may be applicable to the sediments at the McIntosh facility.

Air

The RI has shown that there are minimal or no effects to air from contaminant sources, and federal and state air quality standards are not found to be potential chemical-specific ARARs. These standards are considered as potential action-specific ARARs when considering remedial alternatives that may have air impacts.

Fish and Game

No potential ARARs were identified for fish and game. The Food and Drug Administration (FDA) action levels are potential TBCs. Table 2-7 lists the established FDA action levels for chemicals of potential concern in fish and game. The maximum concentration and the arithmetic mean concentration for these constituents are also listed in Table 2-7.

2.2.2.2 Potential Location-Specific ARARs

Location-specific ARARs impose restrictions based on the concentration of hazardous substances or the conduct of activities in specific locations. These may restrict or preclude certain remedial actions or may apply to certain portions of a site. Examples of location-specific ARARs may include RCRA location requirements, floodplain management requirements or wetlands discharge restrictions. A list of potential location-specific ARARs for the Olin, McIntosh site is presented below.

Endangered Species Act of 1973 (16 USC 1531, generally 50 CFR Parts 81, 225, 402). The Endangered Species Act of 1973 requires federal agencies to ensure, in consultation with the U. S. Department of Interior - Fish and Wildlife Service and the U. S. Department of Commerce - National Marine Fisheries Service, that the activities at a site do not affect the existence of endangered or threatened species or result in a destruction or adverse modification of their habitat.

National Historic Preservation Act [16 USC Sections 461, 469, and 470, generally 40 CFR 6.301(b), 36 CFR Part 800]. This act was promulgated to ensure that the remedial actions proposed at a site do not threaten any historical properties included on or eligible for inclusion on the National Register of Historic Places. The National Historic Preservation Act is a potential location-specific ARAR for the Olin site.

Fish and Wildlife Coordination Act (16 USC 661). This act sets standards for the protection of fish and wildlife when federal actions result in control or structural modification of a stream or water body. It is a potential location-specific and/or action-specific ARAR for remedial actions that may affect water bodies at the site.

Archeological and Historical Preservation Act (16 USC 469a-1). Provides for the preservation of historical and archeological data that could be affected by remedial actions. It is a potential location-specific ARAR in the event that a historic or archeological site is identified.

2.2.2.3 Potential Action-Specific ARARs

Action-specific ARARs govern design, performance, and other technology or activity-based remedial options at a site. These potential ARARs may come into force depending on the various remedial actions being proposed for the site. Action-specific ARARs do not determine the remedial alternative but indicate the way in which selected alternatives must be implemented to establish performance goals. The action-specific potential ARARs for the Olin, McIntosh site for groundwater, surface water, soils and sediment are presented in Table 2-4. These potential ARARs are discussed below.

Clean Water Act. Section 404 of the Clean Water Act empowers the U. S. Army Corps of Engineers to monitor the discharge of excavated or dredged material into the navigable waters of the United States and would be relevant and appropriate for alternatives involving dredging.

The NPDES regulations (40 CFR Part 132) require that permits be obtained from the EPA and ADEM for discharge of pollutants from any point source into waters of the United States. Although the National Contingency Plan (NCP) stipulates that such permits are not required for on-site CERCLA remediation activities, substantive requirements would apply if a remedial alternative includes surface water discharge.

Executive Orders Related to Floodplain (11988) and Wetlands (11990) - EPA's August 6, 1985 Policy on Floodplain and Wetlands Assessments for CERCLA Actions. This executive order is implemented by EPA in its Statement of Procedures on Floodplain Management and Wetlands Protection. These regulations require that an evaluation be made of the potential effects on floodplains and wetlands due to actions taken at a site. The regulations aim to ensure that floodplains and wetlands, to the extent possible, are not adversely affected or directly or indirectly developed by any remedial actions undertaken at a site.

State of Alabama Rules. In addition to the requirements of the Clean Water Act, the state of Alabama regulations concerning discharge of surface water to waters of the state resulting from implementation of CERCLA remedial actions are also potential ARARs.

Section 10 of the Rivers and Harbors Act. This act prohibits the unauthorized obstruction or alteration of any navigable water of the United States. Navigable waters of the U. S. are defined as waters that are subject to the ebb and flow of the tide shoreward to the mean high water mark and/or are presently used, or have been used in the past and may be susceptible to use for transporting interstate or foreign commerce. Structures or work in, above or under navigable waters are regulated under Section 10.

Clean Air Act (42 USC Sections 7401-7642). The National Ambient Air Quality Standards (40 CFR Part 50) establish treatment technology standards for emissions to air from incinerators, surface impoundments, waste piles, landfills and fugitive sources. These standards are potential ARARs for remedial alternatives that result in air emissions during implementation. In addition to the above federal standards, the Alabama Air Quality Regulations are also potential ARARs.

Resource Conservation and Recovery Act (RCRA). The requirements of the RCRA hazardous and solid waste regulations are potential ARARs for the soil and sediment remedial alternatives. The regulation under 40 CFR 261 would be used to define whether the soils and sediments are defined as RCRA hazardous wastes. Material that is not classified as a hazardous waste under RCRA would be subject to the federal solid waste disposal requirements of 40 CFR 241. Any material that is defined as a RCRA hazardous waste would be subject to the more stringent requirements of 40 CFR 264, including the minimum technology requirements (MTRs) for permitted hazardous waste disposal units. Additionally, RCRA hazardous waste would be subject to the Land Disposal Restrictions (LDRs) of 40 CFR 268. The LDRs prohibit the land disposal or "placement" of restricted hazardous waste on land prior to treatment. Wastes treated in accordance with EPA's treatment standards are not subject to LDRs.

On February 16, 1993, EPA published a rule (Federal Register 58(29): 8658-8685) which encourages the use of innovative, cost-effective and protective remedial actions under RCRA Corrective Action and CERCLA. This rule provides for Corrective Action Management Units (CAMUs). A CAMU is a unit in which wastes generated in the course of required remedial actions at the facility are managed. All solid and hazardous wastes, all media (including groundwater, surface water soils and sediments) and debris that contain listed hazardous wastes, or which themselves exhibit a hazardous waste characteristic which results from the remediation, but excluding as-generated waste, can be managed as a CAMU, and returned to the CAMU without triggering LDRs or MTRs. The RCRA action-specific ARARs are discussed further in the detailed analysis of alternatives (Section 4.0).

U. S. Department of Transportation (DOT) Rules for Transport of Hazardous Materials. These requirements under 40 CFR Part 107 are potential ARARs for remedial options that result in off-site transportation of hazardous materials.

In addition to U. S. DOT regulations, the state of Alabama regulations concerning transportation of hazardous materials along Alabama rights-of-way are also potential ARARs.

Occupational Safety and Health Act (OSHA). These regulations govern occupational safety and health issues of workers engaged in on-site field activities. The OSHA regulations are cited in 29 CFR Parts 1904, 1910, and 1926. These regulations are potential ARARs at the Olin site. Depending on the remedial action implemented at the site, air contaminant standards (29 CFR 1910) and/or construction industry standards (29 CFR 1926) may come into force. These standards regulate employee exposure to air contaminants and provide standards for equipment handling and personal protection.

2.2.2.4 To Be Considered

TBCs consist of nonenforceable federal and state guidance, criteria, advisories, etc. These are not ARARs but provide enough relevant information such as risk levels, reference doses, etc. to enable them to be used as protective guidelines in the absence of ARARs to develop cleanup goals. Potential TBCs for the Olin, McIntosh site are listed below. Table 2-4 provides more detail for the TBCs that were considered most significant for developing and evaluating the remedial actions.

- Safe Drinking Water Act
  - 40 CFR Part 143, National Secondary Drinking Water Regulations
  - 40 CFR Part 141, Subpart F, MCLGs
- Alabama Secondary Drinking Water Standards (Alabama Administrative Code, Department of Environmental Management,

Water Division-Water Supply Program, Chapter 335-7-3-Secondary Drinking Water Standards; adopted January 4, 1989).

- Health Effects Assessments (HEAs)
- Recommended Maximum Concentration Limits (RMCLs)
- Action Levels for Poisonous or Deleterious Substances in Human Food and Animal Feed (Title 21, CFR Parts 109 and 509)
- Federal Sole Source Aquifer Requirements
- Public Health Basis for the Decision to List Pollutants as Hazardous Waste under the Clean Air Act (Section 112)
- EPA's Groundwater Protection Strategy
- TSCA Health Data
- Fish and Wildlife Coordination Act (16 USC 661)
- Fish and Wildlife Improvement Act of 1978, and Fish and Wildlife Act of 1956 (16 USC 742a)
- Fish and Wildlife Conservation Act of 1980 (16 USC 2901 generally 50 CFR Part 83)
- Advisories issued by the Fish and Wildlife Service (FWS) and National Wildlife and Fisheries Service (NWFS) under the Fish and Wildlife Coordination Act
- Rivers and Harbors Act of 1899
- National Flood Insurance Act of 1968

- National Institute of Occupational Safety and Health (NIOSH) or Equivalent Recommended Exposure Limits (RELs)

- American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs)

- Health Advisories, EPA Office of Water

- Water Quality Guidance Documents

  - Water-Related Environmental Fate of 129 Priority Pollutants
  - Water Quality Standards Handbook (1983)
  - Technical Support Document for Water Quality-Based Toxics Control

- Drinking Water - National Research Council SNARLS (Safe Drinking Water Committee, Drinking Water and Health, Washington: National Academy of Sciences, 1977)

- Preliminary Protective Concentration Limits (for 40 CFR 261 Appendix VIII "Hazardous Constituents")

- Office of Solid Waste and Emergency Response Directive 9355.0-28 related to control of air emissions from air strippers (is to be considered for remedial actions that utilize air stripping technology)

2.2.3 Potential Soil Action Levels

The fate and transport analysis described in Section 1.4, provides an evaluation of the potential effects on groundwater for the SWMUs/AOCs that were sampled during Phase III. The criteria to judge whether the effects on groundwater are significant is the MCL, i.e., whether contaminant migration from a SWMU/AOC would cause otherwise uncontaminated groundwater to exceed MCLs at the SWMU boundary. The analysis was conservatively conducted by assuming that the source concentration was the

maximum concentration detected in the soils. In cases where site-specific leachate test (TCLP) data were available, the maximum concentration from the TCLP extract was assumed to be the leachate concentration at the source. The following table summarizes the list of SWMUs/AOCs that were evaluated and judged not to be continuing sources of groundwater contamination. The groundwater chemical of potential concern and associated soil concentration used for the analysis is also provided.

SWMU/AOC	Constituent	Source Concentration (mg/kg)
Sanitary Landfill	Chlorobenzene	5.7
	1,2-Dichlorobenzene	2.4
	1,3-Dichlorobenzene	1.0
	1,4-Dichlorobenzene	1.8
	1,2,4-Trichlorobenzene	7.4
	Mercury	27.1[1]
	Lead	62.5
	Selenium	2.2
Lime Ponds	Mercury	1.3[1]
Mercury Cell Plant	Mercury	164[1]
Old Plant Landfill Drainage Ditch	Mercury	10.2[2]
Strong Brine Pond	Mercury	NA[3]
Well Sand Residue Area	Mercury	20.1[1]

NOTES:

1 The concentration in the TCLP extract from the sample with this total soil concentration was used as the leachate concentration at the source.

2 Since the old plant landfill drainage ditch soils are not in a defined area. A quantifiable fate and transport analysis to assess potential impact on groundwater was not performed; however, the potential is judged to be low based on the concentrations. The drainage ditch soils will be considered with the old plant (CPC) landfill remedial alternatives.

3 As stated in the Phase III SAP, the soil samples from the strong brine pond were only analyzed for TCLP mercury. The maximum TCLP extract concentration of 30 $\mu g/l$ mercury was used as the leachate concentration at the source in the fate and transport analysis.

The analytical data indicated the potential for the old plant (CPC) landfill and to a lesser extent, the area west of the former CPC plant to be continuing sources of

groundwater contamination. An analysis was conducted to develop conservative potential soil action levels (PSALs) for these two areas. These soil action levels were developed such that the concentration of leachate percolating through the soils to the groundwater would not cause exceedances of the potential applicable or relevant and appropriate requirements (ARARs) for groundwater. The Safe Drinking Water Act maximum contaminant levels (MCLs) and non-zero maximum contaminant level goals (MCLGs) have been identified as potential ARARs for groundwater at the site. In the analysis, conservative assumptions were made such that the soil action levels developed were lower than levels required to protect groundwater. A report documenting the development of the PSALs including the input and output data from the computer model is presented in Appendix F. This section summarizes the technical approach and the results.

Potential Soil Action Level Constituents

Table 1-10 lists the groundwater chemicals of potential concern from the baseline risk assessment (WCC, 1993). PSALs were evaluated for a subset of this list based on the relative concentrations in the soils and the fate and transport properties of the chemicals. The following table summarizes the constituents for which soil action levels were developed and their respective MCLs.

Soil Action Level Constituents	MCL (µg/l)
Benzene	5.0
Chlorobenzene	100
1,2,4-Trichlorobenzene	70
1,2-Dichlorobenzene	600
1,3-Dichlorobenzene	600
1,4-Dichlorobenzene	75
Mercury[1]	2.0

NOTES:

[1] PSALs for mercury were developed only for the old plant (CPC) landfill area because mercury was not detected in the soils west of the former CPC plant.

Technical Approach

PSALs were developed using the following four steps: 1) estimation of a concentration reduction factor (CRF) due to migration of potential groundwater chemicals of concern through the unsaturated zone; 2) estimation of a concentration reduction factor due to near-field mixing of constituents in the Alluvial Aquifer; 3) back-calculation of allowable leachate concentrations using the values obtained in steps 1 and 2 and the groundwater MCLs; and 4) estimation of PSALs based on the estimated allowable leachate concentrations, chemical-specific factors and soil properties.

The general approach used is that rainwater percolating through a source (soil containing contaminants) would generate leachate by partitioning of the contaminants from the soil to the water. Soil action levels are theoretical soil concentrations at the source that would generate leachate with concentrations sufficient to cause exceedances of the groundwater MCLs. The analyses were conducted for two source intervals in the old plant (CPC) landfill and PSALs were developed separately for each interval. The upper source interval, a combination of the fill/waste and clay, includes the upper 23 feet of soil. The lower source interval was designated as the unsaturated sand directly above the Alluvial Aquifer. The contaminated materials in the upper 14 feet (i.e., 4 to 14 feet) were considered the source for the former CPC plant area.

Two one-dimensional, publicly available contaminant transport models were used to estimate concentration reduction factors for migration through the unsaturated zone, and the results were compared. Models are useful tools to study the effect of variations in the wide range of soil and chemical properties specific to an area. Model results should be interpreted by qualified professionals familiar with site-specific factors. Using two models provided additional insight on the validity of the analyses. The models, PESTAN (CSMS, 1992) and SOLUTE (IGWMC, 1991), consider advection, longitudinal dispersion, linear adsorption and natural decay (e.g., biodegradation) through the soil column. The source concentration for SOLUTE was selected as unity and the concentration at the top of the aquifer was expressed as a fraction of the source concentration. For PESTAN, the concentration in the leachate at the source was estimated to be the chemical-specific aqueous solubility and the model estimated the resulting concentrations at the base of the unsaturated zone.

In addition to estimating the attenuation in the unsaturated zone using the SOLUTE and PESTAN models, a mass balance equation/model was used to estimate the reduction in concentrations due to the near-field mixing of the contaminants in the Alluvial Aquifer. This analysis is equivalent to the Summers model (Summers et al., 1980).

The unsaturated zone transport analyses and near-field mixing were used in combination with the allowable concentrations in the groundwater (MCLs) to back-calculate the PSALs. The relationships between soil and liquid concentrations were calculated from chemical-specific sorption coefficients (Kd), dimensionless Henry's Law constant (H) and soil-specific properties.

Soil action levels for the unsaturated sand in the old plant (CPC) landfill area were estimated with the Summers model approach considering only near-field mixing of contaminants within the Alluvial Aquifer (i.e., no attenuation in the unsaturated zone). This is a very conservative approach and would only be applicable for the sand directly above the Alluvial Aquifer.

Tables 2-8 and 2-9 summarize the PSALs for the old plant (CPC) landfill and the area west of the former CPC plant, respectively[1]. These tables also provide recommended PSALs based on the modeling results and site conditions. The Summers model results produced PSALs that were lower than the other two models because the Summers model does not account for any attenuation in the unsaturated zone. As stated, the soil action levels from the Summers model are applicable only for the sands directly above the water table in the old plant CPC landfill area. PESTAN (without biodegradation) typically produced PSALs that were lower than SOLUTE's because of PESTAN's assumption of instantaneous equilibrium (see paragraph below). The range of values from the PESTAN and SOLUTE models were used to develop PSALs in the fill/waste

[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

and clay material in the old plant (CPC) landfill and the clay/upper sand west of the former CPC plant.

The PSALs from the PESTAN model (without biodegradation) are considered to be biased low due to the assumptions used in the model relative to actual site conditions. The PESTAN model assumes that the source area leaches at the chemical-specific aqueous solubility and that equilibrium between the soil and water is reached instantaneously as rainfall percolates through the soil column. The SOLUTE model uses a more technically rigorous approach by calculating leachate concentrations at the source from the sorption coefficient, which is based on chemical-specific factors and soil properties and is considered to more accurately simulate site conditions.

Biodegradation is an important attenuation mechanism and should be considered for development of PSALs, particularly for constituents such as benzene and chlorobenzene with relatively short half lives. The biodegradation rate is dependent on the physical and chemical conditions of the soil and the contaminant concentrations, and therefore would vary both spatially and temporally. Site-specific biodegradation data were not available, so the selected degradation rates used in the models were from the literature. The literature values were commonly developed from experiments that were conducted under controlled conditions that may be more favorable to biodegradation than conditions at the site. The approach for the modelling was to use conservative biodegradation rates based on these literature values and apply a safety factor of 50.

When these degradation rates were input in the SOLUTE model, the model predicted complete or near complete degradation of the organic constituents in the unsaturated zone. The site groundwater data indicate that this has not been the case in the past, particularly for constituents detected more frequently in the groundwater such as chlorobenzene and 1,4-dichlorobenzene. The results from the PESTAN model with biodegradation did allow calculation of PSALs for most of the constituents.

As stated above, the PSALs produced by the PESTAN model (without biodegradation) were considered biased low due to the method in which the leachate concentration is estimated. Further, the SOLUTE results with biodegradation are not considered appropriate considering the site conditions. Therefore, the recommended soil action

values were selected between the values from SOLUTE, without biodegradation, and those from PESTAN with biodegradation. In some cases, the specific values selected within this range were determined based on comparing the mass in the source areas to the allowable mass based on the PESTAN model (without biodegradation) (see Appendix F). Comparison of these mass calculations provides an indication of the safety factor for each model result without considering biodegradation. The larger the safety factor, the more weight was placed on the results from PESTAN with biodegradation in selecting the recommended PSALs. For example, the recommended PSALs are close to the SOLUTE results (i.e., are on the low end of the range and only minimal biodegradation is considered) for constituents for which calculations of actual mass values present were close to those that the PESTAN model predicted would be required to cause exceedances of MCLs. This specific reasoning for each recommended PSAL is noted in Tables 2-8 and 2-9.

2.2.4 Sediment Quality Criteria/Standards

Sediment criteria or quality standards are not available for developing sediment PRGs. Numerous factors other than the bulk sediment concentrations can influence potential effects on the environment. These include the chemical form of the contaminant; synergistic effects involving other constituents; structural and physiological attributes of the exposed biotic populations and communities; the physical stability of the sediment matrix; various aspects of sediment chemistry (e.g., redox potential, organic carbon content, sulfide content); and various aspects of water quality (e.g., temperature, salinity, pH, hardness). It is therefore the consensus of the relevant literature and experts from the regulatory and scientific communities that absolute values for sediment cleanup criteria for specific constituents of concern are not appropriate and that flexible approaches are more applicable (Chapman, 1989; Fitchko, 1989; Marcus, 1991). While they do not agree on any specific, formal criteria, most authorities concur that the approach selected must simultaneously address a complex set of site-specific, interacting biological, toxicological, geochemical, and economic considerations.

A variety of methods is currently under evaluation by the EPA Scientific Advisory Board (SAB) to develop sediment criteria. All of the methods under consideration have strengths and weaknesses, and it is evident that substantial further research is needed

before scientifically defensible criteria can be promulgated. In the absence of criteria, Olin's approach is to develop a set of remedial action alternatives and subject each to systematic analysis (Section 4.0). Each of the alternatives was evaluated for effectiveness in meeting general remedial goals; reduction in toxicity, mobility, and/or volume; implementability; compliance with ARARs; protectiveness of the environment; and costs. Consideration of these selection factors will ensure that the selected alternative provides a practicable (implementable) and cost-effective remedial strategy which is sufficiently protective of the environment.

2.2.5 Summary of Preliminary Remediation Goals

Preliminary remediation goals (PRGs) for potentially affected media were developed from the results of the baseline risk assessment and the use of potential chemical-specific ARARs. These PRGs were used to define the media that may require remedial action.

OU-1 Groundwater

The groundwater remedial action objective for human health protection is to prevent ingestion/direct contact with groundwater having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent further degradation of the aquifer and restore groundwater quality to appropriate ARARs.

The baseline risk assessment indicated that the calculated exposure to groundwater for all current and future likely exposure pathways shown in Table 2-2 does not exceed the risk-based RAOs. Table 2-3 provides risk-based PRGs based on exposure to the hypothetical future resident (child). As discussed in Section 1.5, Olin believes that this is a very unlikely receptor population because the potential for portions of the site to become residential is virtually nonexistent. The PRGs are therefore based on restoration of the Alluvial Aquifer to the appropriate ARARs rather than risk-based criteria. The Safe Drinking Water Act MCLs and non-zero MCLGs are potential ARARs because the Alluvial Aquifer is a current or potential groundwater source. The

numerical values for these standards are summarized in Table 2-5. The legally enforceable groundwater cleanup standards (which are based on MCLs) that have been established at the site for the ongoing RCRA corrective action program are potential ARARs.

Discontinuing the CAP after meeting the MCLs may allow some groundwater that is currently being captured by the CAP to discharge to surface water. Appendix A provides the results of an analysis to evaluate the theoretical concentrations that would eventually discharge to surface water after MCLs are achieved and the CAP is discontinued. One-dimensional transport through the Alluvial Aquifer was simulated using the publicly available analytical model SOLUTE (IGWMC, 1991). Monitor well PL10S is the RCRA compliance well located closest to a potential surface water discharge location (the Tombigbee River). The analysis was therefore conducted for migration from the eastern edge of the mercury plume in the vicinity of PL10S to the river. The analysis was performed for mercury because mercury was judged to have the greatest potential to exceed the AWQC (See Appendix A). It was assumed that the concentration in the Alluvial Aquifer was at the MCL (2.0 μg/l) and that all the mercury was contained within the current limits of the plume (> 2.0 μg/l as shown on Figure 1-14). The model was used to predict the theoretical maximum concentration at the discharge point. This predicted maximum concentration was then compared to the federal AWQC, chronic criteria for fresh water aquatic life (0.012 μq/l). The modeling results indicated that the highest mercury concentration in the groundwater discharging from the Alluvial Aquifer to the Tombigbee River would be 0.00005 μg/l after about 660 years. The purpose of the modeling was to evaluate the potential need for additional monitoring and contingency measures for protection of surface water to be implemented after MCLs are achieved and the CAP wells are turned off. Based on these results, no additional measures are included in this FS (beyond the monitoring that is required by RCRA). It is recognized however, that prior to discontinuing the CAP further consideration will have to be given to the potential effects on the ecosystem from site groundwater discharging into surface water.

OU-1 Surface Water

The surface water remedial action objective for human health protection is to prevent ingestion/direct contact with surface water having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent contamination in excess of surface water ARARs.

No complete exposure pathways were identified by the baseline risk assessment for human health exposure to OU-1 surface water. The preliminary remediation goal is therefore based on the ARARs. OU-1 discharges are routed either through the existing NPDES system or through areas sampled for Olin's storm water discharge permit. The standards established by NPDES regulations at the wastewater ditch outfall are the appropriate ARARs for OU-1 surface water. The NPDES permit limits are based on the Alabama water quality standards for the receiving water, which is the Tombigbee River. Olin continues to meet their NPDES limits as documented by their ongoing surface water monitoring programs and no remedial action of OU-1 surface water is required. Therefore, PRGs were not developed for OU-1 surface water.

OU-1 Air/Dust Emissions

The human health air/dust emissions remedial action objective is to prevent ingestion/direct contact with contaminated dust from the site having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent the release of contaminated dust where it can be carried by wind to nearby receptors whereby exposure may occur through food ingestion pathways.

The complete exposure pathways for air/dust emissions from OU-1 soils and groundwater were evaluated in the baseline risk assessment as shown on Table 2-2. None of the pathways showed contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a hazard index greater than 1. No chemical-specific ARARs were identified for air. Therefore, PRGs for air/dust emissions were not

developed. The assembled soil remedial alternatives were evaluated for maintaining protection from air/dust emission hazards.

OU-1 Soil

The OU-1 soil remedial action objective for human health protection is to prevent ingestion/direct contact with soils having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a hazard index greater than 1. The environmental protection remedial action objective is to prevent migration of contaminants that would result in groundwater contamination in excess of groundwater remediation goals.

The OU-1 soil exposure pathways (including those from air/dust emissions) and the corresponding carcinogenic cancer risks and noncarcinogenic hazard indices are summarized below:

Receptor	Pathway	Reasonable Maximum Exposure	
		Excess Lifetime Cancer Risk	Chronic H.I.
Adult Resident/Trespasser	Particulate Inhalation	2.25×10^{-10}	1.27×10^{-4}
Adolescent Resident/Trespasser	Particulate Inhalation	2.25×10^{-10}	1.27×10^{-4}
Industrial Worker	Surface Soil/Dermal Surface Soil/Injection Particulate Inhalation	6.26×10^{-8} 1.57×10^{-7} 4.46×10^{-11}	1.21×10^{-3} 2.71×10^{-2} 3.02×10^{-5}
Adult Hypothetical Future Resident[2]	Surface Soil/Dermal Surface Soil/Injection Particulate Inhalation	2.63×10^{-6} 1.05×10^{-6} 2.25×10^{-10}	3.79×10^{-1} 1.69×10^{-2} 1.27×10^{-4}
Child Hypothetical Future Resident[2]	Surface Soil/Dermal Surface Soil/Injection Particulate Inhalation	8.62×10^{-6} 8.36×10^{-7} 2.83×10^{-10}	1.87 2.01×10^{-2} 2.40×10^{-4}

The baseline risk assessment showed that the cumulative cancer risk and hazard index from the complete exposure pathways related to ingestion, direct contact and inhalation of OU-1 soil for the industrial worker and the resident/trespasser do not exceed the

[2] Olin asserts future residential use is unlikely. See Section 2.2.1 for discussion.

risk-based RAOs. A PRG was calculated for mercury based on the hypothetical future OU-1 resident (child) exposure to surface soils (Table 2-3) because the calculated noncarcinogenic hazard index was 1.87, which is greater than the risk-based RAO of 1.0. It is Olin's position that the hypothetical on-site resident is a very unlikely receptor and PRGs from Table 2-3 are therefore very conservative.

The conservative fate and transport analyses described in Section 1.4 are the bases for determining which SWMU/AOC may require remedial action to meet the environmental protection RAO, which is to prevent migration of contaminants that would result in groundwater contamination in excess of groundwater remediation goals. The analyses were conducted to assess whether contaminant migration from a SWMU/AOC would cause otherwise uncontaminated groundwater to exceed the MCLs at the SWMU/AOC boundary. Two areas were evaluated further (the old plant (CPC) landfill and the area west of the former CPC plant), and PRGs (i.e., PSALs) were developed for these two areas. The assembled remedial alternatives were for current and future protection of groundwater, with consideration given to the alternative's protectiveness against direct contact, ingestion and inhalation hazards.

Appropriate remedial alternatives were assembled for the old plant landfill drainage ditch, the lime ponds, the sanitary landfills, the mercury cell plant, and the well sand residue area to provide protection to human health and the environment. The soils within these SWMUs/AOCs contain hazardous constituents. The RI data indicate that these SWMUs/AOCs are not direct contact, ingestion or inhalation hazards based on the OU-1 soil exposure pathways expressed in the baseline risk assessment. The fate and transport analysis (Section 1.4) indicates that they are not continuing sources of groundwater contamination when judged by their effect on groundwater relative to MCLs. The objective for these SWMUs/AOCs is to assemble appropriate alternatives that ensure that conditions remain protective (i.e., the RAOs would not be exceeded) under reasonable future conditions.

OU-2 Sediments

The OU-2 sediment remedial action objective for human health protection is to prevent direct contact with sediments having contaminant concentrations with a cumulative

cancer risk of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent contaminant releases from the ditch and basin sediments that would cause exceedances of surface water remediation goals or fish and game health-based standards or action levels.

The baseline risk assessment indicated that the calculated exposure to OU-2 sediments does not exceed the risk-based RAOs as shown in Table 2-2. The preliminary remediation goals therefore are based on ARARs and preventing exceedances of fish and game health-based standards or action levels. As discussed in Section 2.2.3, numerical cleanup criteria for the sediments have not been established because there are no generally accepted regulatory criteria, and bulk sediment concentrations do not correlate well with the availability of contaminants to fish and other biota. Therefore, rather than defining a cleanup level, a range of alternatives including monitoring, removal and capping actions was considered.

OU-2 Surface Water

The OU-2 surface water remedial action objective is to prevent ingestion/direct contact with surface water having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent contamination in excess of surface water remediation goals and prevent contaminant releases from surface water that cause exceedances of fish and game health-based standards or action levels.

The baseline risk assessment indicated that there is not a significant human-health exposure risk to OU-2 surface water. The preliminary remediation goals are therefore based on the ARARs and preventing exceedances of fish and game health-based standards or action levels. The federal water quality criteria and Alabama water quality standards listed in Table 2-6 are potential ARARs for surface water in the basin and the former discharge ditch. The NPDES permit limits, which are based on the Alabama water quality standards for the receiving water (the Tombigbee River) are potential ARARs for surface water in the wastewater ditch. The assembled sediment remedial alternatives were evaluated for effectiveness at meeting the surface water RAOs. However, compliance with these criteria may be technically impracticable from an

engineering perspective without total disruption or modification of the ecosystem. Compliance with the surface water ARARs is discussed in more detail in the detailed analysis of alternatives (Section 4.0).

OU-2 Fish and Game

The fish and game remedial action objective for protection of human health is to prevent contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent ingestion of contaminated fish and game by higher trophic levels that would exceed fish and game health-based standards or action levels.

As discussed in Section 1.6, over 90 percent of the calculated risk to off-site residents/trespassers that was identified in the baseline risk assessment was from fish ingestion. Approximately two-thirds of the calculated risk was from non-Olin contaminants (i.e., the DDT residues). However, the total excess lifetime cancer risks and hazard indexes were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risks and 1.0 hazard index). The assembled sediment remedial actions were evaluated for effectiveness at reducing long-term constituent concentrations in fish. The FDA action levels, which are listed as TBCs in Table 2-7, are potential preliminary remediation goals.

OU-2 Air Dust Emissions

The human health air/dust emissions RAO is to prevent ingestion/direct contact with contaminated dust from the site having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1. The environmental protection remedial action objective is to prevent the release of contaminated dust to be carried by wind to nearby receptors where exposure may occur through food ingestion pathways.

The complete exposure pathways for air/dust emissions from OU-2 sediment and soils and OU-2 surface water were evaluated in the baseline risk assessment, as shown on

Table 2-2. None of the OU-2 airborne exposure pathways showed contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a hazard index greater than 1. No chemical-specific ARARs were identified for air.

Summary

To meet the PRGs that were described above, remedial alternatives were considered for OU-1 groundwater, OU-1 soils and OU-2 sediments. The OU-1 groundwater remedial alternatives would be for restoration of groundwater to the appropriate ARARs. For OU-1 soils, the remedial alternatives would be to reduce contaminant migration from the soils to the groundwater and continued protection from direct contact, ingestion and inhalation of contaminated soils. Remedial alternatives for OU-2 sediments would be to reduce exposure of fish and other biota to contaminants and to meet the surface water PRGs.

2.3 GENERAL RESPONSE ACTIONS

General response actions (GRAs) are broad classes of actions or remedies that would satisfy the remedial action objectives. The technology types and process options that were used to develop the potential remedial alternatives fall within these broad classes. General response actions are presented in this section for OU-1 groundwater, OU-1 soils and OU-1 sediments. Area and volume estimates for these media are also presented.

2.3.1 OU-1 Groundwater

The following summarizes the basic findings of the remedial investigation that were used to develop OU-1 groundwater general response actions and evaluate groundwater technologies and process options.

- The Alluvial Aquifer has been affected above the preliminary remediation goals and is currently being remediated. The existing RCRA corrective action program, which is required by Olin's post-

closure permit, is effective at controlling and recovering groundwater migrating from any known, past or current sources.

- The focus for this FS relative to OU-1 groundwater is on technologies designed to accelerate the reduction of contaminants. Technologies were also screened to address a potential secondary source, the mercury-containing brine in the weak brine pond area.

- The Alluvial Aquifer is generally unconfined, is composed primarily of sands, and varies in thickness from about 55 to 80 feet in the plant area, thinning to less than 40 feet at locations in the west plant area. In the vicinity of the site, the hydraulic conductivity is estimated to be between 4.0 ft/day and 578 ft/day, and the specific yield is estimated to be 0.20.

- The primary constituents in the groundwater include mercury, chloroform, chlorobenzene and the dichlorobenzene isomers. (Table 1-6 summarizes the constituents detected in the Alluvial Aquifer samples). Total dissolved solids (TDS), primarily chlorides, may also have to be addressed for implementation of the selected treatment technologies and process options.

Figures 1-14 and 1-15 depict the estimated areal extents of mercury and organics in groundwater, respectively. For the purpose of volume calculations, mercury concentrations above the MCL of 2.0 μg/l (the MCL) were used to define the areal extent of affected groundwater, and 50 feet was used as the estimated saturated thickness of the Alluvial Aquifer. Assuming a porosity of 0.30 (Driscoll, 1986), the volume of water in the Alluvial Aquifer to be considered for remediation is approximately 1 x 10^9 gallons. The groundwater volume calculations are discussed in more detail in Section 1.2.4. It should be noted that this estimated in situ volume of affected groundwater is provided for the purpose of screening the technologies and does not represent the total volume of water that would have to be extracted and treated.

The following general response actions have been developed for OU-1 groundwater.

- No Action, which consists of leaving the facility "as is," with no increase in the present level of groundwater cleanup. It should be noted that the current groundwater remediation activities, which are required by the RCRA corrective action program, would be continued under a no-action scenario.

- Institutional Controls, which involve the creation and implementation of mechanisms, both physical and legal, that restrict public and environmental contact with the contaminants without addressing actual remediation of the contamination. Typical institutional controls for groundwater include deed restrictions on groundwater usage, alternative water supplies, and groundwater monitoring.

- Containment, which involves physical restrictions on horizontal and vertical groundwater flow, contaminant mobility and surface infiltration.

- Removal, which involves the physical reduction of contamination through extraction of the groundwater.

- Treatment, which involves on-site, off-site and/or in situ measures to reduce toxicity, mobility and/or volume of the contamination.

- Disposal, which involves discarding contaminated and/or treated groundwater in an approved manner and at an approved site (either on- or off-site).

2.3.2 OU-1 Soils

Preliminary remediation goals (i.e., PSALs) were developed for the old plant (CPC) landfill and the area west of the former CPC plant as described in Section 2.2.3. The RI data and the evaluation in this report (see Sections 1.4 and 1.5) indicate that soils contained within the other SWMUs/AOCs that were sampled for the RI currently meet the RAOs. However, appropriate remedial alternatives to address continuing

compliance with RAOs were assembled for the old plant landfill drainage ditch, the lime ponds, the sanitary landfills, the mercury cell plant and the well sand residue area. The objective was to assemble remedial alternatives to ensure that conditions remain protective.

The basic findings from the RI report that were used to develop general response actions and to evaluate technologies and process options for OU-1 soils are summarized in Sections 2.3.2.1 through 2.3.2.7. More details regarding each of the SWMUs/AOCs sampled for the RI are provided in Section 1.3. The OU-1 soil general response actions are listed in Section 2.3.2.8.

2.3.2.1 Old Plant (CPC) Landfill

The site of the old plant (CPC) landfill was utilized from 1954 until 1972 to neutralize acidic wastewater from CPC plant operations. From 1972 to 1977, the site was used for disposal of general plant debris such as paper, cardboard, wood, small metal containers, scrap plastic and rubber items from the entire plant. The landfill also received organic wastes from the CPC plant. In 1977, prior to RCRA, the landfill was closed with a clay cap, topsoil, and grass, as approved by the ADEM. The cap was upgraded in 1984 to address erosion problems that had occurred.

The Phase III sampling indicated the following characteristics for the old plant (CPC) landfill:

- The material in the landfill (about 4 to 12 feet thick) was characterized as silty clay fill that contains the residue of waste. Shell, rock and wood fragments were encountered, and at one location the landfill material consisted of about six feet of a lime substance. The organic compounds detected in the fill/waste material are predominantly chlorinated benzenes, as summarized in Table 1-2. Based on the Phase III analytical results, the fill/waste zone generally contains less than 0.1 percent chlorinated organics.

- Saturation at the base of the fill/waste zone was apparent in three of the four borings. At one location, an approximate 9-foot layer of loose, saturated silt/clay, with little or no apparent strength, was encountered beneath the fill/waste material. The results of an analysis of this silt/clay were similar to the fill/waste analytical results, except that benzene, which was not found in the fill/waste, was detected in the loose, saturated silt/clay at 2.4 mg/kg (See Table 1-3). A resistivity survey (Appendix C) indicated that the maximum thickness of this zone is in the northwest portion of the landfill and the zone is interpreted to be absent in the southeast corner.

- A stiff, gray, red and brown clay ranging from 3 to 17 feet thick was encountered beneath the fill/waste and saturated zones. Analyses of samples from the base of the clay indicated that volatile organic compounds (acetone, benzene, chlorobenzene and chloroform) were more common in the clay than in the overlying fill/waste material. The target semivolatile chlorinated benzenes were reported (at concentrations up to 74 mg/kg) in clay samples from the two western borings and were not reported in the clay samples from the two eastern borings.

- The TCL organics detected in the sands underlying the clay layer included benzene, chlorobenzene, the dichlorobenzene isomers, chloroform, benzene, 1,1,1-trichloroethane, 1,2,4,5-tetrachlorobenzene, 1,2,4-trichlorobenzene, hexachlorobenzene, and phenol. Similar to the data from the clay samples, there were distinct lateral variations in the reported concentrations in the Alluvial Aquifer, with greater concentrations in the western borings than in the eastern borings.

- Mercury was detected in three of the four landfill fill/waste samples, at concentrations ranging from 21.7 mg/kg to 406 mg/kg. A low mercury concentration (0.42 mg/kg) was reported in the loose silt/clay sample. Mercury was found in only one of the five clay samples, at a

concentration of 0.62 mg/kg, and was not detected in any of the eight Alluvial Aquifer samples.

The fate and transport analysis described in Section 1.4 indicates that the old plant (CPC) landfill is a potential continuing source of groundwater contamination. The recommended PSALs (Table 2-8) were exceeded for mercury in two of the soil samples from the fill/waste zone and for 1,4-dichlorobenzene in one soil sample from the top of the unsaturated sand (20 to 22 feet), near the contact with the overlying clay. The analysis shows that contamination above the recommended PSALs is very is localized, and the probable source is material underlying the fill/waste zone in the western portion of the landfill.

Figure 2-1 shows the existing conditions in the old plant (CPC) landfill area. For the purpose of screening the technologies and developing remedial alternatives, the in-place volume of affected material in the old plant (CPC) landfill was assumed to be 67,000 cubic yards. This volume was calculated based on a landfill size of 300 x 400 x 15 feet deep. The 15-foot depth would encompass all of the fill/waste material and is a reasonable limit for excavation of the soils with conventional excavation equipment. The old plant (CPC) landfill is bordered by a building to the south, an active railroad track adjacent to the west, and a plant drainage ditch adjacent to the north. These physical barriers would render the excavation of the landfill difficult, thereby limiting the excavation depths. The actual limits to the excavation of the landfill would have to be evaluated during the design phase. Additional remedial actions to reduce contaminant migration below 15 feet (15 to 23 feet bgs) were also evaluated. A depth of 23 feet was selected based on the 20- to 22-foot sample from BOP4 where the recommended PSAL for 1,4-dichlorobenzene was exceeded. This depth is also near the contact between the clay and underlying unsaturated sand above the Alluvial Aquifer. Because the volumes are not well-defined, the effects of volume variations on the cost of potential remedial alternatives is presented in Appendix G

The landfill area is capped, so ingestion, direct contact and inhalation of contaminated soils are not considered complete exposure pathways. Remedial alternatives assembled for the old plant (CPC) landfill are primarily for protection of groundwater, with

consideration given to ensuring continued protection from the ingestion, inhalation and direct contact pathways.

2.3.2.2 Area West of the Former CPC Plant

The soils in the CPC plant area consist of 10 to 12 feet of clay overlying unsaturated sands and silts above the Alluvial Aquifer. Groundwater is generally more than 30 feet below ground surface. The two primary organic constituents detected in the clay soils west of the CPC plant were 1,2,4- trichlorobenzene (1.3 mg/kg to 700 mg/kg) and 1,2,4,5-tetrachlorobenzene (0.74 to 750 mg/kg) (See Table 1-4). Additional chlorinated benzenes (mono-, di-, and hexa-) were also detected above a concentration of 1.0 mg/kg. The area is adjacent to the former railroad loading/unloading area, where tetrachlorobenzene was unloaded for use in the production of PCNB. Figure 2-2 shows the former unloading area, which was a triangular area bounded on the north by a railroad spur, on the southwest by a road that is elevated above natural grade, and on the east by a concrete curb of the storage tank area. Any spills would have been contained by these physical features. Therefore, the area depicted in Figure 2-2 (approximately 15,000 square feet) is used to define the lateral extent of contamination resulting from the unloading operations.

The estimated volume used to develop remedial alternatives is 8,000 cubic yards. This volume is based on a 15,000-square-foot area 14 feet deep. Fourteen feet was selected as a conservative estimated thickness of the upper clay layer in the area, assuming any remedial action requiring excavation or in situ treatment would address the entire thickness of this clay.

Remedial alternatives were assembled for the area west of the former CPC plant, primarily for protection of groundwater[1] although the calculated PSALs are above the soil concentrations detected in the soils west of the former CPC plant (see Table 2-9).

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[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater.

The alternatives were also evaluated for protection from hazards related to ingestion, inhalation and direct contact to contaminated soils.

2.3.2.3 Old Plant Landfill Drainage Ditch

The old plant landfill drainage ditch is a former ditch from the old plant (CPC) landfill (when it was used as an acidic wastewater neutralization pond) to the wastewater ditch. Sampling was conducted in the area believed to be the location of the former ditch, but there has been extensive earth work in the area associated with the closure of the old plant (CPC) landfill and there is no longer any surface remnant of the ditch. Hexachlorobenzene (5.6 mg/kg and 2.7 mg/kg) and mercury (0.95 mg/kg and 10.2 mg/kg) were detected in the two old plant landfill drainage ditch samples. It is estimated that the ditch was about 300 linear feet. The soils from the area are believed to be the location of this former ditch and will be included with the old plant (CPC) landfill remedial alternatives. For the purpose of developing remedial alternatives, 1,100 cubic yards of soil from a 20-foot-wide, 5-foot-deep area were considered.

The old plant landfill drainage ditch is not considered a continuing source of groundwater contamination. However, the drainage ditch will be included in the old plant (CPC) landfill alternatives, which were assembled primarily for protection of groundwater. The assembled alternatives were also evaluated for protection from hazards related to ingestion, direct contact and inhalation of the drainage ditch soils.

2.3.2.4 Sanitary Landfills

The sanitary landfills were operated between 1977 and 1984 and received general nonhazardous waste and plant refuse. Records show that waste disposed of in the two sanitary landfills included paper, glass, boxes, wood, plastic, grass clippings, pipe, concrete, and sanitary sludge.

The material encountered in the landfill during the Phase III sampling was generally described as silty clay fill with rocks, wood and shell. Chemical analyses of three sanitary landfill samples indicated the following:

- Hexachlorobenzene concentrations in the three samples ranged from 9.5 mg/kg to 44 mg/kg. Mercury concentrations ranged from 7.8 to 27.1 mg/kg; mercury was not detected in the TCLP extract from any of the sanitary landfill samples. Chlorobenzene, 1,2,4,5-tetrachlorobenzene, 1,2,4-trichlorobenzene, 1,4-dichlorobenzene, and 1,3-dichlorobenzene were detected at < 10 mg/kg in all three samples. Pentachlorobenzene and pentachloronitrobenzene were tentatively identified in the sanitary landfill samples at estimated concentrations ranging from 1.0 mg/kg to 3.6 mg/kg for pentachlorobenzene and 0.16 mg/kg to 31 mg/kg for pentachloronitrobenzene.

- Polynuclear aromatic (PNA) compounds (e.g., fluoranthene, phenanthrene, fluorene, etc.) and other compounds commonly associated with woodtreating products or coal tars were detected in two of the sanitary landfill samples at concentrations up to 4.6 mg/kg (for phenanthrene). Most values were reported as less than 1.0 mg/kg.

- Considering analytical variability and natural variations in soils, the results indicate that TAL analytes (other than mercury) in the sanitary landfill samples are generally within a range commonly found for naturally occurring soils. Lead was detected in one sample at 62.5 mg/kg (estimated), which may be elevated above area background concentrations.

The first sanitary landfill unit was approximately 150 x 200 feet and contained about 4,000 cubic yards of material. The second unit was approximately 600 x 800 feet and contained about 18,000 cubic yards of material. The landfill operational plan indicates that the landfill cells were constructed 6 feet deep by 12 feet wide by 50 feet long. The two landfills were constructed adjacent to each other and there is no discernable boundary between them. Both units were closed in 1984 with a clay cap and vegetative cover under the state of Alabama solid waste management regulations that existed at the time of closure. The sanitary landfills comprise an area of about 12 acres in a relatively remote area of the facility. Based on an estimated depth of 10 feet, the

volume material in the landfill (waste, fill and cap material) is about 200,000 cubic yards.

The fate and transport analysis described in Section 1.4 indicates that the sanitary landfills are not continuing sources of groundwater contamination. The analysis is conservative because it was conducted for infiltration through 8 feet of silty clay, without consideration of the existing cap.

Remedial alternatives for the sanitary landfills were assembled for current and future protection from ingestion, direct contact and inhalation of the landfill soils and protection of surface water runoff from the landfill. The alternatives were also evaluated for increased protection of groundwater.

2.3.2.5 Lime Ponds

The two former lime ponds operated from 1968 to 1976. The west pond contained approximately 5,300 tons of lime waste and the east pond contained approximately 4,200 tons. The ponds were closed in 1979 (prior to RCRA) with a clay cap, topsoil and grass. The closed lime ponds are situated about 10 to 15 feet above natural grade. Based on the Phase III borings, the lime waste in these ponds is covered by 0.5 to 6.0 feet of clay/silty clay and about 10 feet of ash. The ash was used as fill material when the ponds were closed and is described as saturated 6 to 8 feet below the surface. The thickness of the lime waste from the borings was about 3.0 feet for the east pond and about 1.75 feet for the west pond. The total mercury concentrations in the lime waste were 1.3 mg/kg in the east pond and 0.46 mg/kg in the west pond, with TCLP results of 10 μg/l and 3μg/l, respectively.

The fate and transport analysis described in Section 1.4 indicates that the lime ponds are not continuing sources of groundwater contamination. The analysis is based on calculated infiltration rates through the clay caps. This is conservative because the Phase III sampling showed that water is perched above the lime waste layers, indicating that the lime waste has an infiltration rate less than the overlying cap. The lime waste is buried beneath 0.5 to 6 feet of clay and about 10 feet of ash, so the potential for direct contact with the lime is very unlikely. The estimated area of the east lime pond

is 51,000 square feet, and the estimated area of the west lime pond is 18,000 square feet. Based on the lime thickness from the Phase III boring data, the estimated volume of lime waste is 5,700 cubic yards and 1,200 cubic yards for the east and west ponds, respectively. The estimated volume of lime waste and overburden material (ash and clay) is 36,000 cubic yards for the east pond and 9,400 cubic yards for the west pond.

One hypothetical condition that was considered is that seepage could occur along the side slopes of the ponds due to the perched water. This could result in releases of surface water containing very low concentrations of mercury, or possibly failure of the side slopes, which could disrupt containment of the lime waste. Although this is a very unlikely future condition, alternatives were assembled to ensure continued containment of the lime waste and prevention of any mercury-containing surface water runoff from the lime waste.

2.3.2.6 Mercury Cell Plant

The former mercury cell plant is an area that was the site of the structures and operations for the former mercury cell chlor-alkali plant. Decommissioning of the area in 1986 included removal of all aboveground structures. The concrete pads and foundations were left in place; the sumps and trenches were backfilled with clay, and the area was covered with a sealing layer of Durbigum® (a flexible, water-resistant elastomeric roofing material) and asphalt. The capped area is about 260 x 370 feet. The estimated volume of material for developing remedial alternatives is 18,000 cubic yards, based on a thickness of 5 feet.

The fate and transport analysis described in Section 1.4 indicates that the soils in the mercury cell plant are not a continuing source of groundwater contamination. The analysis is very conservative because it was conducted by evaluating infiltration through 6 feet of silty/sandy clay, without consideration of the asphalt, Durbigum® or concrete covers. Remedial alternatives will be developed primarily for continued protection against ingestion, direct contact and inhalation of the soils. These alternatives will also be evaluated for increased protection of groundwater.

2.3.2.7 Well Sand Residue Area

Well sands, which are residues of the natural insoluble material from the salt domes, were generated during the period from 1952 to 1968 from development and operation of the brine wells for the mercury cell chlor-alkali process. During early operation of the mercury cell plant, the well sands were settled from the brine stream and deposited in mounds in the well sand residue area. The well sand in these mounds is a cemented, granular material that has the consistency of sandstone. Samples were collected at ten randomly selected areas and depths within the mounds; the 10 individual samples were ground and composited into one sample for analysis (mercury and TCLP mercury). The total mercury concentration detected in the well sand composite sample was 20.1 mg/kg, and mercury was not detected in the leachate from the TCLP analysis. The estimated volume of material in the well sand residue area is 15,000 cubic yards.

Since mercury was not found to leach from the well sand material, the well sand residue area is not a continuing source of groundwater contamination. Remedial alternatives will be developed primarily for protection against ingestion, direct contact and inhalation hazards.

2.3.2.8 General Response Actions

The following general response actions have been developed for OU-1 soils.

- No Action, which involves leaving the facility "as is" with no provisions for control or cleanup of the contamination.

- Institutional Controls, which involve the creation and implementation of mechanisms, both physical and legal, that restrict public and environmental contact with the contaminants without addressing actual remediation of the contamination. Typical institutional controls for soils include access and deed restrictions.

- Containment, which involves physical actions to isolate contamination from potential exposure and/or restrict contaminant mobility by limiting the possible exposure paths and transport mechanisms.

- Removal, which involves the direct physical removal of the soils through excavation. Removal is commonly conducted in conjunction with soils treatment and/or disposal.

- Treatment, which involves on-site, off-site and/or in situ measures to reduce the toxicity, mobility and/or volume of the contamination in the soils.

- Disposal, which involves discarding contaminated soils and/or treatment residuals in an approved manner and at an approved site (either on- or off-site).

2.3.3 OU-2 Sediments

The following are the basic findings of the site characterization that were used to develop general response actions and evaluate sediment treatment technologies and process options:

- Where applicable, the basin and the ditches were addressed separately because treatment technologies that are suitable for the wastewater ditch may not be suitable for the basin. Wastewater no longer flows in the area referred to as the former discharge ditch and therefore this area is addressed with the basin sediments. The current discharge ditch (i.e., from the wastewater ditch to the Tombigbee River) is addressed with the wastewater ditch sediments.

- The maximum water depth encountered in the basin was 38.5 feet, with approximately two-thirds of the basin relatively flat with a water depth less than 6 feet.

- The primary constituents detected in the basin sediments include mercury, chlorinated benzenes (dominantly hexachlorobenzene) and chlorinated pesticides (4,4'-DDT, 4,4'-DDD and 4,4'-DDE). Mercury and the chlorinated pesticides are generally distributed throughout the basin sediments. The chlorinated benzenes are generally in the southern one-third of the basin. The maximum thickness of contaminated basin sediments is about 7 feet and occurs in the vicinity of the former wastewater ditch.

- The results of the hydrodynamic survey indicate that the basin is generally a depositional area with minimal potential for sediment transport.

- Mercury concentrations detected in the grab sediment samples from the wastewater ditch were generally lower than those detected in the basin. Sixteen of the 35 ditch samples showed mercury concentrations less than 1.0 mg/kg. Hexachlorobenzene was detected at higher concentrations in the wastewater ditch than in the basin, averaging about 200 mg/kg in the wastewater ditch. The chlorinated pesticides were not as common in the sediments from the wastewater ditch as in those from the basin.

- The surficial sediments in the basin were described as tan, black and dark gray silty clays and clayey silts with occasional sands. Except for the samples from the few sandy areas (3 of 22 samples), more than 80 percent of the material passed the No. 200 sieve (silt/clay size). The TOC was generally greater than 10,000 mg/kg because of the natural organic material in the sediments. The water content was commonly more than 40 percent.

- The sediments in the wastewater ditch were described as a mixture of soft silt and clay and firm-to-medium sands. The vertical extent of contamination in the wastewater ditch was estimated to be approximately 5 feet.

The baseline risk assessment indicated that floodplain soils (beyond the submerged areas during low water) are not a human health risk. Further, there was no indication of effects from site constituents on the terrestrial populations or the vegetation. When considered on a localized basis, sediments of the two small ponds north of the basin (the "upper ponds") are likely to pose an even lower risk to ecological receptors than the basin. Mercury was detected in upper ponds but at significantly lower concentrations than in the basin. In performing the dietary exposure calculations for selected ecological receptors (Table 1-12) the geometric mean concentrations of site constituents of concern in accessible (i.e., shallow, <60 cm deep) sediments throughout OU-2 including the upper ponds were used. As noted in Section 1.6, these calculations demonstrated that ecological exposures via the ingestion pathway (considered most important in assessing risk to higher vertebrate receptors such as wading birds) were well below lowest observed effects levels (LOELs) for sensitive birds and mammals. If the analysis was conducted only for the area around the two upper ponds, the geometric mean of the sediment concentrations would be essentially the same for (mercury), and substantially lower for hexachlorobenzene. Potential exposures to ecological receptors would probably be somewhat lower, particularly for aquatic organisms. There are no apparent extremes or "hot spots" (e.g., >40 mg/kg) in the upper ponds. The area encompassed by the upper ponds (about 10 acres in the early phases of isolation after annual flooding) is an even smaller fraction of the foraging territories of the higher vertebrate consumers used as examples in potential dietary exposure calculations. The northernmost of two upper ponds apparently tends to shrink through evaporation to less than a third of its mapped area toward the end of the dry season in most years. (The latter condition was observed in mid- to late autumn of at least two of the years of the RI.) Thus the duration of potential exposures to sediments in the upper ponds by fishes and (particularly) benthic macroinvertebrates, is reduced compared to that in the basin. Therefore, as a base case, sediment remedial actions were considered only for the basin. Figure 2-3 shows the distribution of mercury in the sediments of OU-2. Since the areas of higher concentrations of constituents are found in various areas across the basin, the removal and covering options were considered for the complete basin. Depths for the removal actions were considered as the nominal depth of contamination. This was considered appropriate because, given the pattern of mercury contamination, selected removal or covering of basin sediments was not considered implementable. The volume for removal alternatives was assumed to be 340,000 cubic yards in the basin. This

volume estimate was based on a 2-foot depth of removal across the basin, with additional volume added for consideration of the area near the former wastewater ditch, where mercury and hexachlorobenzene were detected in the deeper sediments. It was assumed that for any remedial action implemented for the upper ponds, it would be done in conjunction with the basin remedial actions using the same remedial technologies. It was assumed that the volume for removal alternatives from the upper ponds would add an additional 26,000 cubic yards to any basin removal action, based on 1-foot depth of removal from both ponds.

Figure 2-4 depicts the existing conditions in the wastewater ditch. The sediment volume for all removal actions in the wastewater ditch was estimated as 43,000 cubic yards, based on 6,300 linear feet of ditch (the entire length of the wastewater ditch and 300 feet of the discharge ditch) and a 6-foot depth.

The following general response actions have been developed for the OU-2 sediments:

- No Action, which involves leaving the facility "as is" with no provisions for control or cleanup of the contamination.

- Institutional Controls, which involve the creation and implementation of mechanisms, both physical and legal, that restrict public and environmental contact with the contaminants without remediation of the contamination. Typical institutional controls for the sediments include access and deed restrictions and may also include monitoring and fishing restrictions.

- Containment, which involves physical mechanisms to isolate contamination from potential exposure and/or restrict contaminant mobility.

- Removal, which involves the direct physical removal of the affected sediments. Removal is commonly conducted in conjunction with sediment treatment and/or disposal.

- Treatment, which involves on-site, off-site and/or in situ measures to reduce toxicity, mobility and/or volume of the contamination in the sediments.

- Disposal, which involves discarding contaminated sediments or treatment residuals in an approved manner, at an approved site (either on- or off-site).

2.4 EVALUATION OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

After media-specific general response actions were developed, as discussed in Section 2.3, the next step in the FS process was to select potential technologies and process options to be screened and evaluated. The purpose of the screening and evaluation is to select the remedial technologies and process options to be used to assemble remedial alternatives. This section describes the screening and evaluation of remedial technologies and process options, which were conducted as follows:

- Identification of remedial technologies and process options

- Screening of remedial technologies and process options

- Evaluation of process options based on effectiveness, implementability, and cost

- Selection of remedial technologies and process options

These activities are described below in more detail.

2.4.1 Identification of Remedial Technologies and Process Options

The term remedial technology refers to general categories of technology types, such as biological treatment, chemical treatment, and thermal destruction. The term process option refers to specific processes within each technology category. For example, under the technology category of biological treatment, there may be aerobic and anaerobic

treatment process options. The technologies and process options were assembled based on a review of the following:

- EPA guidance documents
- EPA's Alternative Treatment Technology Information Center (ATTIC) database
- Pertinent technical journals and seminar/conference proceedings
- EPA's Vendor Information System for Innovative Treatment Technologies (VISITT Version 1.0, June 1992)
- EPA's Cleanup Information Bulletin Board (CLU-IN, April 1991)
- Information provided by equipment/process vendors and remediation contractors
- WCC's past experience in the hazardous waste remediation area

Some of the key EPA guidance documents used in this review were:

- Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA (EPA/540/G-89/004; October 1988 - Interim Final)
- Guide to Treatment Technologies for Hazardous Wastes at Superfund Sites (EPA, 1989)

Table 2-10 lists the potential treatment technologies and corresponding process options for OU-1 groundwater. Tables 2-11 through 2-16 list the potential treatment technologies and corresponding process options for OU-1 soils. These are listed separately for each SWMU/AOC that is being considered. Table 2-17 lists the potential treatment technologies and corresponding process options for OU-2 sediments.

Any of the direct waste treatment technologies (i.e., treatment after removal) for OU-2 may require treatment of process water because of the high water content of the sediment. Depending on the type of treatment, OU-1 technologies for soil may also require process water treatment. Similarly, the sediment and soil treatment technologies may require dewatering or various types of solids processing such as debris removal, screening, grinding or some other processes to make the material acceptable for treatment. While the process water and solids processing steps are critical in the effective implementation of the treatment technologies, they are not screened in this memorandum because they are not considered critical in the selection of the applicable process options. Further consideration was given to process water and process solids options for the detailed analysis of the alternatives, which is presented in Section 4.0.

2.4.2 Screening of Remedial Technologies and Process Options

The remedial technologies and process options identified in Tables 2-10 through 2-17 were first screened on the basis of technical implementability, in accordance with EPA's guidance for performing feasibility studies (EPA, 1988a).

The technologies and the process options that could not be effectively implemented at the facility were screened out by using the information available from the RI site characterization, such as contaminant types, contaminant concentrations, and site characteristics. The screening tables, Tables 2-18 through 2-25, present the entire screening process. They describe the process options, present initial screening comments, and summarize the technology screening process. A description of each process option is included in the tables to allow an understanding of each option and to assist in the evaluation of its technical implementability. The screening comments address the technical feasibility and ability of a given process option to serve its intended purpose. The tables include a statement as to whether each process option is retained or screened out.

2.4.3 Evaluation of Process Options Based on Effectiveness, Implementability, and Cost

This section describes the evaluation of process options that were retained as potentially applicable after the initial screening described in Section 2.4.2 and presented in Tables 2-10 through 2-17. The process options were evaluated based on effectiveness, implementability, and relative cost.

Effectiveness

The effectiveness evaluation focused on three primary considerations:

- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site

Implementability

The implementability evaluation considered both the technical and administrative feasibility of constructing, operating and maintaining a particular process option. The determination that a process option is not technically feasible would generally preclude it from further consideration unless steps could be taken to change the conditions responsible for the determination.

Relative Cost

The cost evaluation included a qualitative (e.g., very high, high, moderate, etc.) estimation of the relative capital and operation and maintenance (O&M) costs

associated with the process options. The cost analysis was made based on engineering judgment. Each process option was evaluated as to whether costs are very high, high, moderate, low, or very low compared to other process options within the technology type. It should be noted that the greatest cost variability during site remediation is generally seen within the technology types, rather than within specific process options in a given technology.

The evaluation of the OU-1 groundwater process options is presented in Table 2-18. The OU-1 soil process option evaluations for the SWMUs/AOCs that are being considered are presented in Tables 2-19 through 2-24. Table 2-25 presents process option evaluation for OU-2 sediments. The screening and evaluation resulted in retention of remedial technologies and process options to be carried forward in the feasibility study process. These retained options are summarized below:

Summary of Retained Process Options
OU-1 Groundwater

General Response Action	Technology Type	Process Option
No Action	(Continuation of Existing CAP)	(Continuation of Existing CAP)
Institutional Actions	Access Restrictions	Deed Restrictions
	Monitoring	Groundwater Monitoring
	Alternative Water Supply	Supply Municipal Water to Area Residents. Retained as a Contingency Measure.
Removal Actions	Extraction	Additional Extraction Wells Extraction with Injection Wells Horizontal Wells Steam Injection
Treatment Actions	Physical/Chemical Treatment	Air Stripping Stream Stripping Activated Carbon Adsorption Dissolved Air Flotation Filtration Precipitation/Flocculation/Sedimentation Membrane Technology Neutralization
Discharge	Off-Site Discharge	Surface discharge through existing NPDES permit

Summary of Retained Process Options OU-1 Soil		
General Response Action	**Technology Type**	**Process Option**
Old Plant (CPC) Landfill		
No Action	None	None
Institutional Actions	Monitoring	Sampling
Containment Actions	Capping	Clay Cap Multi-Media Cap
Removal Actions	Excavation	Conventional Excavation
Treatment Actions	Encapsulation/Fixation	Stabilization/Solidification
	Physical/Chemical	BEST® Liquified Gas LEEP℠ APEG PLUS™ Acid Extraction
	Thermal	Circulating Bed Combustor Rotary Kiln Incineration Infrared Incineration Thermal Desorption
	In Situ	In Situ Stabilization Solidification
Disposal Actions	Off-Site	Off-Site RCRA Landfill Off-Site Non-RCRA Landfill
	On-Site	On-Site RCRA Landfill On-Site Non-RCRA Landfill
	Off-Site RCRA Incineration	Off-Site Incineration
West of Former CPC Plant Area		
No Action	None	None
Institutional Actions	Monitoring	Sampling
Containment Actions	Capping	Clay Cap Multi-Media Cap
Removal Actions	Excavation	Conventional Excavation

Summary of Retained Process Options OU-1 Soil (Continued)		
General Response Action	**Technology Type**	**Process Option**
Treatment Actions	Encapsulation/Fixation	Stabilization/Solidification
	Physical/Chemical	BEST® Liquified Gas LEEP℠ APEG PLUS™
	Thermal	Circulating Bed Combustor Rotary Kiln Incineration Infrared Incineration Thermal Desorption
	In Situ	In Situ Stabilization Solidification
Disposal Actions	Off-Site	Off-Site RCRA Landfill Off-Site Non-RCRA Landfill
	On-Site	On-Site RCRA Landfill On-Site Non-RCRA Landfill
	Off-Site RCRA Incineration	Off-Site Incineration
Sanitary Landfills		
No Action	None	None (Continue existing maintenance programs)
Institutional Actions	Monitoring/Maintenance	Cap Inspection/Maintenance
	Monitoring	Groundwater and Surface Water Monitoring
Containment Actions	Capping	Clay Cap Multi-Media Cap
Lime Ponds		
No Action	None	None (Continue existing maintenance programs)
Institutional Actions	Monitoring/Maintenance	Cap Inspection/Maintenance
	Monitoring	Groundwater Monitoring
Containment Actions	Capping	Clay Cap Multi-Media Cap
Mercury Cell Plant		
No Action	None	None (Continue existing maintenance programs)
Institutional Actions	Monitoring/Maintenance	Cap Inspection/Maintenance
	Monitoring	Groundwater Monitoring

Summary of Retained Process Options OU-1 Soil (Continued)		
General Response Action	**Technology Type**	**Process Option**
Well Sand Residue Area		
No Action	None	None
Containment Actions	Capping	Clay Cap
	Covering	Soil Cover
Removal Actions	Excavation	Conventional Excavation (associated with containment of material)
Disposal	On-Site Disposal	On-Site consolidation (associated with containment of material)

Summary of Retained Process Options OU-2 Sediments		
General Response Action	**Technology Type**	**Process Option**
No Action	None	None
Institutional Actions	Access Restrictions	Fencing Fishing Restrictions
	Monitoring	Sediment and Fish Monitoring
Containment Actions	Encapsulation	Covering Backfilling Stabilization/Solidification
Removal Actions	Excavation	Conventional Excavation
	Dredging	Hydraulic Mechanical
Treatment Actions	Encapsulation/Fixation	Stabilization/Solidification
	Physical/Chemical	BEST® Liquified Gas LEEP℠ Acid Extraction APEG PLUS™
	Thermal	Circulating Bed Combustor Rotary Kiln Incineration Infrared Incineration Thermal Desorption
Disposal Actions	Off-Site	Off-Site RCRA Landfill Off-Site Non-RCRA Landfill
	On-Site	On-Site RCRA Landfill On-Site Non-RCRA Landfill
	Off-Site RCRA Incinerator	Off-Site RCRA Incineration

The retained process options were used to develop the remedial alternatives presented in Section 3.0. The rejected process options were eliminated from further consideration.

TABLES

TABLE 2-1

REMEDIAL ACTION OBJECTIVES

Media	Preliminary Remediation Goal	
	Human Health	Environmental Protection
OPERABLE UNIT 1		
Groundwater	Prevent ingestion/direct contact with groundwater having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1.	Prevent further degradation of the aquifer. Restore groundwater quality to appropriate ARARs.
Soils	Prevent ingestion/direct contact with soils having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1.	Prevent migration of contaminants that would result in groundwater contamination in excess of groundwater remediation goals.
Surface Water	Prevent ingestion/direct contact with surface water having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1.	Prevent contamination in excess of surface water ARARs.
Air Dust Emissions	Prevent direct contact and ingestion of contaminated dust from the site having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1.	Prevent the release of contaminated dust to be carried by wind to nearby receptors where exposure may occur through food ingestion pathways.

TABLE 2-1 (Continued)

REMEDIAL ACTION OBJECTIVES

Media	Preliminary Remediation Goal	
	Human Health	Environmental Protection
OPERABLE UNIT 2		
Sediment	Prevent direct contact with sediments having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1.	Prevent contaminant releases from sediments that cause exceedances of surface water ARARs or exceedances of fish and game health-based standards or action levels.
Surface Water	Prevent ingestion/direct contact with surface water having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a hazard index greater than 1.	Prevent contamination in excess of surface water ARARs. Prevent contaminant releases from surface water that cause exceedances of fish and game health-based standards or action levels.
Fish and Game	Prevent ingestion of fish and game having contaminant concentrations with a cumulative cancer risk in excess of 1×10^{-4} to 1×10^{-6} or a cumulative hazard index greater than 1.	Prevent ingestion of contaminated fish and game by higher trophic levels causing these higher trophic levels to exceed fish and game health-based standards or action levels.

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TABLE 2-2

PATHWAY-SPECIFIC HAZARD INDEXES AND EXCESS LIFETIME CANCER RISKS

Receptor/Pathway	Reasonable Maximum Exposure	
	Excess Lifetime Cancer Risk	Chronic H.I.
Adult Resident/Trespasser		
Adult Surface Water - Dermal	4.27E-08	3.81E-04
Adult Surface Water - Inhalation	0.00E+00	2.52E-05
Adult Sediment - Ingestion	1.72E-07	3.12E-03
Adult Sediment - Dermal	9.54E-08	4.53E-04
Adult Fish Ingestion	8.00E-05	4.46E-01
Adult Domestic Well Water Ingestion	3.09E-06	1.96E-02
Adult Domestic Well Water - Dermal	6.53E-07	4.49E-03
Adult Domestic Well Water - Inhalation	2.22E-07	2.10E-03
Adult Particulate Inhalation (OU-1)	2.25E-10	1.27E-04
Adult Particulate Inhalation (OU-2)	1.14E-11	2.76E-06
Adult Surface Soils - Dermal	1.83E-09	1.60E-05
Adult Surface Soils - Ingestion	4.57E-09	3.25E-04
Cumulative (all pathways)	8.43E-05	4.76E-01
Adolescent Resident/Trespasser		
Adolescent Surface Water - Dermal	2.84E-08	3.81E-04
Adolescent Surface Water - Inhalation	0.00E+00	3.92E-05
Adolescent Sediment Dermal	6.36E-08	4.53E-04
Adolescent Fish Ingestion	5.34E-05	4.46E-01
Adolescent Domestic Well Water Ingestion	3.20E-06	3.05E-02
Adolescent Domestic Well Water - Dermal	4.36E-07	4.50E-03
Adolescent Domestic Well Water - Inhalation	1.26E-07	1.79E-03
Adolescent Surface Soils - Dermal	1.22E-09	1.60E-05
Adolescent Particulate Inhalation (OU-1)	2.25E-10	1.27E-04
Adolescent Particulate Inhalation (OU-2)	1.18E-11	4.29E-06
Adolescent - Sediment Ingestion	3.56E-07	9.71E-03
Adolescent - Surface Soils - Ingestion	9.47E-09	1.01E-03
Cumulative (all pathways)	5.76E-05	4.94E-01
Industrial Worker		
Industrial Worker Groundwater - Dermal	1.45E-06	1.15E-02
Industrial Worker Surface Soils - Dermal	6.26E-08	1.21E-03
Industrial Worker Surface Soil Ingestion	1.57E-07	2.71E-02
Industrial Worker Particulate Inhalation	4.46E-11	3.02E-05
Industrial Worker Groundwater Volatile Compound Inhalation	1.52E-08	1.39E-03
Cumulative (all pathways)	1.69E-06	4.12E-02

TABLE 2-2 (Continued)

PATHWAY-SPECIFIC HAZARD INDEXES AND EXCESS LIFETIME CANCER RISKS

Receptor/Pathway	Reasonable Maximum Exposure	
	Excess Lifetime Cancer Risk	Chronic H.I.
Hypothetical Future Adult OU-1 Resident[1]		
Ingestion of OU-1 Surface Soil	2.63E-06	3.79E-01
Dermal Contact with OU-1 Surface Soil	1.05E-06	1.69E-02
Inhalation of OU-1 Surface Soil Particulates	2.25E-10	1.27E-04
Ingestion of OU-1 Groundwater	5.13E-03	2.15E+01
Inhalation of OU-1 Groundwater Volatile Compounds	2.68E-05	2.59E+00
Dermal Contact with OU-1 Groundwater	1.27E-04	8.39E-01
Dermal Contact with OU-2 Sediment	9.54E-08	4.53E-04
Dermal Contact with OU-2 Surface Soil	1.83E-09	1.60E-05
Ingestion of OU-2 Sediment	1.72E-07	3.12E-03
Ingestion of OU-2 Surface Soil	4.57E-09	3.25E-04
Dermal Contact with OU-2 Surface Water	4.27E-08	3.81E-04
Inhalation of OU-2 Surface Soil Particulates	1.14E-11	2.76E-06
Inhalation of OU-2 Surface Water VOC	0.00E+00	2.52E-05
Ingestion of Fish	8.00E-05	4.46E-01
Cumulative (all pathways)	5.36E-03	2.58E+01
Hypothetical Future Child OU-1 Resident[1]		
Ingestion of OU-1 Surface Soil	8.62E-06	1.87E+00
Dermal Contact with OU-1 Surface Soil	8.36E-07	2.01E-02
Inhalation of OU-1 Surface Soil Particulates	2.83E-10	2.40E-04
Ingestion of OU-1 Groundwater	6.47E-03	4.06E+01
Inhalation of OU-1 Groundwater Volatile Compounds	3.38E-05	4.89E+00
Dermal Contact with OU-1 Groundwater	1.01E-04	1.00E+00
Dermal Contact with OU-2 Sediment	7.58E-08	5.40E-04
Ingestion of OU-2 Surface Soil	1.50E-08	1.60E-03
Ingestion of OU-2 Sediment	5.63E-07	1.53E-02
Dermal Contact with OU-2 Surface Soil	1.45E-09	1.91E-05
Dermal Contact with OU-2 Surface Water	3.39E-08	4.54E-04
Inhalation of OU-2 Surface Soil Particulates	1.44E-11	5.22E-06
Inhalation of OU-2 Surface Water VOC	0.00E+00	4.77E-05
Ingestion of Fish	5.34E-05	4.46E-01
Cumulative (all pathways)	6.66E-03	4.89E+01

NOTES: [1] Receptor conservatively assumes future residential use of Olin property, with residents drinking groundwater from the plume. Olin asserts that both residential use and groundwater consumption is highly unlikely. See Section 6.9 of RI report (WCC 1993) for further discussion.

TABLE 2-3

RISK-BASED PRELIMINARY REMEDIATION GOALS

ALL CURRENT AND LIKELY FUTURE PATHWAYS							HYPOTHETICAL OU-1 FUTURE RESIDENT (CHILD)[1, 2]					
OU-1 Groundwater Dermal							**OU-1 Groundwater Dermal**					
	Carcinogenic-Based (µg/l)			**Non-carcinogenic-Based (µg/l)**			**Carcinogenic-Based (µg/l)**			**Non-carcinogenic-Based (µg/l)**		
Constituent	10^{-6}	10^{-5}	10^{-4}	0.1	1.0	10.0	10^{-6}	10^{-5}	10^{-4}	0.1	1.0	10.0
1,2,4-trichlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	16	160	1,600
1,4-dichlorobenzene	NA	NA	NA	NA	NA	NA	28.8	288	2,880	--[4]	--[4]	--[4]
Benzene	NA	NA	NA	NA	NA	NA	13.7	137	1,370	--[4]	--[4]	--[4]
Beryllium	NA	NA	NA	NA	NA	NA	6.6	66	660	--[4]	--[4]	--[4]
Chlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	601	6,010	60,100
Chloroform	NA	NA	NA	NA	NA	NA	54.1	541	5,410	94.2	942	9,420
Pentachloronitrobenzene	NA	NA	NA	NA	NA	NA	2.79	27.9	279	--[4]	--[4]	--[4]
OU-1 Groundwater Ingestion							**OU-1 Groundwater Ingestion**					
	Carcinogenic-Based (µg/l)			**Non-carcinogenic-Based (µg/l)**			**Carcinogenic-Based (µg/l)**			**Non-carcinogenic-Based (µg/l)**		
Constituent	10^{-6}	10^{-5}	10^{-4}	0.1	1.0	10.0	10^{-6}	10^{-5}	10^{-4}	0.1	1.0	10.0
1,2-dichlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	174	1,740	17,400
1,4-dichlorobenzene	NA	NA	NA	NA	NA	NA	2.8	28	280	1,351	13,510	135,100
1,2,4-trichlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	2.53	25.3	253
Alpha-BHC	NA	NA	NA	NA	NA	NA	0.01	0.1	1.0	--[4]	--[4]	--[4]
Arsenic	NA	NA	NA	NA	NA	NA	0.04	0.4	4.0	0.58	5.8	58
Benzene	NA	NA	NA	NA	NA	NA	2.3	23	230	--[4]	--[4]	--[4]
Beryllium	NA	NA	NA	NA	NA	NA	0.02	0.2	2.0	9.64	96.4	964
Bromodichloromethane	NA	NA	NA	NA	NA	NA	0.5	5	50	--[4]	--[4]	--[4]
Cadmium	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	0.96	9.6	96
Carbon Tetrachloride	NA	NA	NA	NA	NA	NA	0.5	5	50	1.35	13.5	135
Chlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	38.6	386	3860
Chloroform	NA	NA	NA	NA	NA	NA	11.1	110	1,110	19.3	193	1930
Chromium VI	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	9.66	96.6	966
Copper	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	71.53	715.3	7,153

TABLE 2-3 (Continued)

RISK-BASED PRELIMINARY REMEDIATION GOALS

ALL CURRENT AND LIKELY FUTURE PATHWAYS							HYPOTHETICAL OU-1 FUTURE RESIDENT (CHILD)[1,2]					
OU-1 Groundwater Ingestion (Continued)							**OU-1 Groundwater Ingestion (Continued)**					
	Carcinogenic-Based (µg/l)			**Non-carcinogenic-Based (µg/l)**			**Carcinogenic-Based (µg/l)**			**Non-carcinogenic-Based (µg/l)**		
Constituent	**10^{-6}**	**10^{-5}**	**10^{-4}**	**0.1**	**1.0**	**10.0**	**10^{-6}**	**10^{-5}**	**10^{-4}**	**0.1**	**1.0**	**10.0**
Cyanide	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	38.5	385	3,850
Mercury	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	0.58	5.8	58
Nickel	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	38.6	386	3,860
Pentachlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	1.54	15.4	154
Pentachloronitrobenzene	NA	NA	NA	NA	NA	NA	0.26	2.6	26	--[4]	--[4]	--[4]
OU-1 Groundwater VOC Inhalation							**OU-1 Groundwater VOC Inhalation**					
	Carcinogenic-Based (µg/l)			**Non-carcinogenic-Based (µg/l)**			**Carcinogenic-Based (µg/l)**			**Non-carcinogenic-Based (µg/l)**		
Constituent	**10^{-6}**	**10^{-5}**	**10^{-4}**	**0.1**	**1.0**	**10.0**	**10^{-6}**	**10^{-5}**	**10^{-4}**	**0.1**	**1.0**	**10.0**
Benzene	NA	NA	NA	NA	NA	NA	22.4	224	2,240	--[4]	--[4]	--[4]
Chloroform	NA	NA	NA	NA	NA	NA	8	80	800	--[4]	--[4]	--[4]
Chlorobenzene	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	93	930	9,300
Mercury	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	1.6	16	160
OU-1 Soil Ingestion							**OU-1 Soil Ingestion**					
	Carcinogenic-Based (mg/kg)			**Non-carcinogenic-Based (mg/kg)**			**Carcinogenic-Based (mg/kg)**			**Non-carcinogenic-Based (mg/kg)**		
Constituent	**10^{-6}**	**10^{-5}**	**10^{-4}**	**0.1**	**1.0**	**10.0**	**10^{-6}**	**10^{-5}**	**10^{-4}**	**0.1**	**1.0**	**10.0**
Mercury	NA	NA	NA	NA	NA	NA	--[3]	--[3]	--[3]	8.9	89	890

NOTES:

NA Not applicable. The calculated cancer risk is less than 1×10^{-6} and the calculated hazard index is less than 1.0.

[1] Receptor conservatively assumes future residential use of Olin property, with residents drinking groundwater from the plume. Olin asserts that both residential use and groundwater consumption is highly unlikely. See Section 6.9 of RI report (WCC 1993) for further discussion.

[2] The PRGs for the child receptor are listed because these values are more conservative than those calculated for the adult receptor.

--[3] The listed constituent does not have an established slope factor or the calculated cancer risk is less than 1×10^{-4}.

--[4] The listed constituent does not have an established RfD or the calculated hazard index is less than 0.10.

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TABLE 2-4

POTENTIAL ARARs AND TBCs
OLIN CHEMICALS, MCINTOSH, ALABAMA

Medium	Potential ARAR/TBC and Legal Citation	Classification	Description	Applicability
A. Chemical-Specific				
Groundwater	1. Safe Drinking Water Act: 42 USC 300f			
	a. Maximum Contaminant Levels: 40 CFR 141	Relevant and Appropriate	Enforceable standards for public drinking water supply systems.	The Alluvial and Miocene aquifers at the site are considered Class IIA aquifers and potential drinking water sources. The NCP states that MCLs and nonzero MCLGs are ARARs for drinking water sources. Alternate concentration limits may be established for some constituents if attaining MCLs or MCLGs is impractical.
	b. Maximum Contaminant Level Goals 40 CFR 141.50-56	Relevant and Appropriate	Nonenforceable health goals for public water supply systems.	
	2. RCRA Groundwater Protection Standards 40 CFR Part 264 Subpart F	Applicable	Enforceable standards set in RCRA for groundwater protection.	Groundwater cleanup standards listed in Olin's post-closure RCRA permit shall apply to groundwater corrective action at the site.
	3. Alabama Primary Drinking Water Standards: Chapter 335-7-2, Alabama Administrative Code	Relevant and Appropriate	Enforceable standards for public drinking water supply systems.	Same as federal MCLs.
	4. EPA Health Advisories	To Be Considered	Nonenforceable guidelines for public water supply systems.	To be considered as guidelines in the absence of MCLs and MCLGs for remedial actions involving groundwater recovery and treatment at the Olin site.
Surface Water	1. Clean Water Act: 33 USC 1251 et seq.			
	a. Federal Water Quality Criteria	Relevant and Appropriate	Nonenforceable guidelines that are used in conjunction with the water designated use classification to establish surface water quality standards.	Federal Water Quality Criteria are potential ARARs for basin surface water.
Alabama Water Criteria Quality Standards	1. Alabama Water Quality Standards Chapter 335-6-10 Alabama Administrative Code	Relevant and Appropriate	Provide the basis for developing limits for discharges to state waters.	State Water Quality Standards are potential ARARs for basin surface water.
Fish	Section 400 of the Food and Drug and Cosmetic Act	To Be Considered	Action levels pertaining to the transportation, sale, and interstate commerce of food products.	To be considered as potential action levels for fish in OU-2.
B. Location-Specific	1. Endangered Species Act of 1973: 16 USC 1531, 50 CFR 81, 225, 402	Relevant and Appropriate	Requires federal agencies to ensure that action authorized by an agency is not likely to jeopardize the existence of any species on the endangered or threatened list or adversely affect its critical habitat.	The only federal listed threatened or endangered species known to actually occur at the site is the American alligator. Potential effects to the alligator and its habitat will have to be evaluated.
	2. National Historic Preservation Act: 16 USC Section 461, 469 and 470; 40 CFR 6.301(b), 36 CFR 800	Relevant and Appropriate	Sets guidelines for remedial actions at or near historic properties included on or eligible for inclusion on the National Register of Historic Places.	Remedial actions must ensure that potential historic areas are not adversely affected. Cultural resources review may be required.

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TABLE 2-4 (Continued)

POTENTIAL ARARs AND TBCs
OLIN CHEMICALS, MCINTOSH, ALABAMA

Medium	Potential ARAR/TBC and Legal Citation	Classification	Description	Applicability
B. Location-Specific (Continued)	3. Fish and Wildlife Coordination Act: 16 USC 661	Relevant and Appropriate	Set standards for protection of fish and wildlife when federal actions result in control or structural modification of a natural stream or water body.	Would be relevant and appropriate for remedial actions that modify streams and water bodies.
	4. Archeological and Historical Preservation Act 16 USC 469a-1	Relevant and Appropriate	Provides for the preservation of historical and archeological data.	Relevant and appropriate if historical and archeological data would be affected by remedial action. Would possibly have to be addressed for work on the bluff, where there may be historic and archeological data.
C. Action-Specific				
Air	1. Clean Air Act: 42 UC 7401-7642			
	National Ambient Air Quality Standards: 40 CFR 50	Relevant and Appropriate	Standards promulgated for air emissions from specific source categories.	Relevant and appropriate for any treatment technologies that are potential air point sources.
	2. Alabama Air Quality Regulations	Relevant and Appropriate	Standards promulgated for air emissions from specific source categories.	Relevant and appropriate for any treatment technologies that are potential air point sources.
	3. Control of Air Emissions from Air Strippers at Superfund Groundwater Sites: OSWER Directive 9355.0-28	To Be Considered	Policy to guide the selection of controls for air strippers at groundwater sites according to the air quality at the site.	To be considered for discharges from air strippers.
Surface Water	1. Clean Water Act: 33 USC 1252			
	a. National Pollutant Discharge Elimination System (NPDES) permit limitations: 40 CFR 132, 403.5	Applicable	Enforceable standards for discharge of pollutants to surface water. Standards are set to maintain water quality consistent with public health and recreation, propagation and protection of aquatic life and other beneficial uses of water.	Remedial actions at the site involving surface water discharges must adhere to the effluent limitations specified in Olin's federal NPDES permit.
	b. Section 404 Regulates Dredge and Fill Activities to Waters of the U. S.	Relevant and Appropriate	The disposition of dredged or excavated materials in waters of the U. S. is a regulated activity under Section 404.	Relevant and appropriate for remedial actions involving discharge of dredged or fill material.
	2. Executive Orders Related to Floodplains (11988) and Wetlands (11990) - EPA's August 6, 1985 policy on floodplain and wetlands assessments for CERCLA actions.	Relevant and Appropriate	Aims to ensure that floodplains and wetlands are not adversely affected by any remedial actions undertaken at a site. No activities that adversely affect floodplains and wetlands shall be permitted if a practicable alternative is available. If no alternative is available, impacts must be mitigated.	Any dredging, excavation or filling operation, field work disturbing designated wetlands or floodplains are required to adhere to the conditions of the executive orders.
	3. Alabama Surface Water Permit Regulations	Applicable	Enforceable standards for discharge of pollutants to Alabama waters.	Remedial actions at the Olin site involving surface water discharges must adhere to the effluent limitations specified in Olin's Alabama surface discharge permit.
	4. Section 10 of the Rivers and Harbors Act	Relevant and Appropriate	Dredging in navigable waters of the U. S. is regulated under Section 10 of the Rivers and Harbors Act.	Relevant and appropriate for remedial actions involving dredging.

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TABLE 2-4 (Continued)

POTENTIAL ARARs AND TBCs
OLIN CHEMICALS, MCINTOSH, ALABAMA

Medium	Potential ARAR/TBC and Legal Citation	Classification	Description	Applicability
Soil/Sediment Waste Materials	1. Resource Conservation and Recovery Act (RCRA)	Relevant and Appropriate	Enforceable standards for management and disposal of RCRA wastes.	Relevant and appropriate for any on-site or off-site disposal activities or remedial actions involving landfilling, incineration, capping, excavation of soils and materials classified as solid or hazardous waste.
	a. Solid Waste Disposal 40 CFR 241.200-212	Relevant and Appropriate	Regulates the requirements for solid waste disposal facilities.	Relevant and appropriate for the management of solid wastes.
	b. Alabama Solid Waste Program ADEM Admin. Code R. 335-1-X-.XX	Relevant and Appropriate	State regulations governing the storage, transportation, treatment and disposal of solid wastes.	Relevant and appropriate for remedial actions involving storage, transportation, treatment and disposal of solid wastes.
	c. Federal Hazardous Waste Management System: General 40 CFR Part 260 State ADEM Admin. Code R. 335-14-1	Relevant and Appropriate	Establishes procedures and criteria for modification or revocation of any provision in 40 CFR Parts 260-265; ADEM Admin. Code R. 335-14-(1-6).	Relevant and appropriate for delisting hazardous waste at the site generated during remedial actions.
	d. Identification and Listing of Hazardous Waste Federal 40 CFR Part 261 State ADEM Admin. Code R.335-14-2	Relevant and Appropriate	Defines solid wastes which are subject to regulation as hazardous wastes.	Relevant and appropriate for the management of wastes considered to be hazardous.
	e. Standards Applicable to the Generators of Hazardous Waste Federal 40 CFR Part 262 State ADEM Admin. Code R.335-14-3	Relevant and Appropriate	Establishes standards for generators of hazardous waste.	Standards would be relevant and appropriate if any remedial actions involve generation of hazardous waste at the site.

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TABLE 2-4 (Continued)

POTENTIAL ARARs AND TBCs
OLIN CHEMICALS, MCINTOSH, ALABAMA

Medium	Potential ARAR/TBC and Legal Citation	Classification	Description	Applicability
Soil/Sediment Waste Materials (Continued)	f. Standards Applicable to Transporters of Hazardous Waste Federal 40 CFR Part 263 State ADEM Admin. Code R.335-14-4	Applicable	Establishes standards which apply to transportation of hazardous waste.	Applicable for remedial actions at the site involving transport of hazardous waste off-site.
	g. Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities Federal 40 CFR Part 264 State ADEM Admin. Code R.335-14-5	Relevant and Appropriate	Establishes minimum standards that define the acceptable management of hazardous waste for owners and operators of facilities that treat, store, or dispose hazardous wastes.	Relevant and appropriate if a remedial action at the site involves excavation and on-site treatment, storage, or disposal of hazardous wastes.
	h. Land Disposal Restrictions Federal 40 CFR Part 268 State ADEM Admin. Code R.335-14-9	Relevant and Appropriate	Identifies hazardous wastes that are restricted from land disposal and defines those circumstances under which an otherwise prohibited waste could continue to be land-disposed.	Would be relevant and appropriate for remedial action at the site involving land disposal of restricted hazardous wastes.
	i. Hazardous Waste Permit Program Federal 40 CFR Part 270 State ADEM Admin. Code R.335-14-8	Relevant and Appropriate	Establishes provisions concerning basic permitting requirements.	A permit is not required for on-site CERCLA response actions. Substantative requirements as described under 1(g) would have to be addressed.

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TABLE 2-4 (Continued)

POTENTIAL ARARs AND TBCs
OLIN CHEMICALS, MCINTOSH, ALABAMA

Medium	Potential ARAR/TBC and Legal Citation	Classification	Description	Applicability
Soil/Sediment Waste Materials (Continued)	2. USDOTD Rules for Transport of Hazardous Materials: 49 CFR 107	Applicable	Establishes standards for generators of hazardous wastes including waste determination, manifests and pretransport requirements.	Regulates the manifests and the transportation of RCRA hazardous wastes. Applicable to the Olin site if off-site disposal is involved.
Miscellaneous	1. Occupational Safety and Health Act: 29 CFR 1910, 1926	Applicable	Provides enforceable occupational safety and health standards (permissible exposure limits or PELs) for workers engaged in on-site field activities.	These standards regulate employee exposure to air contaminants and provide guidelines for equipment handling and personal protection.
Miscellaneous (Continued)	2. National Institute for Occupational Safety and Health (NIOSH)	To Be Considered	Provides nonenforceable recommended exposure limits (RELs) for occupational activities for chemicals with OSHA PELs.	These are guidelines for worker exposure to air contaminants.
	3. American Conference of Governmental Industrial Hygienists (ACGIH)	To Be Considered	Provides 8-hour time-weighted average concentrations (known as threshold limit values or TLVs) of occupational hazardous chemicals.	These are guidelines for worker exposure to air contaminants.

NOTES:

This table identifies the ARARs and TBCs considered potentially applicable or relevant and appropriate for the remedial alternatives considered in this FS.

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TABLE 2-5

POTENTIAL GROUNDWATER ARARs AND TBCs FOR THE CHEMICALS OF CONCERN (Concentrations in μg/l)

Potential ARARs					To Be Considered							
		Federal Drinking Water Standards		State of Alabama Primary Drinking Water Standard	Health Advisories							
					10-kg Child			70-kg Adult				
Chemicals	Maximum Concentration Detected[3]	MCL	MCLG	MCL	1-Day	10-Day	Longer Term	Longer Term	RfD (μg/kg/d)	DWEL	Lifetime	Cancer Risk at 10^{-4}
Antimony	2,120J	6F[4]	6	NA	15	15	15	15	0.4	15	3	NA
Arsenic	32.7J	50D[1]	NA	50	NA	NA	NA	NA	NA	NA	NA	2
Benzene	350	5F	0	5	200	200	NA	NA	NA	NA	NA	100
Beryllium	115J	4D[4]	40	NA	30,000	30,000	4,000	20,000	5	200	NA	0.8
Bromodichloromethane	65	100D[2]	NA	NA	7,000	7,000	4,000	13,000	20	700	NA	60
Cadmium	95	5F	5	10	40	40	5	20	0.5	20	5	NA
Chlorobenzene	2,500	100F	100	NA	2,000	2,000	2,000	7,000	20	700	100	NA
Chloroform	1,200	100D	NA	NA	4,000	4,000	100	400	10	400	NA	600
Chromium (Total)	719	100F	100	50	NA	NA	NA	NA	NA	NA	NA	NA
Copper	3,430J	1,300[5]	1,300	1,000	NA	NA	NA	NA	NA	NA	NA	NA
1,2-Dichlorobenzene	4,000	600F	600	NA	9,000	9,000	9,000	30,000	90	3,000	600	NA
1,4-Dichlorobenzene	4,100	75F	75	NA	10,000	10,000	10,000	40,000	100	4,000	75	NA
Lead	252	15[5]	0	20	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	146	2F	2	2	NA	NA	NA	2	3	10	2	NA
Pentachlorobenzene	49NJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Pentachloronitrobenzene	11NJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Alpha-BHC	5.6	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Bromobenzene	16NJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Carbon Tetrachloride	8J	5F	0	5	4,000	200	70	300	7	30	NA	30
Cyanide	350J	200F[4]	200	NA	200	200	200	800	22	800	200	NA

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TABLE 2-5 (Continued)

POTENTIAL GROUNDWATER ARARs AND TBCs FOR THE CHEMICALS OF CONCERN (Concentrations in μg/l)

Potential ARARs					To Be Considered							
		Federal Drinking Water Standards		State of Alabama Primary Drinking Water Standard	Health Advisories							
					10-kg Child			70-kg Adult				
Chemicals	Maximum Concentration Detected[3]	MCL	MCLG	MCL	1-Day	10-Day	Longer Term	Longer Term	RfD (μg/kg/d)	DWEL	Lifetime	Cancer Risk at 10^{-4}
Delta-BHC	0.57	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
1,2,4-Trichlorobenzene	220	70F[4]	70	NA	100	100	100	500	10	400	70	NA
1,3-Dichlorobenzene	270	600F	600	NA	9,000	9,000	9,000	30,000	90	3,000	600	NA
Nickel	1,310	100F[4]	100	NA	1,000	1,000	500	1,700	20	600	100	NA
Tetrachlorobenzene isomer	56NJ	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

NOTES:

- NA Not Available
- D Draft
- F Final
- P Proposed
- 1 Under review
- 2 The listed value is for the sum of the trihalogenated methanes
- 3 Maximum concentration in Alluvial Aquifer samples; for inorganics, only total (unfiltered) results are listed
- J Concentration is estimated
- N Presumptive evidence of presence of material
- 4 Standard becomes effective January 17, 1994.
- 5 EPA action level

TABLE 2-6

FEDERAL WATER QUALITY CRITERIA AND ALABAMA WATER QUALITY STANDARDS
(Concentrations in $\mu g/l$)

Chemicals*	Maximum Concentration Detected** (Basin and Former Discharge Ditch)	Potential ARARs						
		Federal Water Quality Criteria				Alabama Water Quality Standards[h]		
		Freshwater Aquatic Life		Human Health - Ingestion Organisms Only		Fresh Water Aquatic Life		Human Health Criteria Fish Consumption Only
		Acute[a]	Chronic[c]	No Risk Level	10^{-5} Cancer Risk in Lifetime	Acute	Chronic	
Alpha-BHC	0.05U	NA	NA	NA	0.31	NA	NA	0.131
Antimony	32U[f]	9000	1600	45000	NA	NA	NA	4300
Arsenic	3U[f]	NA	NA	NA	0.175	NA	NA	NA
Cadmium	2.1[f]	1.8 - 8.6[b][e]	0.66-2[d][e]	NA	NA	1.8 - 8.6[g]	0.66 - 2[g]	NA
Chromium[i]	8.5J[f]	16[b]	11[d]	NA	NA	16	11	3360
Cyanide	36.9[f]	22[b]	5.2[d]	NA	NA	22	5.2	215,000
Lead	3.5J[f]	34 - 200[b][e]	1.3 - 7.7[d][e]	NA	NA	34 - 200[g]	1.3 - 7.7[g]	NA
Mercury	1.8[f]	2.4[b]	0.012[d]	0.146	NA	2.4	0.012	0.587
Nickel	21[f]	790 - 2500[b][e]	88 - 280[d][e]	100	NA	790 - 2500[g]	88 - 280[g]	4580
Zinc	166J[f]	65 - 210[b][e]	59 - 190[d][e]	NA	NA	65 - 210[g]	59 - 190[g]	5000
Chloroform	10U	28900	1240	NA	157	NA	NA	4700
Chlorobenzene	10U	250	NA	NA	NA	NA	NA	20
1,2-Dichlorobenzene	10U	1120	763	2600	NA	NA	NA	17400
1,3-Dichlorobenzene	10U	1120	763	2600	NA	NA	NA	182000
1,4-Dichlorobenzene	10U	1120	763	2600	NA	NA	NA	182000
1,2,4-Trichlorobenzene	10U	NA	NA	NA	NA	NA	NA	15400
Hexachlorobenzene	10U	250	NA	NA	0.0074	NA	NA	0.007
Pentachlorobenzene	NR	250	NA	85	NA	NA	NA	NA
Pentachloronitrobenzene	NR	NA	NA	NA	NA	NA	NA	NA
4,4'-DDT	0.1U	1.1	0.001	NA	0.00024	1.1	0.001	0.006
4,4'-DDD	0.1U	NA	NA	NA	NA	NA	NA	NA

TABLE 2-6 (Continued)

FEDERAL WATER QUALITY CRITERIA AND ALABAMA WATER QUALITY STANDARDS
(Concentrations in $\mu g/l$)

Chemicals*	Maximum Concentration Detected** (Basin and Former Discharge Ditch)	Potential ARARs						
		Federal Water Quality Criteria				Alabama Water Quality Standards[h]		
		Freshwater Aquatic Life		Human Health - Ingestion Organisms Only		Fresh Water Aquatic Life		Human Health Criteria Fish Consumption Only
		Acute[a]	Chronic[c]	No Risk Level	10^{-5} Cancer Risk in Lifetime	Acute	Chronic	
4,4'-DDE	0.1U	1050	NA	NA	NA	NA	NA	NA

NOTES:

NA Not Available
NR Compound was analyzed as part of the Tentatively Identified Compound and was listed as not reported by the laboratory.
J Estimated concentration
U Not detected at or above the detection limit shown.
* List includes ecological as well as human health chemicals of potential concern.
** The maximum concentration for samples collected from the basin and the former discharge ditch. The wastewater ditch is used to route Olin's wastewater and storm water, and the NPDES discharge permit limits are potential ARARs, rather than the water quality criteria.
(a) Instantaneous maximum, not to be exceeded at any time. Applies to all acute aquatic life criteria, except for those noted with (b).
(b) One hour average, not to be exceeded more than once every three years on the average.
(c) Twenty-four hour average. Applies to all chronic aquatic life criteria, except for those noted with (d).
(d) Four day average, not to be exceeded more than once every three years on the average.
(e) By formula dependent on water hardness. Source: Shields, E. J. Pollution Controls, Engineer's Handbook. Federal Water Quality Criteria, p. 65-70.
(f) Maximum concentrations of total inorganic analyses are listed.
(g) For hardness of 50 to 200 mg/l as $CaCO_3$.
(h) Source: Alabama Water Quality Standards. Alabama Administrative Code. Department of Environmental Management, Water Division - Water Quality Program, Chapter 335-6-10.
(i) The water quality criteria is for hexavalent chromium. The surface water samples were analyzed for total chromium.

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TABLE 2-7

FOOD AND DRUG ADMINISTRATION ACTION LEVELS FOR CONSTITUENTS DETECTED IN FISH TISSUE SAMPLES

Analyte	Maximum Concentration Detected[2] (mg/kg)	Arithmetic Mean[2] (mg/kg)	FDA Action Level (mg/kg)
Mercury	2.2	1.03	1.0
DDT_R[1]	9.96[3]	4.06[3]	5.0
Hexachlorobenzene	0.58	0.21	NA

NOTES:

1 DDT_R. Residue (sum of the DDT isomers).
2 Based on the 20 fish filet samples from November 1991 RI sampling.
3 Based on the sum of 4,4'-DDT, 4,4'-DDE and 4,4'-DDD.
NA Not available.

TABLE 2-8

SUMMARY OF POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL

FILL/WASTE AND CLAY					
Constituent	SOLUTE without Biodegradation (mg/kg)	SOLUTE with Biodegradation (mg/kg)	PESTAN without Biodegradation (mg/kg)	PESTAN with Biodegradation (mg/kg)	Recommended Soil Action Level (mg/kg)
Benzene	1.4	-[2]	0.83	467	5.0[4]
Chlorobenzene	65	-[3]	39	83	79[5]
1,2-Dichlorobenzene	1,644[1]	-[2]	1,472	-[2]	1,645[6]
1,3-Dichlorobenzene	1,233[1]	-[2]	2,109	-[2]	1,670[7]
1,4-Dichlorobenzene	105	-[2]	67	179	140[5]
1,2,4-Trichlorobenzene	1,066	-[2]	718	-[2]	1,000[6]
Mercury	65[1]	65	52	52	55[8]

UNSATURATED SAND			
Constituent	Summer's Model (mg/kg)	Recommended Soil Action Levels Lower Portion of Sand (mg/kg)	Recommended Soil Action Levels Upper Portion of Sand
Benzene	0.71	5.0[9]	5.0[9]
Chlorobenzene	32	30[10]	55[11]
1,2-Dichlorobenzene	814	800[10]	1,200[11]
1,3-Dichlorobenzene	610	600[10]	1,130[11]
1,4-Dichlorobenzene	52	50[10]	95[11]
1,2,4-Trichlorobenzene	528	520[10]	750[11]
Mercury	33	30[10]	42[11]

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TABLE 2-8 (Continued)

SUMMARY OF POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL

NOTES:

1. C_{TARGET} is higher than chemical-specific aqueous solubility.
2. Model indicates complete biodegradation before contaminant reaches the Alluvial Aquifer.
3. C_{TARGET} is too high to calculate concentration.
4. The relationship provided in Note 5 results in a benzene soil action value of 206 mg/kg. Considering that the SOLUTE result was 1.4 mg/kg, a value closer to SOLUTE was considered more appropriate.
5. Recommended value is approximately equal to the following:

$$\textit{PESTAN Value With Biodegradation} - \textit{SOLUTE Value Without Biodegradation} \times \left(\frac{\textit{Calculated Mass Table 3-1, Appendix F}}{M_{all}\ \textit{Table 4-1, Appendix F}} \right)$$

6. Approximately equal to SOLUTE without biodegradation.
7. Approximate average of PESTAN without biodegradation and SOLUTE without biodegradation.
8. Approximate average of PESTAN and SOLUTE values.
9. Selected as reasonable value above the Summer's model result. The benzene action level from the Summer's model was unreasonably low considering the high solubility, low half-life and the mass of benzene in the sand.
10. Based on the Summer's model result rounded down to the nearest 10 mg/l mg/kg.
11. Approximate average of the recommended values in the fill/waste and the clay and the recommended values in the sand.

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TABLE 2-9

SUMMARY OF POTENTIAL SOIL ACTION LEVELS
FORMER CPC PLANT AREA

Constituent	SOLUTE without Biodegradation (mg/kg)	SOLUTE with Biodegradation (mg/kg)	PESTAN without[3] Biodegradation (mg/kg)	PESTAN with[3] Biodegradation (mg/kg)	Recommended[3] Soil Action Level (mg/kg)	PESTAN without[4] Biodegradation (Recalculated) (mg/kg)
Benzene	0.64	-[1]	0.5	3.9	3.9[2]	4.17
Chlorobenzene	27	4,324	24	31	30[2]	217
1,2-Dichlorobenzene	735	-[1]	666	894	890[2]	--[5]
1,3-Dichlorobenzene	554	-[1]	522	733	730[2]	--[5]
1,4-Dichlorobenzene	47	1.65×10^5	40	52	50[2]	429
1,2,4-Trichlorobenzene	480	-[1]	416	538	500[2]	6,062

NOTES:

1 Model indicates complete biodegradation in the unsaturated zone.

2 $$\textit{PESTAN Value With Biodegradation} - \textit{SOLUTE Value Without Biodegradation} \times \left(\frac{\textit{Calculated Mass Table 3-1, Appendix F}}{M_{all}\ \textit{Table 4-3, Appendix F}} \right)$$

Values are sometimes rounded down to the nearest 10 mg/kg.

3 Based on the values calculated for the June 5, 1993 potential soil action level report. See Note 4.

4 For development of the remedial alternatives in this FS report, the estimated dimensions of the area west of the former CPC plant were refined based on more accurate topographic maps. The recalculated PSALs are presented in this column. See Appendix F for more discussion.

5 C_{TARGET} is higher than the chemical-specific aqueous solubility.

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TABLE 2-10

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No action (with continuation of the existing RCRA corrective action program (CAP))	Continuation of the existing RCRA CAP	Continuation of the existing RCRA CAP.	Retained	Required for evaluation	
Institutional Actions	Access restriction	Fencing: Fencing the site from potential contaminant exposure.	Screened out	Not applicable to groundwater contamination.	7
Institutional Actions	Access restriction	Deed restrictions: Deeds for property in the area of influence would include restriction on wells.	Retained	Potentially applicable.	7
Institutional Actions	Alternative residential water supply	Water supply from deeper aquifer: Water supply to area residents by installation of Miocene Aquifer wells.	Screened out	No off-site drinking water wells have been impacted by the plume above MCLs.	7
Institutional Actions	Alternative residential water supply	Municipal water supply: Supply of McIntosh city water to area residents.	Retained	No off-site drinking water wells have been impacted by the plume above MCLs. Retained as a contingency measure.	7
Institutional Actions	Monitoring	Groundwater monitoring: Monitoring of on-site and off-site area wells.	Retained	Potentially applicable.	7
Containment Actions	Capping	Clay cap: Compacted clay covered with soil over areas of contamination.	Screened out	Known or suspected source areas have already been capped.	7

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TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Screened out	Known or suspected source areas have already been capped.	7
Containment Actions	Capping	Concrete: Installation of concrete slabs over areas of contamination.	Screened out	Known or suspected source areas have already been capped.	7
Containment Actions	Capping	Multimedia cap: Clay and synthetic membrane covered by soil over areas of contamination.	Screened out	Known or suspected source areas have already been capped.	5
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Retained	Potentially applicable.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and/or concrete (diaphragm) walls.	Retained	Potentially applicable.	5

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TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites. Other vertical barriers like slurry walls are preferred.	5
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Screened out	Retained as a potential soil remedial technology in Table 2-8.	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Innovative technology; not considered applicable for Alluvial Aquifer due to depth of contamination.	5
Removal Actions	Subsurface drains	Interceptor drain: Any conduit buried underground to collect and convey aqueous discharges by gravity flow. Manholes or wet wells are used to collect the flow conveyed by the conduits and pump the discharge aboveground to the treatment system.	Retained	Potentially applicable.	5

TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Removal Actions	Extraction	Additional extraction wells: Installation of additional extraction wells to accelerate contaminant reduction.	Retained	Potentially applicable: The Alluvial Aquifer conditions (transmissivity, specific yield, permeability, etc) are favorable for the application of this technology. Groundwater pump and treat is part of the ongoing RCRA CAP.	5
Removal Actions	Extraction	Extraction with injection wells: Installation of injection wells to accelerate contaminant reduction.	Retained	Potentially applicable.	
Removal Actions	Extraction	Horizontal wells: An innovative technology in which wells are installed horizontally. Can have greater lateral influence than conventional extraction wells. Would be installed to accelerate contaminant reduction either as groundwater extraction or vapor extraction wells.	Retained	Potentially applicable for specific areas.	

TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Removal Actions	Enhanced extraction	Steam injection: Steam is injected into the subsurface soils to enhance the removal of volatile and semi-volatile organics. Technology is applicable for subsurface soils present above or below the groundwater table. Extraction wells pump and treat groundwater and transport steam and vaporized contaminants under vacuum to the surface.	Retained	Potentially applicable. This technology is applicable to only volatile organic compounds and semi-volatile organic compounds. Not applicable to metals.	4, 8
Removal Actions	Enhanced extraction	Vapor extraction: Volatile organics present in the subsurface soils are extracted by a series of injection/ extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. This technology is applicable only for subsurface soils above the water table.	Retained	Potentially applicable for volatile organic compounds.	7
Removal Actions	Enhanced extraction	Solvent injection: Injection of solvents into the groundwater to dissolve and mobilize the organic contaminants - To improve the effectiveness of Pump & Treat system.	Retained	Potentially applicable.	8

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TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Removal Actions	Enhanced extraction	Surfactant injection: Injection of surfactant into the groundwater to dissolve and mobilize inorganics and organics - To improve the effectiveness of Pump & Treat system.	Retained	Potentially applicable.	8
Treatment Actions	Physical/ chemical treatment	Air stripping: A means of treating contaminated water by transferring the contaminants from the aqueous phase to the air phase.	Retained	Potentially applicable: Applicable to organics with Henry's Law Constant > 3.0 x 10^{-3} atm-m^3/mole. Application of heat can increase the volatility of the constituents. Not applicable to metals or inorganics.	1, 2
Treatment Actions	Physical/ chemical treatment	Steam stripping: Is a unit process that uses steam to extract organics from aqueous streams. Can be considered as an alternative to air stripping, if the concentrations of the contaminants are too high or the volatility of the contaminants is too low for air stripping to be effective.	Retained	Potentially applicable to volatile organics. Similar to air stripping.	2
Treatment Actions	Physical/ chemical treatment	Activated carbon adsorption: Is a surface phenomenon in which soluble molecules from a solution are bonded onto a particular substrate.	Retained	Potentially applicable: Removes organics and is also applicable to mercury removal.	1, 2, 6

TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Dissolved air flotation: Separation of solids in a suspension by injecting pressurized air.	Retained	Potentially applicable as a pretreatment technology for solids removal.	
Treatment Actions	Physical/ chemical treatment	Filtration: Removal of suspended solids from a fluid by passage of the fluid through a bed of granular material.	Retained	Potentially applicable as a pretreatment technology for suspended solids removal.	2, 5
Treatment Actions	Physical/ chemical treatment	Precipitation/flocculation/sedimentation: A combination of technologies used to remove inorganics from solution by precipitation, conglomeration, and gravity settling or sedimentation.	Retained	Potentially applicable to inorganics (metals) removal; may also be used as pretreatment options for suspended solids removal.	1, 5
Treatment Actions	Physical/ chemical treatment	Membrane technology: A general term for various membrane processes (Reverse Osmosis, Ultrafiltration, Hyperfiltration, and Electrodialysis) to separate dissolved and suspended material from water. Reverse Osmosis and Ultrafiltration have greater potential for use in site remediation processes than the other membrane processes.	Retained	Potentially applicable for mercury and organics removal.	1, 2, 5, 6
Treatment Actions	Physical/ chemical treatment	Ion exchange: Anions and cations in a dilute aqueous waste are removed from solution through the process of ion exchange.	Retained	Potentially applicable for mercury removal.	2, 5, 6

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TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Distillation: A unit process that separates components of a liquid or sludge mixture by partially vaporizing the mixture and separately recovering the vapors and residue.	Screened out	Distillation is not considered appropriate for treatment of OU-1 groundwater contaminated with mercury and organics: 1. The primary uses for this process are waste oil recovery and solvent recovery. 2. Distillation is generally used to treat salt solutions where high quality water is desirable, such as desalination of seawater for potable use. 3. Distillation is very useful for reclaiming spent solvents from industrial processes, such as the metal finishing industry, or purifying certain aqueous waste streams, such as those heavily contaminated with organics (10,000 ppm)—much higher than those found in OU-1 groundwater.	2, 12, 20, 22

TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Involves the chemical transformation of reactants in which the oxidation state of one reactant is raised while the other is lowered.	Screened out	Presence of organics and inorganics complicates the treatment process. Non-selective process. More toxic by-products may be generated. Uncertainty in the oxidation of the chemicals of concern at the site.	1, 2, 5, 12
Treatment Actions	Physical/ chemical treatment	Neutralization: Neutralization is the interaction of an acid or a base with a solution to adjust the pH of the solution to the desired levels.	Retained	Potentially applicable for pH control at the site.	1, 2, 5

TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological treatment	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Not applicable to mercury removal; mercury may potentially be toxic to the microorganisms. Chloroform, dichlorobenzene, and the higher chlorinated benzenes present at the site may be resistent to biodegradation. Influent concentrations of the chemicals of concern at the site are too low (PPB levels).	6, 7, 9, 10, 11
Treatment Actions	Biological treatment	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Not applicable to mercury removal; mercury may potentially be toxic to the microorganisms. Chloroform, dichlorobenzene, and the higher chlorinated benzenes present at the site may be resistent to biodegradation. Influent concentrations of the chemicals of concern at the site are too low (PPB levels).	6, 7, 9, 10, 11

TABLE 2-10 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 GROUNDWATER

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ treatment	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Not applicable to mercury removal; mercury may potentially be toxic to the microorganisms. Chloroform, dichlorobenzene, and the other higher chlorinated benzenes present at the site may be resistent to biodegradation. Concentrations of the chemicals of concern at the site are too low (PPB levels).	6, 7, 9, 10, 11
Disposal Actions	Discharge	Surface discharge: Discharge through existing NPDES outfall.	Retained	Potentially applicable.	
Disposal Actions	Discharge	Subsurface discharge: Injection into subsurface zones.	Retained	Potentially applicable.	

NOTES:

[1] References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

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TABLE 2-11

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Contaminated areas are surrounded by fences to control access.	Screened out	Access to the plant area is already restricted by fencing and a guarded main entrance.	7
Institutional Actions	Access restrictions	Deed restrictions: Restrictions are placed on deeds concerning land usage.	Screened out	The deed for the McIntosh property already has a statement regarding the presence of hazardous waste on-site.	7
Institutional Actions	Monitoring	Sampling: Periodic monitoring of groundwater in vicinity of SWMUs.	Retained	Increase in monitoring is potentially applicable; monitoring is already conducted as part of RCRA programs.	
Containment Actions	Capping	Clay cap: Compacted clay covered with soil over areas of contamination.	Retained	Known or suspected source areas have already been capped. Potentially applicable for cap improvement.	7
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Retained	Known or suspected source areas have already been capped. Potentially applicable for cap improvement.	7
Containment Actions	Capping	Concrete: Installation of concrete slabs over areas of contamination.	Retained	Known or suspected source areas have already been capped. Potentially applicable either for cap improvement.	7
Containment Actions	Capping	Multimedia cap: Clay and synthetic membrane covered by soil over areas of contamination.	Retained	Known or suspected source areas have already been capped. Potentially applicable for cap improvement.	5

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Screened out	Not applicable as a soil remediation technology (above Alluvial Aquifer). Evaluated as a groundwater technology in Table 2-11 and Table 2-14.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and or concrete (diaphragm) walls.	Screened out	Not applicable as a soil remediation technology (above Alluvial Aquifer). Evaluated as a groundwater technology in Tables 2-10 and 2-18.	5
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites. Other vertical barriers like slurry walls are preferred.	5

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Retained	Potentially applicable for the loose saturated silt/clay zone in the old plant (CPC) landfill. Will be evaluated with the in situ stabilization/solidification technologies (listed as in situ treatment actions on page 13 of 14).	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Innovative technology: Information on the application of this technology to waste site remediation is not available.	5
Removal Actions	Excavation	Conventional excavation: Removal of sediments using conventional excavation equipment such as backhoes.	Retained	Potentially applicable.	
Treatment Actions	Encapsulation/ fixation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Retained	Potentially applicable: More applicable for metals than organics.	13, 15

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Acid extraction: Heavy metals are extracted from the soil by the addition of acid.	Retained	Potentially applicable for mercury.	19
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Retained	Potentially applicable for organics.	1, 4
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Retained	Potentially applicable for organics.	1, 4
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic pollutants from soils, sediments, and sludges.	Retained	Potentially applicable for organics.	1, 4, 16
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Retained	Potentially applicable for chlorinated organics.	17, 18

TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of another.	Retained	Potentially applicable.	1, 2, 5, 12, 15, 17, 20, 21
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	The high percentage of fines (predominantly clay) present in CPC landfill material make this technology less favorable.	15, 17, 19
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 15, 20
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 4, 15, 17, 20

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 15, 17, 20
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	15, 20
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	15
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganic compounds melt and are fused into vitreous solids.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 17, 20, 22, 24
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Retained	Potentially applicable for organics. Volatile mercury could potentially be removed from waste matrix.	4, 18, 19

TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15, 19

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation. The solubility of some of the predominant contaminants is low. The permeability of the soil is low (clayey soil). pH at some of the locations is very acidic.	6, 9, 10, 11, 14, 15, 23
Treatment Actions	In situ	In situ soil flushing: An in situ process where the zone of contamination is flooded with water or a water-surfactant mixture in order to dissolve and mobilize the contaminants. Contaminants are then brought to the surface by a series of extraction wells.	Screened out	The permeability of the soil is low (clayey soil). Variable waste composition complicates this process. Some of the predominant organics have low solubility and high K_{ow} values.	14, 15, 23

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ vacuum and steam extraction: Volatile organics present at the site are extracted by a series of injection/extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. Steam is also injected to raise the soil temperature and thereby enhance the recovery of the organics.	Screened out	The air permeability of the soil is low (clayey soil). The vapor pressure of some of the predominant organics present at the site is low. Not applicable for mercury.	4, 14, 15, 23
Treatment Actions	In situ	In situ vitrification: Is an in situ process whereby the soil and waste is melted into a glassy, solid matrix resistant to leaching and more durable than granite or marble. Organics are destroyed and inorganics are immobilized.	Retained	Potentially applicable.	15
Treatment Actions	In situ	In situ stabilization/solidification: An in situ process in which stabilizing/solidifying agents are added to the soil to reduce the mobility of chemicals by either physically entrapping them or changing their chemical state.	Retained	Potentially applicable.	3, 4, 13, 15

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TABLE 2-11 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ chemical treatment: A process by which a wide range of treatment agents, including precipitating and neutralizing chemicals, oxidizing/reducing agents, dechlorinating and chelating agents are delivered directly to the waste source.	Retained	Potentially applicable.	14, 15
Disposal Actions	Off-site disposal	RCRA landfill: Disposal of wastes in a RCRA landfill.	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	On-site RCRA landfill: Disposal of wastes in an on-site landfill.	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	On-site placement: Treated materials are placed back on-site.	Retained	Potentially applicable.	
Disposal Actions	Off-site incineration	Off-site incineration. Disposal of material at commercial RCRA incinerator.	Retained	Potentially applicable. Presence of metals (including mercury) could influence application of this process.	

NOTES: [1] References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

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TABLE 2-12

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Contaminated areas are surrounded by fences to control access.	Screened out	Access to the plant area is already restricted by fencing and a guarded main entrance.	7
Institutional Actions	Access restrictions	Deed restrictions: Restrictions are placed on deeds concerning land usage.	Screened out	The deed for the McIntosh property already has a statement regarding the presence of hazardous waste on-site.	7
Institutional Actions	Monitoring	Sampling: Periodic monitoring of groundwater in vicinity of SWMUs.	Retained	Increase in monitoring is potentially applicable; monitoring is already conducted as part of RCRA programs.	
Containment Actions	Capping	Clay cap: Compacted clay covered with soil over areas of contamination.	Retained	Potentially applicable.	7
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Retained	Potentially applicable.	7
Containment Actions	Capping	Concrete: Installation of concrete slabs over areas of contamination.	Retained	Potentially applicable.	7

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TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Capping	Multimedia cap: Clay and synthetic membrane covered by soil over areas of contamination.	Retained	Potentially applicable.	5
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Screened out	Not applicable as a soil remediation technology (above Alluvial Aquifer). Evaluated as a groundwater technology in Table 2-10 and Table 2-18.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and or concrete (diaphragm) walls.	Screened out	Not applicable as a soil remediation technology (above Alluvial Aquifer). Evaluated as a groundwater technology in Tables 2-10 and 2-18.	5

TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites. Other vertical barriers like slurry walls are preferred.	5
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Screened out	Not applicable due to very fine-grained cohesive soil west of former CPC plant area.	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Innovative technology: Information on the application of this technology to waste site remediation is not available.	5
Removal Actions	Excavation	Conventional excavation: Removal of sediments using conventional excavation equipment such as backhoes.	Retained	Potentially applicable.	

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TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Encapsulation/ fixation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Retained	Potentially applicable: More applicable for metals than organics.	13, 15
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Retained	Potentially applicable.	1, 4
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Retained	Potentially applicable.	1, 4

TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic pollutants from soils, sediments, and sludges.	Retained	Potentially applicable.	1, 4, 16
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Retained	Potentially applicable.	17, 18
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of another.	Retained	Potentially applicable.	1, 2, 5, 12, 15, 17, 20, 21

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TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	The high percentage of fines (predominantly clay) present west of the former CPC plant make this technology less favorable.	15, 17, 19
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Retained	Potentially applicable.	2, 15, 20
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Retained	Potentially applicable.	2, 4, 15, 17, 20
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Retained	Potentially applicable.	2, 15, 17, 20

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TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Retained	Potentially applicable.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Retained	Potentially applicable.	15, 20
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Retained	Potentially applicable.	15
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganic compounds melt and are fused into vitreous solids.	Retained	Potentially applicable.	2, 17, 20, 22, 24
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Retained	Potentially applicable.	4, 18, 19
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15

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TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15, 19

TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation. The solubility of some of the predominant contaminants is low. The permeability of the soil is low (clayey soil).	6, 9, 10, 11, 14, 15, 23
Treatment Actions	In situ	In situ soil flushing: An in situ process where the zone of contamination is flooded with water or a water-surfactant mixture in order to dissolve and mobilize the contaminants. Contaminants are then brought to the surface by a series of extraction wells.	Screened out	The permeability of the soil is low (clayey soil). Variable waste composition complicates this process. Some of the predominant organics have low solubility and high K_{ow} values.	14, 15, 23

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TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ vacuum and steam extraction: Volatile organics present at the site are extracted by a series of injection/extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. Steam is also injected to raise the soil temperature and thereby enhance the recovery of the organics.	Screened out	The air permeability of the soil is low (clayey soil). The vapor pressure of some of the predominant organics present at the site is low.	4, 14, 15, 23
Treatment Actions	In situ	In situ vitrification: Is an in situ process whereby the soil and waste is melted into a glassy, solid matrix resistant to leaching and more durable than granite or marble. Organics are destroyed and inorganics are immobilized.	Retained	Potentially applicable.	15
Treatment Actions	In situ	In situ stabilization/solidification: An in situ process in which stabilizing/solidifying agents are added to the soil to reduce the mobility of chemicals by either physically entrapping them or changing their chemical state.	Retained	Potentially applicable.	3, 4, 13, 15

TABLE 2-12 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ chemical treatment: A process by which a wide range of treatment agents, including precipitating and neutralizing chemicals, oxidizing/reducing agents, dechlorinating and chelating agents are delivered directly to the waste source.	Retained	Potentially applicable.	14, 15
Disposal Actions	Off-site disposal	RCRA landfill: Disposal of wastes in a RCRA landfill.	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	On-site RCRA landfill: Disposal of wastes in an on-site landfill.	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	On-site placement: Treated materials are placed back on-site.	Retained	Potentially applicable.	
Disposal Actions	Off-site incineration	Off-site incineration. Disposal of material at commercial RCRA incinerator.	Retained	Potentially applicable.	

NOTES: [1] References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

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4 9 0196

TABLE 2-13

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Construct fence around sanitary landfills to control access.	Screened out	Access to the plant area is already restricted by fencing and a guarded main entrance.	7
Institutional Actions	Access restrictions	Deed restrictions: Restrictions are placed on deeds concerning land usage.	Screened out	The deed for the McIntosh property already has a statement regarding the presence of hazardous waste onsite.	7
Institutional Actions	Monitoring/ maintenance	Cap inspection/maintenance: Develop, implement and document routine cap inspection, maintenance and cap improvement program.	Retained	Potentially applicable.	7
Institutional Actions	Monitoring	Groundwater and surface water monitoring: Increased groundwater monitoring in vicinity of sanitary landfill area. Implement surface water monitoring program at regular frequency in areas affected by runoff from the sanitary landfills.	Retained	Potentially applicable	7
Containment Actions	Capping	Clay cap: Compacted clay covered with soil over sanitary landfills.	Retained	Potentially applicable.	7
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Screened out	Size of landfill makes process not applicable when considering other capping options.	7

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Capping	Concrete: Installation of concrete slabs over areas of contamination.	Screened out	Size of landfill makes process not applicable when considering other capping options.	7
Containment Actions	Capping	Multimedia cap: Clay and synthetic membrane covered by soil over sanitary landfills.	Retained	Potentially applicable.	5
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Screened out	Area too large for practical applicability. Technology is used primarily to prevent migration of contaminated groundwater. Sanitary landfills are not a continuing source of groundwater contamination.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and or concrete (diaphragm) walls.	Screened out	Technology is used primarily to prevent lateral migration of contaminated groundwater. Sanitary landfills are not a continuing source of groundwater contamination.	5

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites. Technology is used primarily to prevent migration of contaminated groundwater. Sanitary landfills are not a continuing source of groundwater contamination.	5
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Screened out	Technology is used primarily to prevent migration of contaminated groundwater. Sanitary landfills are not a continuing source of groundwater contamination.	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Technology is used primarily to prevent migration of contaminated groundwater. Sanitary landfills are not a continuing source of groundwater contamination. Innovative technology: Information on the application of this technology to waste site remediation is not available.	5
Removal Actions	Excavation	Conventional excavation: Removal of soils using conventional excavation equipment such as backhoes.	Retained	Potentially applicable.	

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Removal Actions	Excavation	Excavation followed by mechanical separation: Excavate and then separate potentially contaminated soil from construction and other debris.	Retained	Potentially applicable.	21
Treatment Actions	Encapsulation/ fixation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Retained	Potentially applicable: More applicable for metals than organics.	13, 15
Treatment Actions	Physical/ chemical treatment	Acid extraction: Heavy metals are extracted from the soil by the addition of acid.	Retained	Not applicable for organics. Potentially applicable for mercury.	19
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	1, 4

TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	1, 4
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic pollutants from soils, sediments, and sludges.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	1, 4, 16
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	17, 18
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of another.	Screened out	Potentially applicable for organics and mercury but in aqueous solution.	1, 2, 5, 12, 15, 17, 20, 21

4 9 0199 Woodward-Clyde

TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	The high percentage of fines (predominantly clay) present in sanitary landfill material make this technology less favorable.	15, 17, 19
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	2, 15, 20
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	2, 4, 15, 17, 20
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	2, 15, 17, 20

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	15, 20
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Screened out	Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	15
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganic compounds melt and are fused into vitreous solids.	Screened out	Presence of metals (including mercury) could influence application of this process. Not applicable for mercury. Organic concentrations are too low for this technology to be applicable.	2, 17, 20, 22, 24
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Retained	Potentially applicable for organics. Volatile mercury could potentially be removed from waste matrix.	4, 18, 19

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15

TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation.	6, 7, 9, 10, 11, 15, 19

4 9 0201 Woodward-Clyde

TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Variable waste composition present at the site causes inconsistent biodegradation by variation in biological activity. Not applicable for mercury. Mercury could potentially be toxic. Some of the predominant organics (e.g., higher chlorinated benzenes) present at the site are either recalcitrant or resistant to biodegradation. The solubility of some of the predominant contaminants is low. The permeability of the soil is low (clayey soil).	6, 9, 10, 11, 14, 15, 23
Treatment Actions	In situ	In situ soil flushing: An in situ process where the zone of contamination is flooded with water or a water-surfactant mixture in order to dissolve and mobilize the contaminants. Contaminants are then brought to the surface by a series of extraction wells.	Screened out	The permeability of the soil is low (clayey soil). Variable waste composition complicates this process. Some of the predominant organics have low solubility and high K_{ow} values.	14, 15, 23

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ vacuum and steam extraction: Volatile organics present at the site are extracted by a series of injection/extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. Steam is also injected to raise the soil temperature and thereby enhance the recovery of the organics.	Screened out	The air permeability of the soil is low (clayey soil). The vapor pressure of some of the predominant organics present at the site is low. Not applicable for mercury.	4, 14, 15, 23
Treatment Actions	In situ	In situ vitrification: Is an in situ process whereby the soil and waste is melted into a glassy, solid matrix resistant to leaching and more durable than granite or marble. Organics are destroyed and inorganics are immobilized.	Screened out	Concentrations are too low for this technology to be applicable. Not applicable for mercury. Mercury could volatize and escape.	15
Treatment Actions	In situ	In situ stabilization/solidification: An in situ process in which stabilizing/solidifying agents are added to the soil to reduce the mobility of chemicals by either physically entrapping them or changing their chemical state.	Retained	Potentially applicable.	3, 4, 13, 15

4 9 0202

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TABLE 2-13 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ chemical treatment: A process by which a wide range of treatment agents, including precipitating and neutralizing chemicals, oxidizing/reducing agents, dechlorinating and chelating agents are delivered directly to the waste source.	Screened out	Concentrations are too low for this technology to be applicable.	14, 15
Disposal Actions	Off-site disposal	Landfill: Disposal of wastes in an off-site landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	Landfill: Disposal of wastes in an on-site landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	Off-site incineration	Off-site incineration. Disposal of material at commercial RCRA incinerator.	Retained	Potentially applicable. Presence of metals (including mercury) could influence application of this process.	

NOTES:

1 References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

2 Based on knowledge of the material, it is very unlikely that it would be classified as a RCRA hazardous waste and solid waste disposal options are assumed. If further characterization would indicate classification as hazardous waste, the landfill option would be upgraded to RCRA disposal.

TABLE 2-14

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Construct fence around lime ponds to control access.	Screened out	Access to the plant area is already restricted by fencing and a guarded main entrance.	7
Institutional Actions	Access restrictions	Deed restrictions: Restrictions are placed on deeds concerning land usage.	Screened out	The deed for the McIntosh property already has a statement regarding the presence of hazardous waste onsite.	7
Institutional Actions	Monitoring/ maintenance	Cap inspection/maintenance: Develop, implement and document routine cap inspection, maintenance and cap improvement program.	Retained	Potentially applicable.	7
Institutional Actions	Monitoring	Groundwater monitoring: Increased groundwater monitoring in vicinity of lime ponds.	Retained	Potentially applicable.	
Containment Actions	Capping	Clay cap: Compacted clay covered with soil over the lime ponds.	Retained	Potentially applicable.	7
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Screened out	Considering location and size of lime ponds, other capping options are more applicable.	7
Containment Actions	Capping	Concrete: Installation of concrete slabs over areas of contamination.	Screened out	Considering location and size of lime ponds, other capping options are more applicable.	7
Containment Actions	Capping	Multimedia cap: Clay and synthetic membrane covered by soil over lime ponds.	Retained	Potentially applicable.	5

4 9 0203 Woodward-Clyde

TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Retained	Potentially applicable to prevent lateral migration of perched water.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and or concrete (diaphragm) walls.	Retained	Potentially applicable to prevent lateral migration of perched water.	5
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites.	5

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TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Retained	Potentially applicable to prevent lateral migration of perched water.	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Innovative technology: Information on the application of this technology to waste site remediation is not available.	5
Removal Actions	Excavation	Conventional excavation: Removal of soils using conventional excavation equipment such as backhoes.	Retained	Potentially applicable.	
Removal Actions	Excavation	Excavation followed by mechanical separation: Excavate and then separate potentially contaminated soil from construction and other debris.	Retained	Potentially applicable.	21
Removal Actions		Remove perched groundwater: Install wells and pump groundwater.	Retained	Potentially applicable.	5

4 9 0201 Woodward-Clyde

TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Encapsulation/ fixation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Screened out	Mercury is already contained within lime matrix.	13, 15
Treatment Actions	Physical/ chemical treatment	Acid extraction: Heavy metals are extracted from the soil by the addition of acid.	Retained	Potentially applicable for mercury.	19
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Screened out	Not applicable for mercury.	1, 4
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Screened out	Not applicable for mercury.	1, 4

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TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic pollutants from soils, sediments, and sludges.	Screened out	Not applicable for mercury.	1, 4, 16
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Screened out	Not applicable for mercury.	17, 18
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of another.	Screened out	Potentially applicable for mercury but in aqueous solution.	1, 2, 5, 12, 15, 17, 20, 21
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	The low permeability lime matrix makes this technology not applicable. Technology not applicable for mercury.	15, 17, 19

4 9 0205 Woodward-Clyde

TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Screened out	Not applicable for mercury.	2, 15, 20
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Screened out	Not applicable for mercury.	2, 4, 15, 17, 20
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Screened out	Not applicable for mercury.	2, 15, 17, 20
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Screened out	Not applicable for mercury.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Screened out	Not applicable for mercury.	15, 20
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Screened out	Not applicable for mercury.	15

TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganic compounds melt and are fused into vitreous solids.	Screened out	Not applicable for mercury.	2, 17, 20, 22, 24
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Screened out	Not applicable for mercury at low concentrations in lime matrix.	4, 18, 19
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15, 19

4 9 0206

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TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Not applicable for mercury.	6, 9, 10, 11, 14, 15, 23
Treatment Actions	In situ	In situ soil flushing: An in situ process where the zone of contamination is flooded with water or a water-surfactant mixture in order to dissolve and mobilize the contaminants. Contaminants are then brought to the surface by a series of extraction wells.	Screened out	The low permeability of the lime matrix makes this process not applicable.	14, 15, 23

TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ vacuum and steam extraction: Volatile organics present at the site are extracted by a series of injection/extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. Steam is also injected to raise the soil temperature and thereby enhance the recovery of the organics.	Screened out	Not applicable for mercury.	4, 14, 15, 23
Treatment Actions	In situ	In situ vitrification: Is an in situ process whereby the soil and waste is melted into a glassy, solid matrix resistant to leaching and more durable than granite or marble. Organics are destroyed and inorganics are immobilized.	Screened out	Not applicable for mercury. Mercury could volatize and escape.	15
Treatment Actions	In situ	In situ stabilization/solidification: An in situ process in which stabilizing/solidifying agents are added to the soil to reduce the mobility of chemicals by either physically entrapping them or changing their chemical state.	Screened out	Mercury is already contained within lime matrix.	3, 4, 13, 15

4 9 0207 Woodward-Clyde

TABLE 2-14 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ chemical treatment: A process by which a wide range of treatment agents, including precipitating and neutralizing chemicals, oxidizing/reducing agents, dechlorinating and chelating agents are delivered directly to the waste source.	Screened out	Concentrations are too low for this technology to be applicable.	14, 15
Disposal Actions	Off-site disposal	Landfill: Disposal of wastes in an off-site landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	Landfill: Disposal of wastes in an on-site landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	Off-site incineration	Off-site incineration. Disposal of material at commercial RCRA incinerator.	Screened out	Not applicable for mercury.	

NOTES:

1 References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

2 Based on knowledge of the material, it is very unlikely that it would be classified as a RCRA hazardous waste and solid waste disposal options are assumed. If further characterization would indicate classification as hazardous waste, the landfill option would be upgraded to RCRA disposal.

TABLE 2-15

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Construct fence around mercury cell plant to control access.	Screened out	Access to the plant area is already restricted by fencing and a guarded main entrance.	7
Institutional Actions	Access restrictions	Deed restrictions: Restrictions are placed on deeds concerning land usage.	Screened out	The deed for the McIntosh property already has a statement regarding the presence of hazardous waste onsite.	7
Institutional Actions	Monitoring/ maintenance	Cap inspection/maintenance: Develop, implement and document routine cap inspection, maintenance and cap improvement program.	Retained	Potentially applicable.	7
Institutional Actions	Monitoring	Groundwater monitoring: Increased groundwater monitoring in vicinity of mercury cell plant.	Retained	Potentially applicable.	
Containment Actions	Capping	Clay cap: Place clay cap over asphalt cover to further inhibit infiltration.	Retained	Potentially applicable.	7
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Screened out	Asphalt cover already constructed over area. Maintenance of cover will be evaluated.	7
Containment Actions	Capping	Concrete: Installation of concrete over asphalt cover.	Retained	Potentially applicable.	7

4 9 0208 Woodward-Clyde

TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Capping	Multimedia cap: Place multimedia cap over asphalt cover to further inhibit infiltration.	Retained	Potentially applicable.	5
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Screened out	Technology is used primarily to prevent lateral migration of contaminated groundwater. The mercury cell plant soils are not a continuing source of groundwater contamination.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and or concrete (diaphragm) walls.	Screened out	Technology is used primarily to prevent lateral migration of contaminated groundwater. The mercury cell plant soils are not a continuing source of groundwater contamination.	5

TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites. Technology is used primarily to reduce vertical infiltration and prevent leaching of contaminants from the soils. The mercury cell plant soils are not a continuing source of groundwater contamination.	5
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Screened out	Technology is used primarily to reduce vertical infiltration and prevent leaching of contaminants from the soils. The mercury cell plant soils are not a continuing source of groundwater contamination.	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Innovative technology: Information on the application of this technology to waste site remediation is not available.	5
Removal Actions	Excavation	Conventional excavation: Removal of soils using conventional excavation equipment such as backhoes.	Retained	Potentially applicable.	

4 9 0209 Woodward-Clyde

TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Removal Actions	Excavation	Excavation followed by mechanical separation: Excavate and then separate potentially contaminated soil from construction and other debris.	Retained	Potentially applicable.	21
Treatment Actions	Encapsulation/ fixation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Retained	Potentially applicable.	13, 15
Treatment Actions	Physical/ chemical treatment	Acid extraction: Heavy metals are extracted from the soil by the addition of acid.	Retained	Potentially applicable for mercury.	19
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Screened out	Not applicable for mercury.	1, 4

TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Screened out	Not applicable for mercury.	1, 4
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic pollutants from soils, sediments, and sludges.	Screened out	Not applicable for mercury.	1, 4, 16
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Screened out	Not applicable for mercury.	17, 18
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of another.	Screened out	Potentially applicable for mercury but in aqueous solution.	1, 2, 5, 12, 15, 17, 20, 21

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TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	The low permeability clay soils makes this technology not applicable. Technology not applicable for mercury.	15, 17, 19
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Screened out	Not applicable for mercury.	2, 15, 20
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Screened out	Not applicable for mercury.	2, 4, 15, 17, 20
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Screened out	Not applicable for mercury.	2, 15, 17, 20

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TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Screened out	Not applicable for mercury.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Screened out	Not applicable for mercury.	15, 20
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Screened out	Not applicable for mercury.	15
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganic compounds melt and are fused into vitreous solids.	Screened out	Not applicable for mercury.	2, 17, 20, 22, 24
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Retained	Potentially applicable.	4, 18, 19
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15

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TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Not applicable for mercury.	6, 9, 10, 11, 14, 15, 23
Treatment Actions	In situ	In situ soil flushing: An in situ process where the zone of contamination is flooded with water or a water-surfactant mixture in order to dissolve and mobilize the contaminants. Contaminants are then brought to the surface by a series of extraction wells.	Screened out	The low permeability of the clay soils makes this process not applicable.	14, 15, 23

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TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ vacuum and steam extraction: Volatile organics present at the site are extracted by a series of injection/extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. Steam is also injected to raise the soil temperature and thereby enhance the recovery of the organics.	Screened out	Not applicable for mercury.	4, 14, 15, 23
Treatment Actions	In situ	In situ vitrification: Is an in situ process whereby the soil and waste is melted into a glassy, solid matrix resistant to leaching and more durable than granite or marble. Organics are destroyed and inorganics are immobilized.	Screened out	Not applicable for mercury. Mercury could volatize and escape.	15
Treatment Actions	In situ	In situ stabilization/solidification: An in situ process in which stabilizing/solidifying agents are added to the soil to reduce the mobility of chemicals by either physically entrapping them or changing their chemical state.	Retained	Mercury is already contained within lime matrix.	3, 4, 13, 15

4 9 0212 Woodward-Clyde

TABLE 2-15 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ chemical treatment: A process by which a wide range of treatment agents, including precipitating and neutralizing chemicals, oxidizing/reducing agents, dechlorinating and chelating agents are delivered directly to the waste source.	Screened out	Clay soils would inhibit effective implementation of this technology.	14, 15
Disposal Actions	Off-site disposal	Landfill: Disposal of wastes in an off-site landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	Landfill: Disposal of wastes in an on-site landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	Off-site incineration	Off-site incineration. Disposal of material at commercial RCRA incinerator.	Screened out	Not applicable for mercury.	

NOTES:

1 References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

2 Based on knowledge of the material, it is very unlikely that it would be classified as a RCRA hazardous waste and solid waste disposal options are assumed. If further characterization would indicate classification as hazardous waste, the landfill option would be upgraded to RCRA disposal.

TABLE 2-16

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Construct fence around well sand residue area to control access.	Screened out	Well sand area is already fenced.	7
Institutional Actions	Access restrictions	Deed restrictions: Restrictions are placed on deeds concerning land usage.	Screened out	The deed for the McIntosh property already has a statement regarding the presence of hazardous waste onsite.	7
Institutional Actions	Monitoring	Groundwater and surface water monitoring: Increased groundwater monitoring in vicinity of well sand residue area. Implement surface water monitoring program at regular frequency in areas affected by runoff from well sand.	Retained	Potentially applicable.	
Containment Actions	Capping	Clay cap: Compacted clay covered with soil over sanitary landfills.	Retained	Potentially applicable.	7
Containment Actions	Capping	Asphalt: Spray application of a layer of asphalt.	Screened out	Considering distribution of well sand (i.e., in mounds) and size of area, other capping/covering options are more applicable.	7
Containment Actions	Capping	Concrete: Installation of concrete slabs over areas of contamination.	Screened out	Considering location and distribution of well sands, other capping/covering options are more applicable.	7

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TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Capping	Multimedia cap: Clay and synthetic membrane covered by soil over well sand.	Retained	Potentially applicable.	5
Containment Actions	Covering	Soil cover: Place soil cover over well sand to further prevent potential for human contact to well sand and surface water runoff from well sand material. Vegetate soil cover to prevent erosion.	Retained	Potentially applicable.	
Containment Actions	Vertical barriers	Sheet piling: Sheet piles act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Sheet piles can be made of wood, pre-cast concrete, or steel. Steel piles are the most effective in terms of groundwater cut-off and cost.	Screened out	Technology is used primarily to prevent lateral migration of contaminated groundwater. Based on the TCLP test, mercury does not leach from the well sand material and therefore it is not a continuing source of groundwater contamination.	5
Containment Actions	Vertical barriers	Slurry walls: Slurry walls act as low-permeability subsurface barrier walls that either contain, capture, or redirect groundwater flow at the site. Soil-bentonite slurry walls are the most common slurry walls. Less common are the cement-bentonite and or concrete (diaphragm) walls.	Screened out	Technology is used primarily to prevent lateral migration of contaminated groundwater. Based on the TCLP test, mercury does not leach from the well sand material and therefore it is not a continuing source of groundwater contamination.	5

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TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Containment Actions	Vertical barriers	Grouting: A process whereby one of a variety of fluids is injected into a rock or soil mass where it is set in place to reduce water flow and strengthen the formation. Grouting includes such technologies as rock grouting, and grout curtains.	Screened out	Has not yet been proven to be effective and reliable for hazardous waste sites. Technology is used primarily to prevent lateral migration of contaminated groundwater. Based on the TCLP test, mercury does not leach from the well sand material and therefore it is not a continuing source of groundwater contamination.	5
Containment Actions	Horizontal barriers	Grout injection: Drilling through the site and injecting a grout to form a horizontal or curved barrier to prevent the downward migration of contaminants.	Screened out	Technology is used primarily to prevent lateral migration of contaminated groundwater. Based on the TCLP test, mercury does not leach from the well sand material and therefore it is not a continuing source of groundwater contamination.	5
Containment Actions	Horizontal barriers	Block displacement: Displacement and bottom sealing of a block of earth isolated by perimeter barriers, by continued grout or slurry pumping to prevent the downward migration of contaminants.	Screened out	Innovative technology: Information on the application of this technology to waste site remediation is not available. Technology is used primarily to prevent lateral migration of contaminated groundwater. Based on the TCLP test, mercury does not leach from the well sand material and therefore it is not a continuing source of groundwater contamination.	5

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TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Removal Actions	Excavation	Conventional excavation: Removal of well sands using conventional excavation equipment such as backhoes. In case of well sand residue area, would also include technologies to move material around.	Retained	Potentially applicable.	
Treatment Actions	Encapsulation/ fixation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Screened out	Mercury is already stabilized in well sand matrix.	13, 15
Treatment Actions	Physical/ chemical treatment	Acid extraction: Heavy metals are extracted from the soil by the addition of acid.	Screened out	Not applicable for well sand matrix.	19

TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Screened out	Not applicable for mercury.	1, 4
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Screened out	Not applicable for mercury.	1, 4
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic pollutants from soils, sediments, and sludges.	Screened out	Not applicable for mercury.	1, 4, 16
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Screened out	Not applicable for mercury.	17, 18

4 9 0215 Woodward-Clyde

TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of another.	Screened out	Potentially applicable for mercury but in aqueous solution.	1, 2, 5, 12, 15, 17, 20, 21
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	Not applicable for well sand matrix.	15, 17, 19
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Screened out	Not applicable for mercury.	2, 15, 20

TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Screened out	Not applicable for mercury.	2, 4, 15, 17, 20
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Screened out	Not applicable for mercury.	2, 15, 17, 20
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Screened out	Not applicable for mercury.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Screened out	Not applicable for mercury.	15, 20
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Screened out	Not applicable for mercury.	15
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganic compounds melt and are fused into vitreous solids.	Screened out	Not applicable for mercury.	2, 17, 20, 22, 24

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TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Screened out	Not applicable for mercury at low concentrations and in well sand matrix.	4, 18, 19
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15, 19
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Not applicable for mercury.	6, 7, 9, 10, 11, 15, 19

TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Not applicable for mercury.	6, 9, 10, 11, 14, 15, 23
Treatment Actions	In situ	In situ soil flushing: An in situ process where the zone of contamination is flooded with water or a water-surfactant mixture in order to dissolve and mobilize the contaminants. Contaminants are then brought to the surface by a series of extraction wells.	Screened out	Not applicable for well sand matrix.	14, 15, 23
Treatment Actions	In situ	In situ vacuum and steam extraction: Volatile organics present at the site are extracted by a series of injection/extraction wells. The vapors are extracted by applying either vacuum or pressure or a combination of both. Steam is also injected to raise the soil temperature and thereby enhance the recovery of the organics.	Screened out	Not applicable for mercury.	4, 14, 15, 23

4 9 0217

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TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Treatment Actions	In situ	In situ vitrification: Is an in situ process whereby the soil and waste is melted into a glassy, solid matrix resistant to leaching and more durable than granite or marble. Organics are destroyed and inorganics are immobilized.	Screened out	Not applicable for mercury. Mercury could volatize and escape.	15
Treatment Actions	In situ	In situ stabilization/solidification: An in situ process in which stabilizing/solidifying agents are added to the soil to reduce the mobility of chemicals by either physically entrapping them or changing their chemical state.	Screened out	Mercury is already stabilized within well sand matrix.	3, 4, 13, 15
Treatment Actions	In situ	In situ chemical treatment: A process by which a wide range of treatment agents, including precipitating and neutralizing chemicals, oxidizing/reducing agents, dechlorinating and chelating agents are delivered directly to the waste source.	Screened out	Not applicable for well sand matrix.	14, 15
Disposal Actions	Off-site disposal	Landfill: Disposal of wastes in a RCRA landfill.[2]	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	Landfill: Disposal of wastes in an on-site landfill.[2]	Retained	Potentially applicable.	

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TABLE 2-16 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-1 SOIL IN WELL SAND RESIDUE AREA

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References[1]
Disposal Actions	On-site disposal	On-site consolidation: Materials is placed back on-site.	Retained	Potentially applicable.	
Disposal Actions	Off-site incineration	Off-site incineration. Disposal of material at commercial RCRA incinerator.	Screened out	Not applicable for mercury.	

NOTES:

1 References and other sources of information that were used to evaluate the technologies and process options are provided at the end of Table 2-17.

2 Based on knowledge of the material, it is very unlikely that it would be classified as a RCRA hazardous waste and solid waste disposal options are assumed. If further characterization would indicate classification as hazardous waste, the landfill option would be upgraded to RCRA disposal.

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4 9 0218

TABLE 2-17

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
No Action	None	None	Retained	Required for consideration by NCP.	7
Institutional Actions	Access restrictions	Fencing: Contaminated areas are surrounded by fences to control access.	Retained	Potentially applicable.	7
Institutional Actions	Access restrictions	Fishing restrictions: To prevent human consumption of the fish in the ponded waters in OU-2.	Retained	Potentially applicable.	7
Institutional Actions	Monitoring	Sediment and fish monitoring: Periodic monitoring of the sediment and fish quality and monitoring sedimentation rates in OU-2.	Retained	Potentially applicable.	
Containment Actions	Encapsulation	Capping: For the ditches, would involve covering (e.g., with fresh soil, asphalt, concrete) the contaminated portions of the ditches to prevent the erosion, re-suspension, and transport of the suspended sediment, and reduce infiltration. Covering: For the basin, would involve the placement of imported sediment over existing sediments by pumping from a barge or dredge through a diffuser head over the sediment.	Retained	Potentially applicable.	17

4 9 0210 Woodward-Clyde

TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Containment Actions	Encapsulation	Backfilling: A form of containment that consists of covering the sediments to an above-grade elevation.	Retained	Potentially applicable.	17
Containment Actions	Encapsulation	Sedimentation: Deposition of clean sediments over existing contaminated sediments to isolate the contaminated sediments from potential receptors; either from natural processes or mechanisms to enhance or expedite sedimentation.	Retained	Potentially applicable.	5, 17
Containment Actions	Encapsulation	Stabilization/solidification: Cement, quicklime, or other grouting materials can be applied to the surface of, or mixed with, bottom sediments to create a seal which minimizes leaching and erosive transport of contaminated sediments.	Retained	Potentially applicable.	5
Removal Actions	Excavation	Conventional excavation: Removal of sediments using conventional excavation equipment such as backhoes or draglines.	Retained	Potentially applicable.	
Removal Actions	Dredging	Mechanical: Mechanical dredges remove sediments by the direct application of mechanical force to dislodge sediment material. The dislodged sediment material is scooped away with a bucket.	Retained	Potentially applicable.	21

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Removal Actions	Dredging	Hydraulic: Centrifugal pumps are used to remove sediments in a liquid slurry form.	Retained	Potentially applicable.	21
Removal Actions	Dredging	Pneumatic: Are similar to hydraulic dredges. Use compressed air and/or hydrostatic pressure instead of centrifugal force to remove sediments.	Retained	Potentially applicable.	13, 21
Treatment Actions	Encapsulation	Stabilization/solidification: A technology by which the mobility of a chemical waste is reduced by either physically entrapping the waste and/or changing its chemical state. This technology can be categorized by the primary stabilizing agent used: cement-based, pozzolanic- or silicate based, thermoplastic-based, or organic polymer-based.	Retained	Potentially applicable: more applicable for metals than organics	15
Treatment Actions	Physical/ chemical treatment	Basic Extraction Sludge Treatment (BEST®): Is a solvent extraction process that uses one or more secondary or tertiary amines (usually triethylamine [TEA]) to separate organics from soils and sludges.	Retained	Potentially applicable for organics.	1, 4
Treatment Actions	Physical/ chemical treatment	Liquified gas: Liquified gas is used as solvent to extract organics from sludges, contaminated soils, and wastewater. Carbon dioxide is used for wastewaters and propane is used for sludges and contaminated soil.	Retained	Potentially applicable for organics.	1, 4

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Physical/ chemical treatment	Low-Energy Solvent Extraction Process (LEEP℠): Uses common organic solvents to extract and concentrate organic constituents from soils, sediments, and sludges.	Retained	Potentially applicable for organics.	1, 4, 16
Treatment Actions	Physical treatment	Super critical extraction: Certain gases (e.g., carbon dioxide, propane, butane) are used as solvents for organic compounds when they are maintained at or near their critical pressure and temperature.	Retained	Potentially applicable for organics.	16
Treatment Actions	Physical/ chemical treatment	Acid extraction: Heavy metals are extracted from the sediment by the addition of acids.	Retained	Potentially applicable for mercury.	19
Treatment Actions	Physical/ chemical treatment	APEG™: Alkali metals hydroxides/ polyethylene glycols are used to dehalogenate certain classes of chlorinated organics.	Retained	Potentially applicable for chlorinated organics.	15, 17
Treatment Actions	Physical/ chemical treatment	APEG-PLUS™: Similar to APEG™. Specifically uses potassium hydroxide and dimethyl sulfoxide to aid dehalogenation.	Retained	Potentially applicable for chlorinated organics.	17, 18

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Physical/ chemical treatment	Catalytic dehydrochlorination: Is based on the reaction of polychlorinated hydrocarbons with high pressure hydrogen gas in the presence of a catalyst. The feed must be in either a liquid or gaseous form with the inorganic and inert constituents removed.	Screened out	Applicable only for polychlorinated hydrocarbons. Feed must be either in a liquid or gaseous form.	20
Treatment Actions	Physical/ chemical treatment	Oxidation/reduction: Process is applied to destroy hazardous waste components or convert the hazardous components to less hazardous forms by raising the oxidation state of one reactant and lowering that of the another.	Retained	Potentially applicable for mercury and organics removal.	1, 2, 5, 12, 15, 17, 20, 21
Treatment Actions	Physical/ chemical treatment	Electrolytic oxidation: Cathodes and anodes are immersed in a tank containing a waste to be oxidized. Metals are plated out on the cathodes when an electric current is imposed.	Screened out	Primarily applicable to aqueous solution. This process is primarily applied for cyanide removal.	17, 20
Treatment Actions	Physical/ chemical treatment	Chemical hydrolysis: Process of breaking a bond in a molecule so that it will go into ionic solution by the addition of chemicals, by irradiation or biologically. The cloven molecule can then be further treated by other means to reduce toxicity.	Screened out	Not applicable for sediment matrix. Not applicable for the chemicals of concern in OU-2.	17, 20, 21

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Physical/ chemical treatment	Chelation: A chelating molecule is used to form ligands with metal ions and make the metals unsuitable to form ionic salts which can precipitate. Chelation is used to keep metals in solution and to aid in dissolution for their subsequent transport and removal (e.g., soil washing).	Screened out	Not applicable -mercury is present in the sediment matrix not in solution.	17
Treatment Actions	Physical/ chemical treatment	Soil washing: Technology that uses water and mechanical action to remove hazardous constituents that adhere physically to soil particles. Soil washing separates the fine-grained particles from the coarser fraction. It makes use of the fact that contaminants have tendency to adhere to organic carbon and fine-grained soil fraction (silt and clay) as opposed to coarse-grained mixed fraction (sand and gravel).	Screened out	The high percentage of fines (predominantly clay) make this technology less favorable.	15, 17, 19
Treatment Actions	Physical/ chemical treatment	Heavy media separation: Process for separating two solid materials which have significantly different absolute densities. Solids are placed in a fluid with a specific gravity so that the lighter solid floats while the heavier sinks.	Screened out	Not applicable for the matrix and chemicals of concern in OU-2.	17

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Thermal	Fluidized bed: Waste is injected into a hot agitated bed of sand whereby combustion occurs.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 15, 20
Treatment Actions	Thermal	Circulating bed combustor: Variation of fluidized bed incinerator - Uses higher air velocity and circulating solids to create a larger and highly turbulent combustion zone.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 4, 15, 17, 20
Treatment Actions	Thermal	Rotary kiln incineration: Involves the controlled combustion of organic wastes under net oxidizing conditions.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	2, 15, 17, 20
Treatment Actions	Thermal	Wet air oxidation: Breaks down suspended and dissolved oxidizable inorganic and organic materials by oxidation in a high-temperature, high-pressure, aqueous environment.	Screened out	Primarily applied to the treatment of aqueous waste streams. Presence of metals (including mercury) could influence application of this process.	5, 15, 21, 22

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Thermal	Supercritical water oxidation: Involves thermal destruction of organics in waste water based on the ability of many organic compounds to dissolve in super critical water.	Screened out	Applicable to aqueous organic solution/ slurry or mixed organic/inorganic waste. Presence of metals (including mercury) could influence application of this process.	2, 5, 17, 22
Treatment Actions	Thermal	Molten glass: Uses a pool of molten glass as the heat transfer mechanism to destroy organics and to capture ash and inorganics.	Screened out	Primarily used to treat any solid or liquid such as plastics, asphalts, PCB or pesticides. Presence of metals (including mercury) could influence application of this process.	17, 20
Treatment Actions	Thermal	Infrared incineration: Uses silicon carbide elements to generate thermal radiation beyond the red end of the visible spectrum.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	4, 15, 17, 20, 22
Treatment Actions	Thermal	Pyrolysis: Destruction of organic material in the absence of oxygen at a higher temperature.	Retained	Potentially applicable for organics. Presence of metals (including mercury) could influence application of this process.	15, 20

TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Thermal	Vitrification: A process by which organics are destroyed and inorganics are immobilized into a glassy material.	Retained	Potentially applicable. Presence of metals (including mercury) could influence application of this process.	15
Treatment Actions	Thermal	Advanced electric reactor: Uses electrically heated fluid walls to pyrolyze waste. Inorganics compounds melt and are fused into vitreous solids.	Retained	Primarily applied to soils. Presence of metals (including mercury) could influence application of this process.	2, 17, 20, 22, 24
Treatment Actions	Thermal	Plasma torch: Functions by contacting the waste feed with a gas which has been energized into its plasma state by an electrical discharge.	Screened out	Primarily applicable to liquid wastes. Presence of metals (including mercury) could influence application of this process.	22, 20
Treatment Actions	Thermal	Multiple hearth incinerator: Waste is fed through the furnace roof where a rotating air-cooled central shaft with air-cooled rabble arms and teeth plows the waste across the top hearth to dropholes where it falls to the next successive hearth until the ash is discharged at the bottom.	Screened out	Used for disposal of sludges, tars, solids, gases and liquid combustible wastes (through nozzles) Not recommended for hazardous wastes. Presence of metals (including mercury) could influence application of this process.	5, 17, 22

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Thermal	Thermal desorption: Uses heat in a controlled environment to cause various organic compounds to volatilize and thereby be removed from contaminated material.	Retained	Potentially applicable for the organics present at the site. Volatile mercury could also potentially be removed from the material.	4, 18, 19
Treatment Actions	Thermal	Slagging - offgas: This system operates under very high temperatures and converts the metal compounds into molten slag. Slagging may require air emission control systems.	Screened out	Applicable for metals with very high concentrations only. Presence of metals (including mercury) could influence application of this process.	19
Treatment Actions	Biological	Aerobic: Degradation of organics using microorganisms in an aerobic environment.	Screened out	Not applicable for mercury. Mercury could potentially be toxic. Hexachlorobenzene is a recalcitrant organic.	6, 7, 9, 10, 11, 15
Treatment Actions	Biological	Anaerobic: Degradation of organics using microorganisms in an anaerobic environment.	Screened out	Not applicable for mercury. Mercury could potentially be toxic. Hexachlorobenzene is a recalcitrant organic.	6, 7, 9, 10, 11, 15

TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Treatment Actions	Biological	Slurry phase: Excavated soil, sludge, or sediment is mixed with water to form a slurry that is agitated with environment amenable to biodegradation. Slurry is dewatered and the solids are disposed upon completion of the process.	Screened out	Not applicable for mercury. Mercury could potentially be toxic. Hexachlorobenzene is a recalcitrant organic.	6, 9, 10, 11, 15, 19
Treatment Actions	Biological	Solid phase: Excavated soils are placed on a lined treatment bed, tank, or building. Microbial growth is facilitated by adding nutrients and other additives into the soil. Air and water may also be supplied to the soil.	Screened out	Not applicable for mercury. Mercury could potentially be toxic. Hexachlorobenzene is a recalcitrant organic.	6, 9, 10, 11, 15, 19
Treatment Actions	In situ	In situ bioreclamation: System of injection and recovery wells introduce bacteria and nutrients to degrade contamination.	Screened out	Not applicable for mercury. Mercury could potentially be toxic. Hexachlorobenzene is a recalcitrant organic.	6, 9, 10, 11, 14, 15, 23
Disposal Actions	Off-site disposal	RCRA landfill: Disposal of wastes in a RCRA landfill.	Retained	Potentially applicable.	
Disposal Actions	Off-site disposal	Non-RCRA landfill: Disposal of wastes in a non-RCRA landfill.	Retained	Potentially applicable.	
Disposal Actions	On-site disposal	On-site RCRA landfill: Disposal of wastes in an on-site landfill.	Retained	Potentially applicable.	

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TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

General Response Actions	Technology Type	Process Description	Status	Screening Comments	References
Disposal Actions	On-site disposal	On-site non-RCRA landfill: Treated materials are placed back on-site.	Retained	Potentially applicable.	
Disposal Actions	Off-site incinerator	Off-site RCRA incineration: Disposal of material at commercial RCRA incinerator.	Retained	Potentially applicable. Presence of metals (including mercury) could influence application of this process.	

REFERENCES

1. Superfund University Training Institute. 1991. Treatment technologies course. Presented by U. S. Environmental Protection Agency, Risk Reduction Engineering Laboratory; and University of Cincinnati, Ohio. April 24-26.

2. U. S. EPA. 1986. Mobile treatment technologies for superfund wastes. U. S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C. EPA/540/2-86/003(f). September.

3. U. S. EPA. 1990. The Superfund Innovative Technology Evaluation Program: Technology Profiles. U. S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. EPA/540/5-90/006. November.

4. U. S. EPA. 1991. The Superfund Innovative Technology Evaluation Program: Technology Profiles. Fourth edition. U. S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. EPA/.540/5-91/008. November.

5. U. S. EPA. 1985. Remedial Action at Waste Disposal Sites. Revised. U. S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA//625/6-85/006. October.

TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

REFERENCES (Continued)

6. Nyer, E. K. 1992. Groundwater treatment technology. Second edition. Van Nostrand Reinhold, New York, NY.

7. U. S. EPA. 1988. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. Interim final. U. S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/G-89/004. October.

8. Kovalick, W., Jr. 1992. "In situ Treatment of Contaminated Groundwater: An Inventory of Research and Field Demonstrations and A Role for EPA in Improving Groundwater Remediations." In U. S. Environmental Protection Agency's Alternative Treatment Technology Information Center (ATTIC) Database. May 12, 1992.

9. U. S. EPA. 1990. Subsurface Remediation Guidance Tables 1 & 2. Office of Emergency and Remedial Response, Washington, D.C. EPA/540/2-90/011a.

10. U. S. EPA. 1991. Soil Transport and Fate Database 2.0 and Model Management System. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, U. S. Environmental Protection Agency, ADA, OK. June.

11. AWMA and HWAC. 1992. Bioremediation: The State of Practice in Hazardous Waste Remediation Operations. A live satellite seminar jointly sponsored by Air & Waste Management Association and HWAC. January 9, 1992.

12. Rich, G., and Cherry, Kenneth. 1987. Hazardous Waste Treatment Technologies. Puvan Publishing Co., Northbrook, IL.

13. U. S. EPA. 1986. Handbook for Stabilization/Solidification of Hazardous Wastes. U. S. Environmental Protection Agency, Hazardous Waste Engineering Laboratory, Cincinnati, OH. EPA/540/2-86/001. June.

14. U. S. EPA. 1990. Handbook on In Situ Treatment of Hazardous Waste-Contaminated Soils. U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory, Cincinnati, OH. EPA/540/2-90/002. January.

15. U. S. EPA. 1988. Technology Screening Guide for Treatment of CERCLA Soils and Sludges. U.S. Environmental Protection Agency, Office of Emergency and Remedial Response, Washington, D.C. EPA/540/2-88/004. September.

TABLE 2-17 (Continued)

INITIAL SCREENING OF TECHNOLOGIES AND PROCESS OPTIONS FOR OU-2 SEDIMENT

REFERENCES (Continued)

16. McCoy and Associates. "A Guide to Innovative Nonthermal Hazardous Waste Treatment Processes." The Hazardous Waste Consultant. Vol. VII, No. 6: 4.1-4.32. November/December 1989.

17. WCC. 1992. Candidate Technologies Technical Memorandum for the Olin Chemicals/McIntosh Plant Site. Woodward-Clyde Consultants. Baton Rouge, LA.

18. McCoy and Associates. "Contaminated Soil-Regulatory Issues and Treatment Technologies." The Hazardous Waste Consultant. Vol. IX, No. 5: 4.1-4.24. September/October 1991.

19. U. S. EPA. 1992. Vendor Information System for Innovative Treatment Technologies (VISITT) User Manual (Version 1.0). U. S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Technology Innovation Office (OS-110W), Washington, D.C., EPA/542/R-92/001. June.

20. U. S. EPA. 1987. A compendium of Technologies Used in the Treatment of Hazardous Wastes. U. S. Environmental Protection Agency, Center for Environmental Research Information, Cincinnati, OH. EPA/625/8-87/014. September.

21. U. S. EPA. 1991. Remediation of Contaminated Sediments. U. S. Environmental Protection Agency, Office of Research and Development, Washington, D.C. EPA/625/6-91/028. April.

22. U. S. EPA. 1989. Guide to Treatment Technologies for Hazardous Wastes at Superfund Sites. U. S. Environmental Protection Agency, Office of Environmental Engineering and Technology Demonstration, Washington, D.C. EPA/540/2-89/052. March.

23. U. S. EPA. 1990. Assessing UST Corrective Action Technologies: Site Assessment and Selection of Unsaturated Zone Treatment Technologies. U. S. Environmental Protection Agency, Risk Reduction Engineering Laboratory, Cincinnati, OH. EPA/600/2-90/011. March.

24. McCoy and Associates. "A Guide to Innovative Thermal Hazardous Waste Treatment Processes." The Hazardous Waste Consultant. Vol. VIII, No. 6: 4.1-4.40. November/December 1990.

TABLE 2-18

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
No Action - Continuation of the existing RCRA CAP	Continuation of the existing RCRA cap.	**Continuation of the existing RCRA CAP**	The CAP is effective at controlling contaminant migration and moderately effective at contaminant reduction.	Already implemented.	No additional costs.
Institutional Actions	Access restrictions	**Deed restrictions**	Effectiveness depends upon continued future implementation. Does not reduce contamination.	Legal requirements and authority.	Negligible cost.
Institutional Actions	Monitoring	**Groundwater monitoring**	Effective for monitoring the groundwater conditions during and after remedial action.	Easily implementable.	Low capital, low O&M.
Institutional Actions	Alternative water supply	**Municipal Water****	Contingency measure that would be effective at preventing exposure to contaminated groundwater if future monitoring indicates it is warranted.	Implementable - Cooperation of residents would be required.	Low to moderate capital, very low to no O&M.

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TABLE 2-18 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
Containment Actions	Vertical barriers	Sheet piling	Interlocks of the steel piles are not water tight. The locks may never seal in a sandy soil and grouting may be necessary which would be costly. Only effective at containment - does not reduce contamination unless used with other technologies (e.g. extraction).	Implementable - Could be implemented in the localized areas of most concern; however difficult at the required depth (up to 100 ft).	Moderate to high capital, very low O&M.
Containment Actions	Vertical barriers	Slurry walls	Effectiveness strongly contingent on proper implementation Only effective at containment - does not reduce contamination unless used with other technologies (e.g. extraction).	Implementable - Could be implemented in the localized areas of most concern; however difficult at the required depth (up to 100 ft). Careful monitoring required during implementation.	Moderate capital, very low O&M.
Removal Actions	Subsurface drains	Interceptor drains	Effective for soluble contaminants.	Primarily applicable to shallow depths. Very difficult to implement for Alluvial Aquifer.	Moderate capital, moderate O&M.

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TABLE 2-18 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
Removal Actions	Extraction	**Additional extraction wells**	Effective for soluble contaminants, well established as demonstrated by CAP.	Easily implementable.	Moderate capital, moderate O&M.
Removal Actions	Extraction	**Extraction with Injection wells**	Effective for control of groundwater movement and soluble contaminant removal.	Easily implementable	Moderate capital, moderate O&M.
Removal Actions	Extraction	**Horizontal wells**	Potentially effective innovative technology. Offers several advantages over vertical wells. Effectiveness of this technology for groundwater or vapor extraction requires further evaluation.	Potentially implementable for specific areas; would require further evaluation.	Cost depends upon the use of this technology in conjunction with the above - ground treatment system. Could potentially result in savings in operating and maintenance costs over the life of the remediation project.
Removal Actions	Enhanced extraction	**Steam injection**	Not effective for the removal of mercury. Potentially effective at reducing organic concentration above and below water table in Alluvial Aquifer.	Implementable; pilot-scale treatability testing required.	Moderate capital, moderate O&M.

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TABLE 2-18 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
Removal Actions	Enhanced extraction	Vapor extraction	Not effective for the removal of mercury. Not effective for semivolatile organics present at the site. Only effective above the water table.	Implementable.	Moderate capital, moderate O&M.
Removal Actions	Enhanced extraction	Solvent injection	Primarily applicable to organics. Innovative technology. Limited increased effectiveness over extraction wells alone.	Implementable, but injection and handling of solvents is a major disadvantage. Bench- and pilot-scale treatability studies would be required.	Moderate capital, moderate O&M.
Removal Actions	Enhanced extraction	Surfactant extraction	Applicable to inorganics and organics Innovative technology. Limited increased effectiveness over extraction wells alone	Implementable - Injection and handling of surfactants is a major disadvantage. Bench- and pilot-scale treatability studies would be required.	Moderate capital, moderate O&M.
Treatment Actions	Physical/chemical treatment	**Air stripping**	Applicable to volatile organics.	Readily implementable. Existing CAP includes air stripping.	Moderate capital, moderate O&M.

TABLE 2-18 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
Treatment Actions	Physical/chemical treatment	**Steam stripping**	Applicable to volatile organics. Energy-intensive process. More applicable, when compared with air stripping, to contaminants with either higher concentrations or lower volatility.	Implementable.	Moderate to high capital and O&M.
Treatment Actions	Physical/chemical treatment	**Activated carbon adsorption**	Effective for mercury and organics removal.	Readily implementable. Existing CAP includes carbon adsorption.	Moderate capital, moderate O&M.
Treatment Actions	Physical/chemical treatment	**Dissolved air[2] flotation**	Effective for removal of solids.	Implementable.	Moderate capital and O&M.
Treatment Actions	Physical/chemical treatment	**Filtration[2]**	Effective for removal of suspended solids.	Readily implementable.	Moderate capital and O&M.
Treatment Actions	Physical/chemical treatment	**Precipitation/ flocculation/ sedimentation**	Effective for mercury and suspended solids removal.	Implementable. Bench-scale treatability testing required (e.g., to determine optimum combination of pH, precipitating and flocculating agents).	Moderate to high capital, moderate O&M.

TABLE 2-18 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
Treatment Actions	Physical/chemical treatment	**Membrane technology**	Effective for mercury removal. Effective for the removal of brackish waters. May need extensive pretreatment of the groundwater.	Implementable. Bench-scale treatability testing required.	High capital and O&M. Typically not used for general metals treatment.
Treatment Actions	Physical/chemical treatment	Ion exchange	Effective for mercury removal. Needs disposal of regeneration solution. Other process options which are more favorable to the site conditions are retained.	Implementable for mercury. Bench-scale treatability testing required.	Moderate to high capital and O&M.
Treatment Actions	Physical/chemical treatment	**Neutralization[2]**	Effective for pH control.	Implementable.	Moderate capital and O&M.
Disposal Actions	Discharge	**Surface discharge through existing NPDES permit**	Effective and reliable.	Readily implemented - facility already maintains NPDES permit.	Low capital, very low O&M.

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TABLE 2-18 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 GROUNDWATER BASED ON EFFECTIVENESS, IMPLEMENTABILITY AND COST

General Response Actions	Technology type	Process options*	Effectiveness[1]	Implementability	Cost
Disposal Actions	Discharge	Injection into subsurface zones	Effective if implemented properly.	Would require extensive hydrogeologic evaluation to ensure protection of drinking water aquifers. Subject to agency permit.	Moderate capital and O&M.

NOTES:

1 The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:

- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

2 Retained as potential pretreatment process option.

* Shaded process options are retained.

** Retained as a contingency measure.

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TABLE 2-19

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
No Action	None	None	The no action alternative would not prevent further contaminant migration downward to the Alluvial Aquifer. Although most areas beneath the landfill showed concentrations that were below the recommended preliminary soil action levels (PSALs), indicating only localized areas may be a continuing source. No action would include continued operation of the groundwater corrective action program (CAP) and Olin is committed by the legally enforceable RCRA post-closure permit to operate the ongoing corrective action program until the established cleanup standards are achieved. The RCRA CAP is effective at controlling off-site migration of the plume and at preventing exposure of surrounding residents to contaminated groundwater.	Implementable.	None
Institutional Actions	Monitoring	**Sampling**	Aids in the post-closure monitoring of SWMUs. Does not reduce contamination.	Readily implementable.	Low capital and O&M.
Containment Actions	Capping	**Clay cap**	Effective, susceptible to cracking, but has self-healing properties.	Easily implementable.	Low capital, low O&M.

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TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Containment Actions	Capping	Asphalt cap	Effective but susceptible to weathering and cracking; clay or multimedia cap more applicable for CPC landfill.	Easily implementable.	Low capital, high O&M.
Containment Actions	Capping	Concrete cap	Effective but susceptible to weathering and cracking; clay or multimedia cap more applicable for CPC landfill.	Easily implementable.	High capital, low O&M.
Containment Actions	Capping	**Multi-media cap**	Effective, proven, and reliable technology.	Easily implementable.	Moderate capital, low O&M.
Removal	Excavation	**Conventional excavation**	Effective method for waste and soil excavation.	Readily implementable.	Moderate capital, low to moderate O&M.
Treatment	Encapsulation/ fixation	**Stabilization/ solidification**	Effective in reducing the mobility of the chemicals and in also reducing the exposure to the contaminants. Primarily applicable to metals, although organics can be stabilized/solidified.	Implementable. Bench-scale testing would be required to determine the applicability of this technology to the organic wastes present at the site.	Moderate capital, low O&M.
Treatment	Physical/ chemical	**BEST®[2]**	Potentially effective in extracting the organics present at the site. Does not destroy the contaminants. Further treatment and/or disposal is necessary. Not applicable for mercury removal.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.

TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Physical/ chemical	**Liquified gas[2]**	Potentially effective in extracting the organics present at the site. Does not destroy the contaminants. Further treatment and/or disposal is necessary. Not applicable for mercury removal.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**LEEP™[2]**	Potentially effective in extracting the organics present at the site. Does not destroy the contaminants. Further treatment and/or disposal is necessary. Not applicable for mercury removal.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**APEG-PLUS™[2]**	Similar to APEG™. Potentially effective for dechlorinating the chlorinated organics present at the site. Not applicable for mercury removal. Further treatment (e.g., incineration, biological treatment, carbon adsorption) and/or disposal of the dechlorinated chemicals is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**Acid extraction**	Effective for mercury removal. Further treatment and disposal of mercury is necessary.	Implementable. Bench- and/or pilot-scale testing may be required.	Moderate capital, moderate O&M.

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TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Physical/ chemical	Oxidation/ reduction	Applicable to slurry with very low suspended solids content. Variable waste composition present at the site complicates this non-selective process. Presence of mixed wastes (mercury and organics) complicates this process. Chlorinated organics present at the site may form harmful byproducts. Chemical oxidation/reduction of the chlorinated organics at the site may be incomplete requiring further treatment.	Implementable. Bench- or pilot-scale treatability testing would be required.	Moderate capital, moderate O&M.
Treatment	Thermal	Fluidized bed	Destroys organics. Less effective than circulating bed combustor. Mercury, being a volatile metal, may impact process.	Implementable.	High capital and O&M.
Treatment	Thermal	**Circulating bed combustor[3]**	Effective and reliable. Destroys organics. Mercury, being a volatile metal, may impact process.	Implementable.	High capital and O&M.

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TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Thermal	**Rotary kiln[3] incineration**	Proven and reliable. Creates high particulates especially if the waste matrix has significant fines. Mercury, being a volatile metal, may impact process.	Implementable.	High capital and O&M.
Treatment	Thermal	**Infrared[3] incineration**	Effective and reliable technology. Destroys organics. Mercury, being a volatile metal, may impact process.	Implementable.	High capital and O&M.
Treatment	Thermal	Pyrolysis	Organics are destroyed. May require auxiliary fuel for low BTU wastes. Applicable to solids, sludges, and viscous liquids. Innovative technology - other thermal technologies that are more applicable to soils and are widely available are preferred.	Implementable.	High capital and O&M.
Treatment	Thermal	Vitrification	Organics are destroyed. Offers advantages over other thermal technologies when dealing with mixed and complex wastes. Mercury, being a volatile metal, may impact process. Innovative technology - other thermal technologies that are more demonstrated and widely available are preferred.	Implementable.	Moderate to high capital and O&M.

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TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Thermal	Advanced electric reactor	Effective for organics removal. Post-treatment for incomplete combustion may be required. Mercury, being a volatile metal, may impact process. Innovative technology - other incineration technologies which are more reliable and proven are preferred.	Implementable.	High capital and O&M.
Treatment	Thermal	**Thermal desorption**	Effective for the desorption of volatile and semivolatile organics. Volatile mercury could be desorbed. Further treatment and/or disposal is needed.	Implementable. Moisture content has to be low. Solids processing will be required as a pre-treatment step.	Moderate capital, moderate O&M.
Treatment	In situ	In situ vitrification	Effective for the destruction of the organics present at the site. Technology is best used for mixed, complex, and radioactive wastes. The concentrations of the organics present at the site are too low for this technology to be effectively implemented. Mercury, being a volatile metal, may impact process.	Implementable. This technology at the present time is being marketed by few vendors. Needs specialized equipment and trained operators. Not yet widely implemented for CERCLA sites.	High capital and O&M.

TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	In situ	**In situ stabilization/ solidification**	Effective in reducing the mobility of the chemicals. The in-situ process is more complicated and is more difficult to implement than the ex-situ process.	Bench-scale treatability studies would be required to determine the effectiveness of this technology for the site. May also require pilot-scale testing to evaluate applicability to in situ conditions.	Moderate capital, low O&M.
Treatment	In situ	In situ chemical treatment	The presence of various organic chemicals and mercury at the site along with naturally occurring organic and inorganic substances complicates the use of this process. The products of treatment may be more mobile and/or toxic than the parent chemicals. Limited information is currently available on the effectiveness and applicability of this process. Effectiveness of this technology is contingent upon treatability studies.	Bench- and pilot-scale treatability studies would be required. This process has not been widely demonstrated and in most cases is in bench- and/or pilot-scale testing.	Moderate capital and low O&M.

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TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site	**Off-site RCRA landfill**	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site.	Implementable. Waste has to be transported to the landfill. Land disposal restrictions may apply.	Very high capital, none to low O&M.
Disposal	Off-site	**Off-site non-RCRA landfill**	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site. Waste material would have to be nonhazardous.	Implementable. Waste has to be transported to the landfill. Waste material would have to be nonhazardous.	Very high capital, none to low O&M.
Disposal	On-site	**On-site RCRA landfill**	Effective for containment of waste. No reduction of chemical toxicity or volume.	Difficult to implement - minimum technical requirements (MTR) and land dispoal restrictions may apply. Agency and state/public acceptance could interfere.	Very high capital, moderate O&M.
Disposal	On-site	**On-site non-RCRA landfill**	Effective. Environmental impact is reduced at the site because of the treated materials.	Implementable. MTR and land disposal restrictions may apply.	Moderate capital and O&M.

TABLE 2-19 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN OLD PLANT (CPC) LANDFILL BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site incineration	**Off-site RCRA incineration**	Effective in the destruction of organics.	Implementable.	Very high capital

NOTES:

1 The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:

- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

2 Chemical extraction and dechlorination are retained. Further evaluation is required to select the most applicable process option.

3 Thermal treatment is retained. Further evaluation is required to select the most applicable process option.

* Shaded process options are retained.

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TABLE 2-20

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
No Action	None	None	The no action alternative would not prevent further contaminant migration downward to the Alluvial Aquifer, although soil concentrations were below the recommended preliminary soil action levels (PSALs), indicating a low potential for the soils to be a continuing source. No action would include continued operation of the groundwater corrective action program (CAP). Olin is committed by the legally enforceable RCRA post-closure permit to operate the ongoing corrective action program until the established cleanup standards are achieved. The RCRA CAP is effective at controlling off-site migration of the plume and at preventing exposure of surrounding residents to contaminated groundwater.	Implemetable.	None
Institutional Actions	Monitoring	**Sampling**	Aids in the post-closure monitoring of SWMUs. Does not reduce contamination.	Readily implementable.	Low capital and O&M.
Containment Actions	Capping	**Clay cap**	Effective, susceptible to cracking, but has self-healing properties.	Easily implementable.	Low capital, low O&M.

TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Containment Actions	Capping	Asphalt cap	Effective but susceptible to weathering and cracking; clay or multimedia cap more applicable for soils west of former CPC plant area.	Easily implementable.	Low capital, high O&M.
Containment Actions	Capping	Concrete cap	Effective but susceptible to weathering and cracking; clay or multimedia cap more applicable for soils west of former CPC plant area.	Easily implementable.	High capital, low O&M.
Containment Actions	Capping	**Multi-media cap**	Effective, proven, and reliable technology.	Easily implementable.	Moderate capital, low O&M.
Removal	Excavation	**Conventional excavation**	Effective method for waste and soil excavation.	Readily implementable.	Moderate capital, low to moderate O&M.
Treatment	Encapsulation/ fixation	**Stabilization/ solidification**	Effective in reducing the mobility of the chemicals and in also reducing the exposure to the contaminants. Primarily applicable to metals, although organics can be stabilized/solidified.	Implementable. Bench-scale testing would be required to determine the applicability of this technology to the organic wastes present at the site.	Moderate capital, low O&M.
Treatment	Physical/ chemical	**BEST®[2]**	Potentially effective in extracting the organics present at the site. Does not destroy the contaminants. Further treatment and/or disposal is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.

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TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Physical/ chemical	**Liquified gas**[2]	Potentially effective in extracting the organics present at the site. Does not destroy the contaminants. Further treatment and/or disposal is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**LEEP™**[2]	Potentially effective in extracting the organics present at the site. Does not destroy the contaminants. Further treatment and/or disposal is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**APEG-PLUS™**[2]	Similar to APEG™. Potentially effective for dechlorinating the chlorinated organics present at the site. Further treatment (e.g., incineration, biological treatment, carbon adsorption) and/or disposal of the dechlorinated chemicals is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	Oxidation/ reduction	Applicable to slurry with very low suspended solids content. Chlorinated organics present at the site may form harmful byproducts. Chemical oxidation/reduction of the chlorinated organics at the site may be incomplete requiring further treatment.	Implementable. Bench- or pilot-scale treatability testing would be required.	Moderate capital, moderate O&M.
Treatment	Thermal	Fluidized bed	Destroys organics. Less effective than circulating bed combustor.	Implementable.	High capital and O&M.

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TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Thermal	**Circulating bed combustor[3]**	Effective and reliable. Destroys organics.	Implementable.	High capital and O&M.
Treatment	Thermal	**Rotary kiln[3] incineration**	Proven and reliable. Creates high particulates especially if the waste matrix has significant fines.	Implementable.	High capital and O&M.
Treatment	Thermal	**Infrared[3] incineration**	Effective and reliable technology. Destroys organics.	Implementable.	High capital and O&M.
Treatment	Thermal	Pyrolysis	Organics are destroyed. May require auxiliary fuel for low BTU wastes. Applicable to solids, sludges, and viscous liquids. Innovative technology - other thermal technologies that are more applicable to soils and are widely available are preferred.	Implementable.	High capital and O&M.
Treatment	Thermal	Vitrification	Organics are destroyed. Offers advantages over other thermal technologies when dealing with mixed and complex wastes. Innovatice technology - other thermal technologies that are more demonstrated and widely available are preferred.	Implementable.	Moderate to high capital and O&M.

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TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Thermal	Advanced electric reactor	Effective for organics removal. Post-treatment for incomplete combustion may be required. Innovative technology - other incineration technologies which are more reliable and proven are preferred.	Implementable.	High capital and O&M.
Treatment	Thermal	**Thermal[3] desorption**	Effective for the desorption of volatile and semivolatile organics. Further treatment and/or disposal is needed.	Implementable. Moisture content has to be low.	Moderate capital, moderate O&M.
Treatment	In situ	In situ vitrification	Effective for the destruction of the organics present at the site. Technology is best used for mixed, complex, and radioactive wastes. The concentrations of the organics present at the site are too low for this technology to be effectively implemented.	Implementable. This technology at the present time is being marketed by few vendors. Needs specialized equipment and trained operators. Not yet widely implemented for CERCLA sites.	High capital and O&M.

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TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	In situ	**In situ stabilization/ solidification**	Effective in reducing the mobility of the chemicals. The in-situ process is more complicated and is more difficult to implement than the ex-situ process.	Bench-scale treatability studies would be required to determine the effectiveness of this technology for the site. May also require pilot-scale testing to evaluate applicability to in situ conditions.	Moderate capital, low O&M.
Treatment	In situ	In situ chemical treatment	The presence of various organic chemicals at the site along with naturally occurring organic and inorganic substances complicates the use of this process. The products of treatment may be more mobile and/or toxic than the parent chemicals. Limited information is currently available on the effectiveness and applicability of this process. Effectiveness of this technology is contingent upon treatability studies.	Bench- and pilot-scale treatability studies would be required. This process has not been widely demonstrated and in most cases is in bench- and/or pilot-scale testing.	Moderate capital and low O&M.

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TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site	**Off-site RCRA landfill**	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site.	Implementable. Waste has to be transported to the landfill. Land disposal restrictions may apply.	Very high capital, none to low O&M.
Disposal	Off-site	**Off-site non-RCRA landfill**	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site. Waste material would have to be nonhazardous.	Implementable. Waste has to be transported to the landfill. Waste material would have to be nonhazardous.	Very high capital, none to low O&M.
Disposal	On-site	**On-site RCRA landfill**	Effective for containment of waste. No reduction of chemical toxicity or volume.	Difficult to implement - minimum technical requirements (MTR) and land dispoal restrictions may apply. Agency and state/public acceptance could interfere.	Very high capital, moderate O&M.
Disposal	On-site	**On-site non-RCRA landfill**	Effective. Environmental impact is reduced at the site because of the treated materials.	Implementable. MTR and land disposal restrictions may apply.	Moderate capital and O&M.

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TABLE 2-20 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN AREA WEST OF FORMER CPC PLANT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site incineration	**Off-site RCRA incineration**	Effective in the destruction of organics.	Implementable.	Very high capital

NOTES:

1 The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:
- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

2 Chemical extraction and dechlorination are retained. Further evaluation is required to select the most applicable process option.

3 Thermal treatment is retained. Further evaluation is required to select the most applicable process option.

* Shaded process options are retained.

TABLE 2-21

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
No Action	None	**None**	Effective. Sanitary landfills are not a continuing source of groundwater contamination. No unacceptable risk to human health or the environment from exposure to contaminated soils exists.	Implementable.	No additional costs.
Institutional Actions	Monitoring/ maintenance	**Cap inspection/ maintenance**	Effective. Would ensure continued protection to human health and environment. Maintenance program will be documented. As erosion areas develop or as inspection reveals areas of inadequate cap depth, repairs will be made by importing soil to recover the areas. Grass will then be re-established.	Easily implementable.	Low capital, low O&M.
Institutional Actions	Monitoring	**Groundwater and surface water monitoring**	Would provide additional monitoring to ensure continued protection of groundwater and surface water.	Readily implementable.	Low capital and O&M.
Containment Actions	Capping	**Clay cap**	Effective at preventing contact to contaminated soils and increased protection of groundwater.	Easily implementable.	Low capital, low O&M.
Containment Actions	Capping	**Multi-media cap**	Effective at preventing contact to contaminated soils and increased protection of groundwater.	Easily implementable.	Moderate capital, low O&M.

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TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal	Excavation	Conventional excavation	Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective at ensuring long-term protectiveness.	Readily implementable.	Moderate capital, low to no O&M.

TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal Actions	Excavation	Excavation followed by mechanical separation	Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective at ensuring long-term protectiveness.	Moderately difficult to implement.	Moderate capital, low to no O&M.

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TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Encapsulation/ fixation	Stabilization/ solidification	The primary purpose of this technology is to reduce infiltration of contaminants from the soil matrix to the groundwater. Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. Therefore this technology would provide marginal if any increased effectiveness over existing conditions.	Implementable. Bench-scale testing would be required. Debris in landfill could make difficult.	High capital, low O&M.
Treatment	Physical/ chemical treatment	Acid Extraction	Mercury concentrations are too low for effective use of this technology and it would not treat the organics that are present. Removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective as ensuring long-term protectiveness.	Difficult to implement. Bench-scale testing would be required. Debris in landfill could make difficult. Disposal or treatment of residuals would be required.	High capital, low to no O&M.

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TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Thermal	Thermal desorption	Effective for the desorption of volatile and semivolatile organics. Volatile mercury could be desorbed. Further treatment and/or disposal is needed. Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective at ensuring long-term protectiveness.	Implementable. Moisture content has to be low. Solids processing will be required as a pre-treatment step. Debris in landfill could make difficult.	Very high capital, low to no O&M.

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TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	In situ	In situ stabilization/ solidification	Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. Therefore this technology would provide marginal if any increased effectiveness over existing conditions.	Bench-scale treatability studies would be required. May also require pilot-scale testing to evaluate applicability to in situ conditions. Debris in landfill could make difficult.	Moderate to high capital, low O&M.

TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site	Off-site landfill	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site. Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective at ensuring long-term protectiveness.	Implementable. Waste has to be transported to the landfill. Land disposal restrictions may apply.	Very high capital, none to low O&M.

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TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	On-site	On-site landfill	Effective for containment of waste. No reduction of chemical toxicity or volume. Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective at ensuring long-term protectiveness.	Difficult to implement - minimum technical requirements (MTR) and land disposal restrictions may apply. Agency and state/public acceptance could interfere.	Very high capital, moderate O&M.

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TABLE 2-21 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN SANITARY LANDFILLS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site incineration	Off-site RCRA incineration	Effective in the destruction of organics. Landfill soils are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that do not involve potential worker exposure from excavation and are less costly, would be as effective at ensuring long-term protectiveness.	Implementable.	Very high capital

NOTES:

[1] The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:
- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

* Shaded process options are retained.

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TABLE 2-22

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
No Action	None	**None**	Effective. Lime ponds are not a continuing source of groundwater contamination. No unacceptable risk to human health or the environment from exposure to lime waste exists.	Implementable.	No additional costs.
Institutional Actions	Monitoring/ maintenance	**Cap inspection/ maintenance**	Effective. Would ensure continued protection to human health and environment. Maintenance program will be documented. As erosion areas develop or as inspection reveals areas of inadequate cap depth, repairs will be made by importing soil to recover the areas. Grass will then be re-established.	Easily implementable.	Low capital, low O&M.
Institutional Actions	Monitoring	**Groundwater monitoring**	Would provide additional monitoring to ensure continued protection of groundwater.	Readily implementable.	Low capital and O&M.
Containment Actions	Capping	**Clay cap**	Effective at preventing contact to lime waste and increased protection of groundwater.	Easily implementable.	Low capital, low O&M.
Containment Actions	Capping	**Multi-media cap**	Effective at preventing contact to lime waste and increased protection of groundwater. Provides increased protectiveness over clay cap due to drainage layer.	Easily implementable.	Moderate capital, low O&M.

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TABLE 2-22 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Contaminant	Vertical barriers	Sheet pilings	If implementable, potentially effective at preventing lateral migration of perched water. Capping techniques would be more effective, easier to implement and less cost.	Difficult to implement due to steep slope of lime ponds in vicinity of where sheet piles would be constructed.	Moderate capital, low O&M.
Contaminant	Vertical barriers	Slurry walls	If implementable, potentially effective at preventing lateral migration of perched water. Capping technologies would be more effective, easier to implement and less cost.	Difficult to implement due to steep slope of lime ponds in vicinity of where slurry wall would be constructed.	Moderate capital, low O&M.
Contaminant	Horizontal barriers	Grout Injection	If implementable, potentially effective at preventing lateral migration of perched water. Capping technologies would be more effective, easier to implement and less cost.	Difficult to implement due to ash matrix.	Moderate capital, low O&M.

TABLE 2-22 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal	Excavation	Conventional excavation	Lime ponds are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the ponds were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of lime waste to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that are easier to implement and less cost, would be as effective at ensuring long-term protectiveness.	Readily implementable.	Moderate capital, low to no O&M.

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TABLE 2-22 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal Actions	Excavation	Excavation followed by mechanical separation	Lime ponds are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the ponds were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of lime waste to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that are easier to implement and less cost, would be as effective at ensuring long-term protectiveness.	Moderately difficult to implement.	Moderate capital, low to no O&M.
Removal Actions	Groundwater extraction	Remove perched groundwater	Unless wells were very closely spaced, perched water would remain. Technologies to reduce infiltration would be more effective. Recovered water may require treatment.	Would take numerous wells for effective implementation. Ash matrix may cause plugging of wells.	Moderate capital, low to moderate O&M.

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TABLE 2-22 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Physical/ chemical treatment	Acid extraction	Mercury concentrations are too low for effective use of this technology. Process would also have questionable effectiveness at removing mercury from lime matrix. Removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that are easier to implement and less cost would be as effective at ensuring long-term protectiveness.	Difficult to implement. Bench-scale testing would be required. Disposal or treatment of residuals would be required.	High capital, low to no O&M.

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TABLE 2-22 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site	Off-site landfill	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site. Waste material would have to be nonhazardous. Lime ponds are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the ponds were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of lime waste to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that are easier to implement and less cost, would be as effective at ensuring long-term protectiveness.	Implementable. Waste has to be transported to the landfill. Waste material would have to be nonhazardous.	Very high capital, none to low O&M.

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TABLE 2-22 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE LIME PONDS BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	On-site	On-site landfill	Effective. Environmental impact is reduced at the site because of the treated materials. Lime ponds are not a continuous source of groundwater contamination. The fate and transport analysis indicates that even if the ponds were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of lime waste to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. Other alternatives that are easier to implement and less cost, would be as effective at ensuring long-term protectiveness.	Implementable. MTR and land disposal restrictions may apply.	Moderate capital and O&M.

NOTES:

1 The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:
- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

* Shaded process options are retained.

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TABLE 2-23

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
No Action	None	None	Effective. Soils in mercury cell plant area are not a continuing source of groundwater contamination. No unacceptable risk to human health or the environment from exposure to contaminated soils.	Implementable.	No additional costs.
Institutional Actions	Monitoring/ maintenance	**Cap inspection/ maintenance**	Effective. Would ensure continued protection to human health and environment. Maintenance program will be documented. As inspection reveals areas of inadequate cover or damage to cover (i.e., cracks), repairs will be made by application of asphalt.	Easily implementable.	Low capital, low O&M.
Institutional Actions	Monitoring	**Groundwater monitoring**	Would provide additional monitoring to ensure continued protection of groundwater.	Readily implementable.	Low capital and O&M.
Containment Actions	Capping	Clay cap	Would not provide increased protectiveness from human health and environmental exposure to contaminated soils (i.e., compared to properly maintained existing capping system). Mercury cell plant soils are not a continuing source of groundwater contamination. Clay cap would provide marginal, if any, increased protectiveness to groundwater.	Easily implementable.	Low capital, low O&M.

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TABLE 2-23 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Contaminant Actions	Capping	Concrete	Would not provide increased protectiveness from human health and environmental exposure to contaminated soils (i.e., compared to properly maintained existing capping system). Mercury cell plant soils are not a continuing source of groundwater contamination. Concrete cap would provide marginal, if any, increased protectiveness to groundwater.	Easily implementable.	Moderate capital, low O&M.
Containment Actions	Capping	Multi-media cap	Would not provide increased protectiveness from human health and environmental exposure to contaminated soils (i.e., compared to properly maintained existing capping system). Mercury cell plant soils are not a continuing source of groundwater contamination. Multimedia cap would provide marginal, if any, increased protectiveness to groundwater.	Easily implementable.	Moderate capital, low O&M.

TABLE 2-23 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal	Excavation	Conventional excavation	Soils in mercury cell plant area are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the area was not capped the soils would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions.	Readily implementable.	Moderate capital, low to no O&M.

TABLE 2-23 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal Actions	Excavation	Excavation followed by mechanical separation	Soils in mercury cell plant area are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the area was not capped the soils would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions.	Moderately difficult to implement.	Moderate capital, low to no O&M.
Treatment	Physical/ chemical treatment	Acid extraction	Questionable effectiveness due to clay matrix. Removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions.	Difficult to implement. Bench-scale testing would be required. Disposal or treatment of residuals would be required.	High capital, low to no O&M.

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TABLE 2-23 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Treatment	Thermal	Thermal desorption	Volatile mercury could be desorbed. Further treatment and/or disposal is needed. Soils in mercury cell plant area are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the soils were not capped they would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions.	Bench-scale tests would be required to determine implementability for mercury. Solids processing would be required as a pretreatment step. Potential debris could make difficult.	Very high capital, low to no O&M.

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TABLE 2-23 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site	Off-site landfill	Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site. Soils in mercury cell plant area are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the area was not capped the soils would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions.	Implementable. Waste has to be transported to the landfill. Land disposal restrictions may apply.	Very high capital, none to low O&M.

TABLE 2-23 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE MERCURY CELL PLANT AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	On-site	On-site landfill	Effective for containment of waste. No reduction of chemical toxicity or volume. Soils in mercury cell plant area are not a continuing source of groundwater contamination. The fate and transport analysis indicates that even if the area was not capped the soils would not be a continuing source of groundwater contamination. The cap prevents contact of contaminated soils to humans and contaminated surface water runoff that could affect the environment. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions.	Difficult to implement - minimum technical requirements (MTR) and land disposal restrictions may apply. Agency and state/public acceptance could interfere.	Very high capital, moderate O&M.

NOTES:

[1] The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:

- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

* Shaded process options are retained.

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4 9 0251

TABLE 2-24

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE WELL SAND RESIDUE AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
No Action	None	None	Effective. The well sands are not a continuing source of groundwater contamination. No unacceptable risk to human health or the environment from exposure to well sand exists.	Implementable.	No additional costs.
Institutional Actions	Monitoring	Groundwater and surface water monitoring	Groundwater monitoring would provide marginal, if any, increased effectiveness over existing conditions because the well sands do not leach mercury (based on the TCLP test) and there are existing RCRA quarterly monitor wells in the area. Surface water monitoring is already conducted directly downgradient of the well sand area for Olin's stormwater sampling program.	Readily implementable.	Low capital and O&M.
Containment Actions	Capping	Clay cap	Would be effective at preventing contact to well sand and would provide increased protection to groundwater and surface water.	Easily implementable.	Low capital, low O&M.

4 9 0252
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TABLE 2-24 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE WELL SAND RESIDUE AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Containment Actions	Capping	Multi-media cap	Would be effective at preventing contact to well sand and would provide increased protection to groundwater and surface water. The multi-media cap may provide additional protection from infiltration than other capping/covering options, but would provide only marginal, if any, increased protectiveness. The well sands do not leach mercury (based on the TCLP tests) and therefore reduction of infiltration is not the primary objective of the capping/covering options.	Easily implementable.	Moderate capital, low O&M.
Containment Actions	Covering	Soil cover	Would be effective at preventing contact to well sand and would provide increased protection to groundwater and surface water.	Easily implementable.	Low capital, low O&M.

TABLE 2-24 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE WELL SAND RESIDUE AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Removal	Excavation	**Conventional excavation**	The TCLP test indicates that mercury does not leach from the well sand and therefore the material is not a continuing source of groundwater contamination. The stormwater permit sampling showed that there is no unacceptable surface water runoff from the area. The sands are fenced to control access. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. The containment options, which are easier to implement and less cost, would be as effective at ensuring long-term protectiveness. Because the well sands are in mounds, re-grading and moving the material may be required prior to containment. Therefore excavation is retained for use with the containment options.	Readily implementable.	Moderate capital, low to no O&M.

TABLE 2-24 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE WELL SAND RESIDUE AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	Off-site	Off-site landfill	The TCLP test indicates that mercury does not leach from the well sand and therefore the material is not a continuing source of groundwater contamination. The stormwater permit sampling showed that there is no unacceptable surface water runoff from the area. The sands are fenced to control access. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. The containment options, which are easier to implement and less cost, would be as effective at ensuring long-term protectiveness.	Implementable. Waste has to be transported to the landfill. Land disposal restrictions may apply.	Very high capital, none to low O&M.

TABLE 2-24 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE WELL SAND RESIDUE AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	On-site	On-site disposal	The TCLP test indicates that mercury does not leach from the well sand and therefore the material is not a continuing source of groundwater contamination. The stormwater permit sampling showed that there is no unacceptable surface water runoff from the area. The sands are fenced to control access. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. The containment options, which are easier to implement and less cost, would be as effective at ensuring long-term protectiveness.	Difficult to implement - minimum technical requirements (MTR) and land disposal restrictions may apply. Agency and state/public acceptance could interfere.	Very high capital, moderate O&M.

TABLE 2-24 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-1 SOIL IN THE WELL SAND RESIDUE AREA BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process Options*	Effectiveness[1]	Implementability	Cost
Disposal	On-site	**On-site consolidation**	The TCLP test indicates that mercury does not leach from the well sand and therefore the material is not a continuing source of groundwater contamination. The stormwater permit sampling showed that there is no unacceptable surface water runoff from the area. The sands are fenced to control access. Removal followed by disposal or removal followed by treatment actions would provide marginal, if any, increased effectiveness over existing conditions. The containment options, which are easier to implement and less cost, would be as effective at ensuring long-term protectiveness. On-site consolidation is retained for containment options in which the material would be re-graded and moved, as preparation for the cover or capping material.	Implementable.	Moderate to low capital and O&M.

NOTES:

1 The effectiveness evaluation is based on the ability of the process option to achieve the remedial action objective. The evaluation focused on the following:
- The potential effectiveness of process options in handling each medium and meeting the goals identified in the general response actions.
- The effectiveness of the process options in protecting human health and the environment during the construction and implementation phases.
- The proven history and reliability of the process options with respect to contaminants and conditions such as those at the site.

* Shaded process options are retained.

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TABLE 2-25

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
No Action	None	**None**	Considered effective for protection of human health. Effectiveness at meeting environmental remediation goals is questionable and additional investigation is planned.	Implementable.	None
Institutional Actions	Access restrictions	**Fencing**	Provides access restrictions thereby reducing exposure to the chemicals. Does not reduce contamination.	Easily implementable.	Low capital and O&M costs.
Institutional Actions	Access restrictions	**Fishing restrictions**	Regulates human consumption of any contaminated fish. Does not reduce contamination.	Easily implementable. Some fishing restrictions already exist. Would require increased enforcement.	Low capital and O&M costs.
Institutional Actions	Monitoring	**Sediment and fish monitoring**	Effective in monitoring the quality of fish and sediment. Monitoring of sedimentation rates could be used to assess the rate of natural recovery. Does not reduce contamination. Does not eliminate exposure of fish to the contaminants.	Easily implementable.	Low capital and O&M costs.

TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Containment Actions	Encapsulation	**Covering**	Potentially applicable for basin to reduce exposure to contaminated sediments. Potentially effective for ditches in reducing exposure to the contaminated sediments and in containing sediment transport. May be effective to some extent in restricting the downward migration of the contaminants. Contaminant concentration is not reduced.	Could not be implemented in basin without disruption of the OU-2 basin ecosystem. Moderately difficult to implement in wastewater ditch due to extent of ditch and the necessity to reroute the flow.	Moderate capital, low O&M.
Containment Actions	Encapsulation	**Backfilling**	Effective in reducing exposure to the contaminated sediments and in containing sediment transport. May be effective to some extent in restricting the downward migration of the contaminants. Contaminant concentration is not reduced. Basin ecosystem would be modified and the site hydrology altered. Land use is altered.	Moderately difficult to implement due to the very high volume of backfill required. Would require permitting due to the impact on wetlands.	Moderate capital, low O&M.

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TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Containment Actions	Encapsulation	Sedimentation	Effective in reducing exposure to the contaminated sediments and in containing sediment transport. May be effective to some extent in restricting the downward migration of the contaminants. Contaminant concentration is not reduced. Is a slower process than other encapsulation processes.	Difficult to implement due to dynamic nature of basin hydraulics. Hydrologic and sedimentation studies would have to be conducted. Pilot-scale testing may be required for enhanced or expedited sedimentation processes.	Moderate capital and low O&M.
Containment Actions	Encapsulation	**Stabilization/[1] solidification**	Effective in reducing exposure to the contamination. Effective in reducing the mobility of the contaminants. Will destroy the biotic zone of the basin. Is more applicable to the ditch sediments.	Implementable for ditch sediments. Bench-scale testing would be required.	Moderate to high capital, low O&M.
Removal	Excavation	**Conventional excavation[1]**	Effective method for removing dry ditch sediments and soils. Not applicable to basin sediments.	Easily implementable for ditch sediments.	Moderate capital, low to moderate O&M.
Removal	Dredging	**Mechanical**	Effective for sediment dredging. Large amounts of sediments may be resuspended. Dredged material must be rehandled.	Implementable.	Moderate to High.

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TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Removal	Dredging	**Hydraulic**	Effective for sediment dredging. Resuspension of sediments is limited. Production capacity generally higher than mechanical dredging. Rehandling of dredged material could be eliminated. Large volumes of water removed with the sediment must be treated. Most debris cannot be removed.	Some of the hydraulic dredges are only transportable on navigable waters. Some dredges have vessel length/draft limitation.	Moderate.
Removal	Dredging	Pneumatic	Effectiveness similar to that of the hydraulic dredges. Pneumatic dredges produce slurries of higher solids content and cause less resuspension of sediments.	Not widely available. Pneumatic dredges require a minimum of 7 1/2 feet of water. This depth limitation will be a limiting factor for its application at the OU-2 basin.	Moderate.
Treatment	Encapsulation/ fixation	**Stabilization/ solidification**	Effective in reducing the mobility of the chemicals and in also reducing the exposure to the contaminants. Primarily applicable to metals although some organics can also be stabilized/solidified.	Bench- and/or pilot-scale testing would be required.	Moderate to high capital, low O&M.
Treatment	Physical/ chemical	**BEST®[2]**	Potentially effective in extracting hexachlorobenzene and other organics at the site. Not effective for mercury removal. Does not destroy the contaminants. Further treatment and/or disposal is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.

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TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Treatment	Physical/ chemical	**Liquified gas**[2]	Potentially effective in extracting hexachlorobenzene and other organics at the site. Not effective for mercury removal. Does not destroy the contaminants. Further treatment and/or disposal is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**LEEP**[SM2]	Potentially effective in extracting hexachlorobenzene and other organics at the site. Not effective for mercury removal. Does not destroy the contaminants. Further treatment and/or disposal is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	Supercritical extraction	Similar to liquified gas extraction but operates at different pressures and temperatures. Potentially effective for extracting hexachlorobenzene and other organics at the site. Not effective for mercury removal. Does not destroy the contaminants. Further treatment and/or disposal is necessary. Liquified gas has been experienced to be more practical than this technology.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	**Acid extraction**	Effective for mercury removal. Further treatment and disposal of mercury is necessary.	Implementable. Bench- and/or pilot-scale testing may be required.	Moderate capital, moderate O&M.

4 9 0257

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TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Treatment	Physical/ chemical	APEG™	Effective for dechlorinating chlorinated organics. Not applicable for mercury removal. Further treatment (e.g., incineration, biological treatment, carbon adsorption) and/or disposal of the dechlorinated chemicals is necessary.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.
Treatment	Physical/ chemical	APEG-PLUS™[2]	Similar to APEG™. Effective for dechlorinating the hexachlorobenzene. Not applicable for mercury removal. Further treatment (e.g., incineration, biological treatment, carbon adsorption) and/or disposal of the dechlorinated chemicals is necessary. This process is potentially more applicable than APEG™.	Implementable. Bench- and/or pilot-scale testing would be required.	Moderate capital, moderate O&M.

TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Treatment	Physical/ chemical	Oxidation/ reduction	Applicable to slurry with very low suspended solids content. Presence of mixed wastes (metals and organics) complicates this process. Chlorinated organics present at the site may form harmful byproducts. Chemical oxidation of the chlorinated organics at the site may be incomplete requiring further treatment. The high organic content present at the site complicates the redox reactions, requiring large amounts of reagents.	Implementable. Treatability testing would be required.	Moderate capital, moderate O&M.
Treatment	Thermal	Fluidized bed	Destroys organics. Not applicable to mercury removal. Mercury being a volatile metal may impact the process. Less effective than circulating bed combustor.	Implementable.	High capital and O&M costs.
Treatment	Thermal	**Circulating bed combustor**[3]	Recently demonstrated effective and reliable. Destroys organics. Not applicable for mercury removal. Mercury being a volatile metal may impact the process. Is more efficient than fluidized bed	Implementable. Availability is questionable.	High capital and O&M costs.

4 9 0258 Woodward-Clyde

TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Treatment	Thermal	**Rotary kiln[3] incineration**	Proven and reliable. Mercury may impact the process. Creates high particulates.	Implementable. Mobile units available.	High capital and O&M costs.
Treatment	Thermal	**Infrared[3] incineration**	Effective and reliable technology. Destroys organics. Mercury may impact the process. Applicable to silt/clay particle sizes and high moisture content (up to 50 percent by weight).	Implementable. Mobile units available.	High capital and O&M costs.
Treatment	Thermal	Pyrolysis	Organics are destroyed. May require auxiliary fuel for low BTU wastes. Mercury may impact the process. Applicable to solids, sludges, and viscous liquids. Other thermal processes, which are more conducive to sediments, (fine silty clay) are preferred.	Other available mobile technologies that can process high volumes per day are preferred.	High capital and O&M costs.
Treatment	Thermal	Vitrification	Organics are destroyed. Mercury may impact this process. Other thermal technologies that are more widely demonstrated are more applicable.	Implementable. Moisture content has to be very low.	High to moderate capital and O&M costs.
Treatment	Thermal	Advanced electric reactor	Effective for organics removal. Post-treatment for incomplete combustion may be required. Mercury may impact the process. Innovative technology.	Other incineration technologies are considered more reliable and are proven more applicable	High capital and O&M costs.

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TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Treatment	Thermal	**Thermal desorption**	Effective for the desorption of volatiles and semi-volatiles. Elemental mercury may also be desorbed. Further treatment and/or disposal is needed.	Implementable. Moisture content has to be low.	Moderate capital, moderate O&M.
Disposal	Off-site	**Off-site RCRA landfill**	Sediments in OU-2 have to be dewatered thoroughly. Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site.	Implementable. Waste has to be transported to the landfill. Land ban restrictions may apply.	Very high capital, none to low O&M.
Disposal	Off-Site	**Off-site non-RCRA landfill**	Sediments in OU-2 have to be dewatered thoroughly. Effective for containment of waste. No reduction of chemical toxicity or volume. Contaminants are removed from the site.	Implementable if material is classified as nonhazardous. Waste has to be trasported to landfill.	High to very high capital, none to low O&M.
Disposal	On-site	**On-site RCRA landfill**	Sediments in OU-2 have to be dewatered thoroughly. Effective for containment of waste. No reduction of chemical toxicity or volume.	Difficult to implement - minimum technical requirements (MTR) and land disposal restrictions may apply. Agency and state/public acceptance could interfere.	Very high capital, moderate O&M.
Disposal	On-site	**On-site non-RCRA landfill**	Effective. Environmental impact is reduced at the site because of the treated materials	Implementable. MTR and land ban restrictions may apply.	Moderate to high capital and O&M costs.

4 9 0259 Woodward-Clyde

TABLE 2-25 (Continued)

EVALUATION OF PROCESS OPTIONS FOR OU-2 SEDIMENT
BASED ON EFFECTIVENESS, IMPLEMENTABILITY, AND COST

General Response Actions	Technology Type	Process options*	Effectiveness	Implementability	Cost
Disposal	Off-site incinerator	**Off-site RCRA incineration**	Effective in the destruction of organics. May require pretreatment or residuals treatment for mercury.	Implementable.	Very high capital.

NOTES:

1 Retained for ditches only.
2 Chemical extraction and dechlorination are retained as a sediment treatment technology for organics. Further evaluation is required to select the most applicable process option.
3 Thermal treatment is retained. Further evaluation is required to select the most applicable process option.

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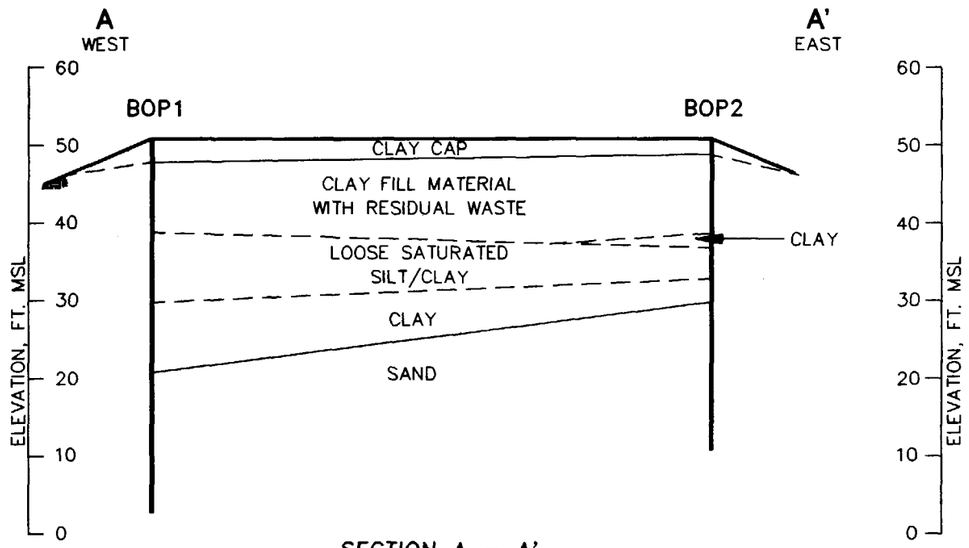
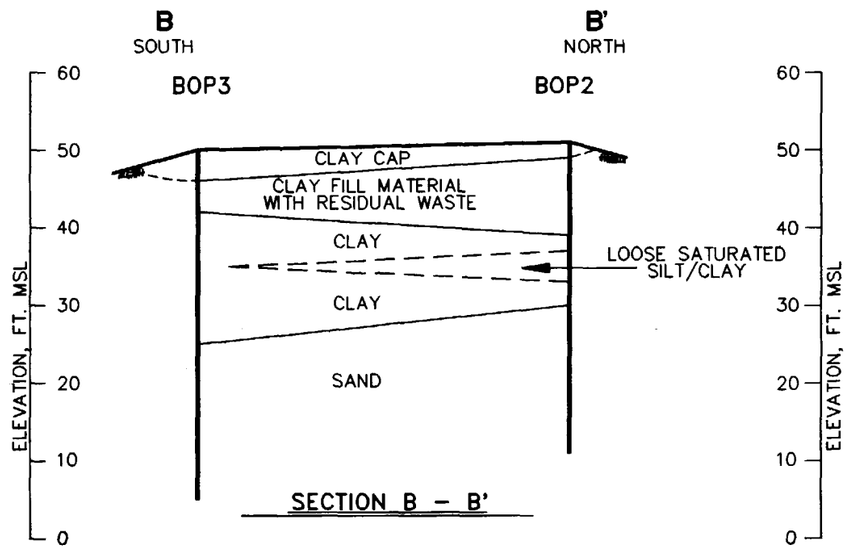
FIGURES



SECTION A – A'

HORIZONTAL SCALE: 1 INCH=80 FEET

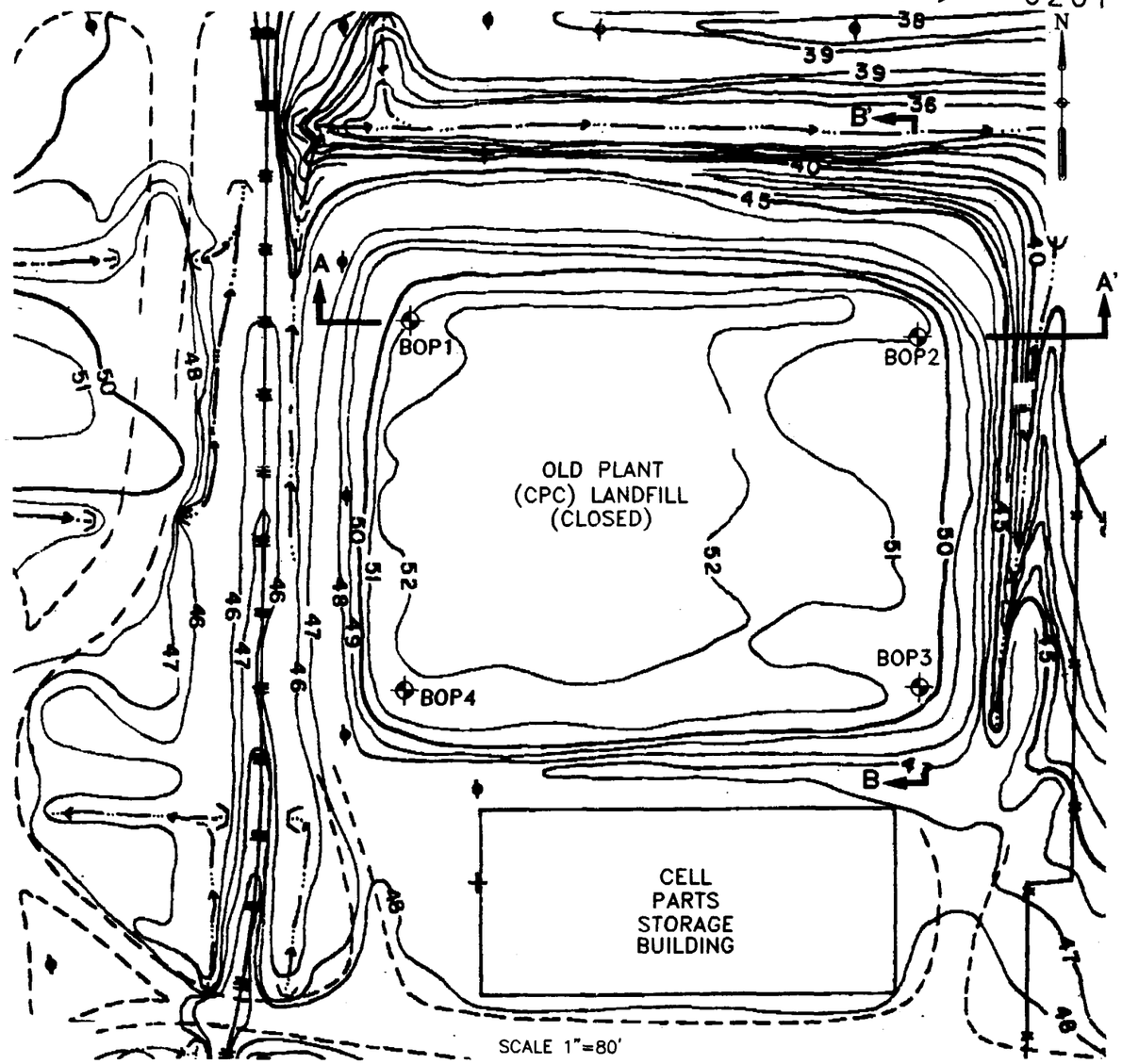
80' 0 80'



SECTION B – B'

HORIZONTAL SCALE: 1 INCH=80 FEET

80' 0 80'



DATE	REVISION	DRWN/CHKD

OU-1 CPC LANDFILL

Woodward-Clyde Consultants
Consulting Engineers, Geologists
and Environmental Scientists
Baton Rouge, Louisiana

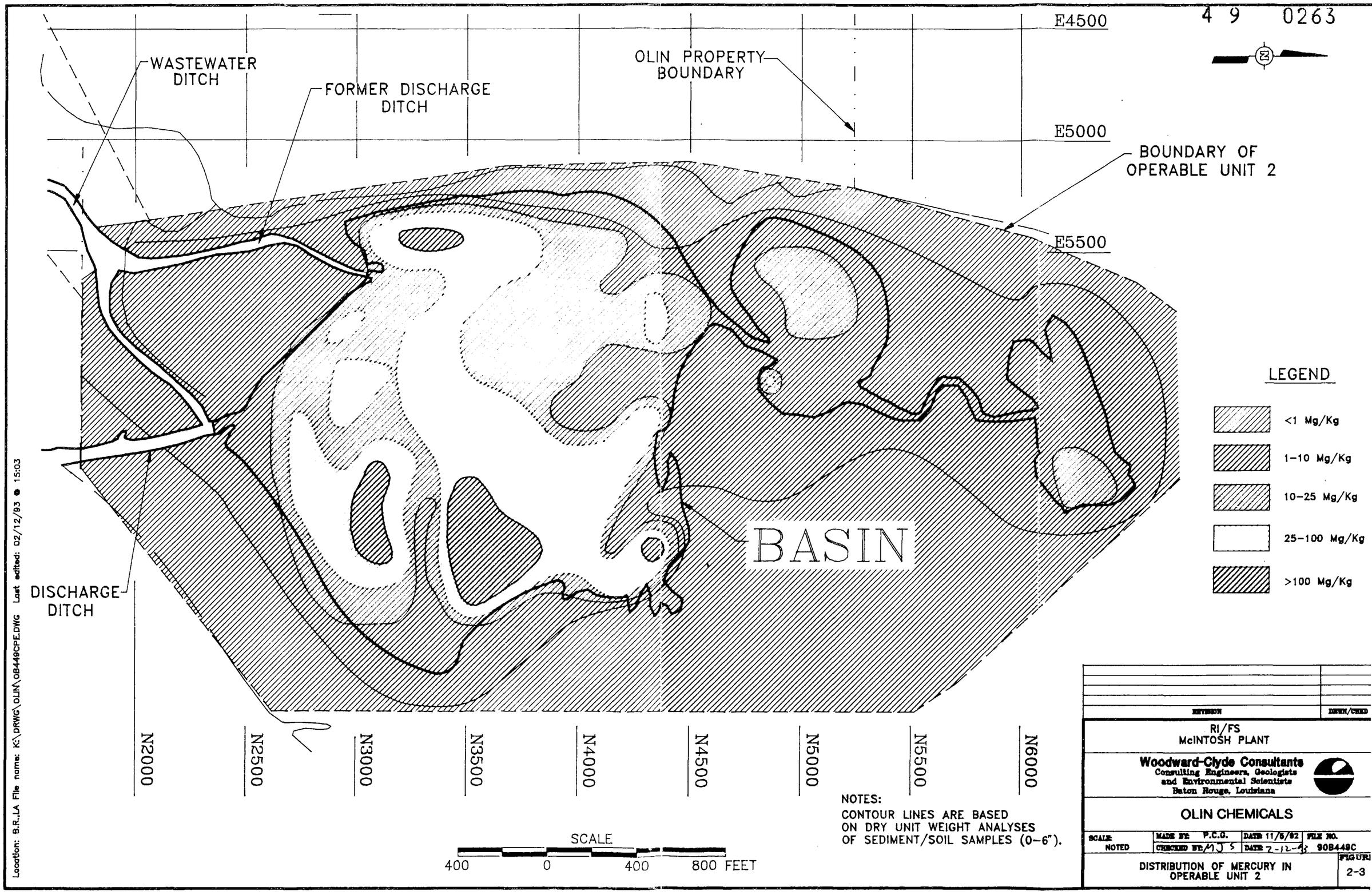
OLIN CHEMICALS

SCALE:	MADE BY: G. THORNTON	DATE: 3/19/93	FILE NO.
AS SHOWN	CHECKED BY:	DATE: 5/4/93	90B449C

OLD PLANT (CPC) LANDFILL
EXISTING SITE CONDITIONS
(PLAN VIEW AND CROSS SECTIONS)

FIGURE 2-1

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CBA.DWG Last edited: 05/04/93 @ 11:50



NOTES:
CONTOUR LINES ARE BASED ON DRY UNIT WEIGHT ANALYSES OF SEDIMENT/SOIL SAMPLES (0-6").

Location: B.R.,LA File name: K:\DRWG\OLIN\0B449CPE.DWG Last edited: 02/12/93 @ 15:03

REVISION	DRWN/CHKD

RI/FS
McINTOSH PLANT

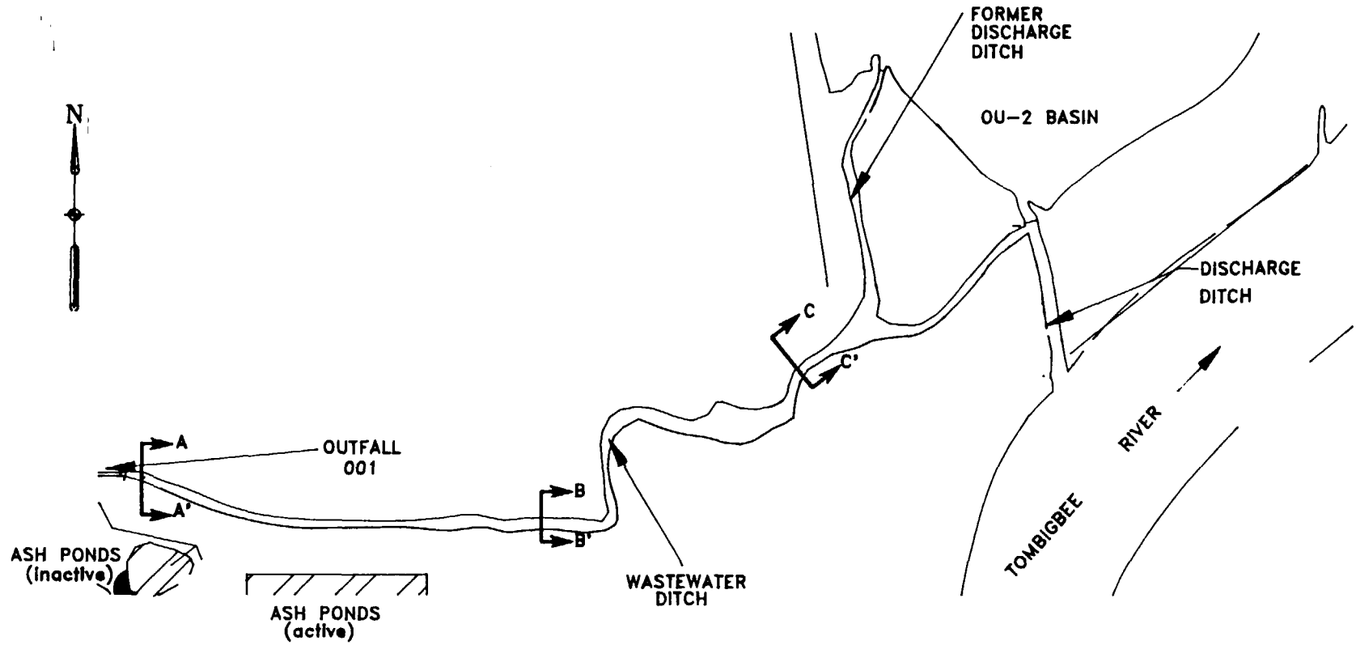
Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists
Baton Rouge, Louisiana

OLIN CHEMICALS

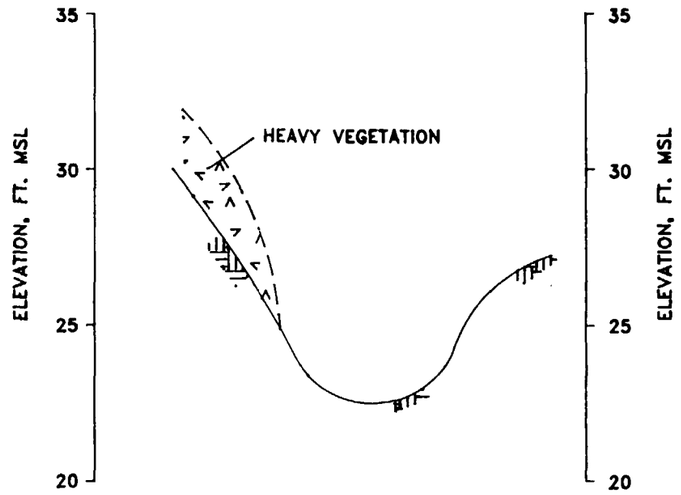
SCALE: NOTED	MADE BY: P.C.G.	DATE 11/5/92	FILE NO. 90B449C
	CHECKED BY: MJS	DATE 2-12-93	

DISTRIBUTION OF MERCURY IN OPERABLE UNIT 2

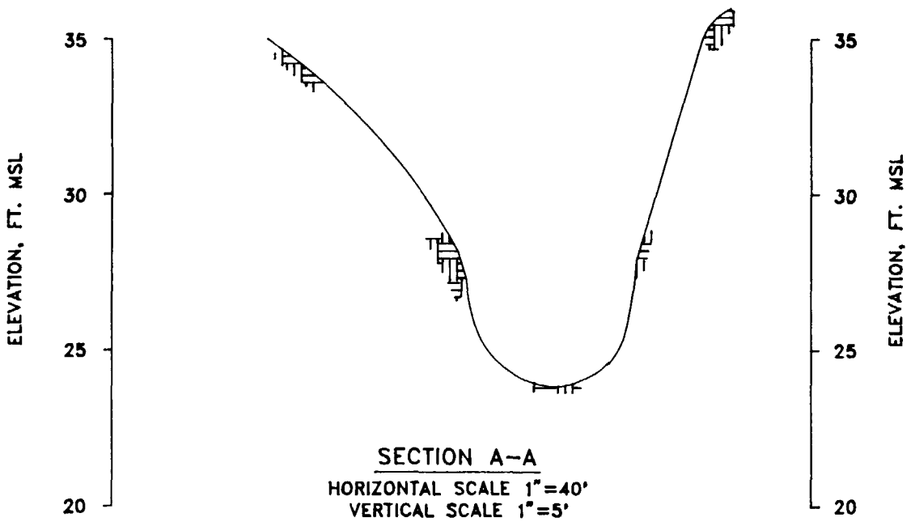
FIGURE 2-3



PLAN VIEW
N.T.S.



SECTION C-C
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'



SECTION A-A
HORIZONTAL SCALE 1"=40'
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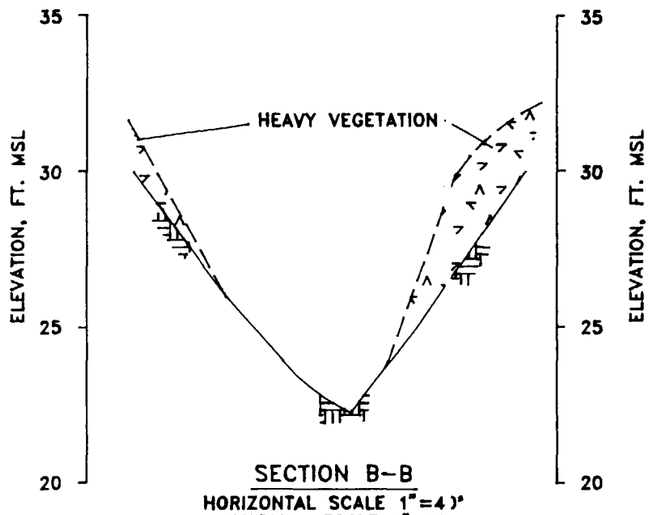


SECTION B-B
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'

DATE	REVISION	DRWN/CHKD

OU-2 WASTEWATER DITCH

Woodward-Clyde Consultants
Consulting Engineers, Geologists and Environmental Scientists
Baton Rouge, Louisiana

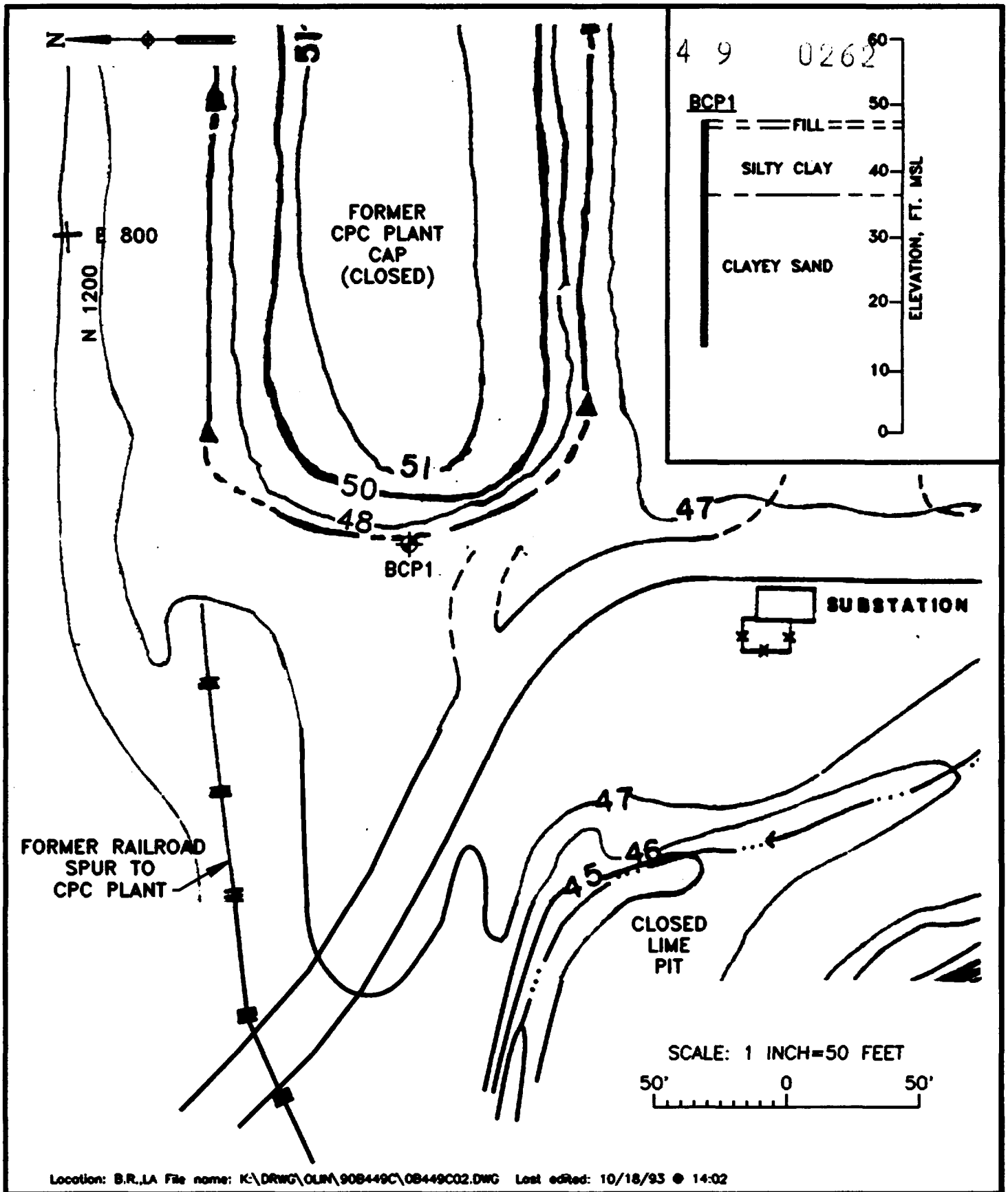
OLIN CHEMICALS

SCALE: 1"=40'	MADE BY: J. BICKFORD	DATE: 3/20/88	FILE NO. 90B449C
	CHECKED BY: F. Sierra	DATE: 5/3/93	

OU-2 WASTEWATER DITCH
EXISTING SITE CONDITIONS
(PLAN VIEW AND CROSS SECTIONS)

FIGURE 2-4

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CEA.DWG Last edited: 04/07/93 ● 14:59



Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449C02.DWG Last edited: 10/18/93 @ 14:02

OLIN CHEMICALS	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	OU-1 SOILS EXISTING SITE CONDITIONS AREA WEST OF FORMER CPC PLANT (PLAN VIEW & CROSS SECTION)	FILE NO. 90B449C FIG. NO. 2-2
	SCALE: AS NOTED · DRAWN BY: PCG · DATE: 10/20/93 · CHKD. BY: · DATE:		

Section 3

3.0
DEVELOPMENT AND SCREENING OF REMEDIAL ACTION ALTERNATIVES

Remedial alternatives were developed to provide a range of cleanup options to address the RAOs for potentially affected media. These alternatives were assembled from the retained technology types and process options described in Section 2.0 for OU-1 groundwater, OU-1 soil and OU-2 sediment. This section describes the assembled alternatives and provides the initial screening of alternatives based on effectiveness, implementability and cost.

Effectiveness was evaluated by considering each alternative's ability to protect human health and the environment and reduce the toxicity, mobility and volume of contaminants. Implementability was evaluated by considering both the administrative and technical feasibility of constructing, maintaining and operating the alternatives. A major consideration was how the process options would work together for the implementation of alternatives.

For the screening of alternatives, more emphasis was placed on effectiveness and implementability than on cost. Cost was qualitatively evaluated as low, moderate, high and very high. This evaluation was performed primarily by comparing unit costs among the alternatives within the same medium using the following sources: EPA's Vendor Information System for Innovative Treatment Technologies (VISITT Version 1.0, June 1992); database; EPA's Alternative Treatment Technology Information Center (ATTIC) bulletin board system; superfund innovative technology evaluation (SITE) documents; R.S. Means Site and Construction Cost Manual; technology vendors; and past and current experience with similar projects. Although the emphasis was on comparative rather than actual cost, the following is a general cost range associated with the qualifiers used for screening of the alternatives:

Groundwater Alternatives (Based on total alternative cost)

< $1,000,000 - Low
$1,000,000 to $5,000,000 - Moderate
>5,000,000 to $10,000 - High
>$10,000 - Very High

Soil and Sediment Alternatives (Based on unit cost)

< $75 per cubic yard - Low
$75 to $225 per cubic yard - Moderate
$225 to $500 per cubic yard - High
> $500 per cubic yard - Very High

3.1 OU-1 GROUNDWATER ALTERNATIVES

The RI data indicated that the existing Corrective Action Program (CAP) is effective at controlling contaminant migration from any known past or current sources. A description of the CAP is presented in Section 1.2.4. Continuation of the existing CAP is considered the no-action alternative because Olin is required by a legally enforceable RCRA post-closure permit to maintain the CAP until the established cleanup standards are achieved. The assembled groundwater alternatives also include institutional actions involving increased groundwater monitoring and control of groundwater usage. The other assembled alternatives were designed to increase the rate of contaminant removal through extraction or enhanced extraction and would be implemented to augment the RCRA CAP. Based on the RI activities, a potential location for additional groundwater recovery actions was identified to the south of the closed weak brine pond where there is a structural low in the top of the Miocene clay. This is an area where mercury-containing dense brine may have accumulated from past releases. Another potential area for groundwater recovery is the old plant (CPC) landfill, which was identified as a potential continuing source of organics to the groundwater.

Olin's current groundwater treatment systems consist of a combination of pH adjustment, activated carbon adsorption, and air stripping. The treatment systems for

the assembled alternatives include these same treatment steps. Treatment to reduce the total dissolved solid (TDS) concentrations may also be required to continue to meet NPDES discharge limits. The discharge method for the assembled alternatives is through Olin's existing NPDES permitted outfall.

Each of the OU-1 groundwater alternatives is described in more detail below.

Groundwater Alternative A: No Action With Continuation of Existing RCRA CAP

Alternative A is the no action alternative with continuation of the existing groundwater CAP. For the purpose of evaluation, this alternative will be the baseline for comparison to the other groundwater alternatives.

Effectiveness:	The CAP is effective at controlling contaminant migration and moderately effective at contaminant removal. Olin is required by their RCRA post-closure permit to operate the CAP until the cleanup criteria are achieved.
Implementability:	Already implemented.
Cost:	No additional costs.
Screening Comments:	The NCP requires that this alternative be retained for consideration in the detailed analysis for comparison to the other alternatives.

Groundwater Alternative B: Institutional Actions

Alternative B would consist of implementing institutional controls. The institutional controls that were retained in Section 2.0 included additional groundwater monitoring of on-site and off-site wells, deed restrictions on surrounding areas that would restrict groundwater usage, and providing an alternative water supply (municipal) to area residents. These institutional controls would be implemented to limit the potential exposure to receptors and would not reduce the toxicity, mobility or volume of contaminants.

Effectiveness: Deed restrictions on the Olin property would have limited effectiveness. There are no future use scenarios that would include use of groundwater on the Olin property because Olin has a practice of retaining ownership of any property with a remedial action in place. Additionally, as required by RCRA, the deed for the McIntosh property already has a statement regarding the presence of hazardous waste on the site. The RI data indicate that the CAP controls off-site migration and therefore deed restrictions on off-site property and off-site monitoring would have limited increased effectiveness at protecting human health. On-site monitoring may be effective in combination with other alternatives. Providing municipal water to area residents is retained as a contingency measure to be implemented if warranted by future monitoring.

Implementability: Deed restrictions on off-site private property may be difficult to implement. On-site and off-site monitoring are easily implementable. Providing municipal water to area residents is implementable but would depend on cooperation of residents.

Cost: Groundwater monitoring would require low capital costs for implementation, consisting mainly of well installation. Deed restriction cost is difficult to estimate but probably would be low compared to other process options. O&M cost, which would involve periodic sampling of wells, would also be low. Providing municipal water to area residents would have low capital and low O&M costs.

Screening Comments: Institutional actions were not retained as a separate alternative due to the limited effectiveness. Additional on-site groundwater monitoring was retained as a component of some of the OU-1 soil remedial alternatives. Providing municipal water to area residents was retained as a contingency measure to be implemented if warranted by monitoring.

Groundwater Alternatives C1 through C3: Extraction/Treatment/Discharge

Alternatives C1 through C3 would consist of extraction, treatment, and discharge of contaminated groundwater. The existing corrective action program is effective at

controlling contaminant migration. The three alternatives would be modifications of the existing CAP to accelerate contaminant removal.

Alternative C1 would consist of installing and operating two additional extraction wells in the interior portions of the mercury and organic plumes. Two target areas were identified as continuing sources of groundwater contamination, the old plant (CPC) landfill and the mercury-containing dense brine from the weak brine pond. Two vertical extraction wells were considered suitable for this alternative based on the areal extent of the target areas and the radius of influence created by the existing CAP wells. Alternative C2 would include installing injection and extraction wells to accelerate recovery in these two areas. Alternative C3 would consist of installing a horizontal extraction well at the base of the Alluvial Aquifer in the vicinity of the weak brine pond to expedite removal of the mercury-containing dense brine. Alternative C3 would also include a vertical extraction well for organic removal in the old plant (CPC) landfill area.

The primary groundwater treatment process options retained in Section 2.0 that would be considered for alternatives C1 through C3 include the following:

- Carbon adsorption for removal of mercury and as a polishing step for the organic constituents.
- Air stripping for removal of volatile organic and selected semivolatile constituents.
- Membrane filtration (e.g., reverse osmosis) to reduce TDS concentrations.

Other process options were retained and would be considered for pretreatment of the groundwater in conjunction with one or more of the primary treatment options listed above. The treated water would be discharged through Olin's existing NPDES system.

Effectiveness: C1 (Vertical Extraction Wells) - The existing CAP indicates that extraction wells are very effective at limiting the mobility of constituents and containing the contamination within the boundaries

of the facility. Extraction wells are moderately effective at reducing contaminant volume. Additional extraction wells in interior portions of the plume would increase the rate of contaminant removal. These additional extraction wells would not decrease the effectiveness of the hydraulic control produced by the existing CAP because they are interior wells. There may be some reduction in flow rate from the existing wells and/or an extension in the radius of influence outward from the center of the plume.

C2 - (Extraction and Injection Wells) - The CAP extraction wells produce very distinct capture zones, with a large volume of water moving through the contaminated areas to the wells. Effective control and plume movement can be attained with extraction wells as demonstrated by the existing CAP. Based on the analysis presented in Appendix A, extraction accompanied by injection wells would have limited increased effectiveness and may actually decrease the hydraulic control produced by the existing CAP, thus increasing the potential for movement of the plume off-site.

C3 - (Vertical and Horizontal Extraction Wells) - Horizontal wells would be more effective than vertical extraction wells at recovery of the mercury-containing dense brine. The dense brine would tend to accumulate as a separate phase. With movement toward the extraction wells, the brine would be less likely to remain in a separate phase and dilution would reduce the effectiveness of removal. A horizontal well within or near the dense brine area would have an effect similar to multiple extraction wells by reducing the distance the dense brine would have to migrate before capture and extraction. The horizontal wells would be installed in combination with a vertical extraction well in the old plant (CPC) landfill area. These additional extraction wells would not decrease the effectiveness of the hydraulic control produced by the existing CAP because they are interior wells. There may be some reduction in flow rate from the existing wells and/or an extension in the radius of influence outward from the center of the plume.

Treatment - Carbon adsorption and air stripping are effective treatment methods for the contaminated groundwater, as demonstrated by the existing CAP. Both treatment methods transfer contaminants from one medium to another without

reduction in toxicity or volume, although carbon would be disposed of off-site in a secure landfill, reducing mobility. Treatment for total dissolved solids may be necessary to meet the NPDES discharge limits. Reverse osmosis (RO) was evaluated as a potential TDS treatment option. Based on preliminary discussions with vendors, RO would be very expensive. Olin is evaluating other options for TDS, such as recycling the discharge from the carbon adsorber and air stripper to the brine system of the chlorine plant.

Implementability: Extraction/treatment alternatives are readily implementable; installation of injection wells and horizontal wells would be more difficult, but could be implemented. Additional characterization prior to design must be conducted to obtain a better definition of the brine layer and thus define the appropriate location and length of the horizontal well.

Cost: Moderate capital, moderate O&M. Alternatives C2 and C3 would be more expensive to implement than C1.

Screening Comments: Alternatives C1 and C3 were retained for the detailed analysis. Alternative C1 was retained for vertical wells in the areas of the old plant landfill and the weak brine pond area. Alternative C3 was retained for a combination of a vertical well in the area of the old plant landfill and a horizontal well in the area of mercury-containing dense brine accumulation. Alternative C2 was not retained because based on the analysis presented in Appendix A, it would have limited increased effectiveness over the C1 alternative and it may increase the potential for off-site migration.

Groundwater Alternative D: Enhanced Extraction/Treatment/Discharge

Alternative D would consist of enhanced extraction using steam injection that would be implemented in conjunction with the existing CAP or with a modification of the existing CAP. The steam injection system would be installed in localized areas for removal of the organics from the sands of the unsaturated and saturated zones. The recovered steam would either be condensed and treated with the groundwater or treated with gas-phase activated carbon.

Effectiveness:	Semivolatile compounds are present at low concentrations in the alluvial aquifer in the unsaturated zone. Removal efficiency for such compounds would be low, leaving residual contamination.
Implementability:	Bench- and field-scale testing would be required to demonstrate applicability of technology. Steam injection has not yet been widely demonstrated and applied for hazardous waste site remediation.
Cost:	High capital and moderate-to-high O&M costs.
Screening Comments:	Alternative D was screened out. The removal efficiency is expected to be low for the semivolatile compounds, thus limiting effectiveness. Also, the implementability of this alternative is very uncertain.

3.2 OU-1 SOIL ALTERNATIVES

Remedial action alternatives for OU-1 soils are developed and screened against effectiveness, implementability, and cost in this section. The alternatives are assembled for different areas found in the site characterization to contain hazardous substances. These areas generally correspond to several of the designated SWMUs/AOCs at the site. The alternatives are grouped by those areas identified as potential continuing sources of groundwater contamination and those not so identified. The old plant (CPC) landfill and the area west of the former CPC plant were identified as potential continuing sources of groundwater contamination. The old plant landfill drainage ditch, sanitary landfills, lime ponds, mercury cell plant, and well sand residue area were areas found in the site characterization to contain hazardous substances, but were not identified as potential continuing sources of groundwater contamination. (See Sections 1.3 and 1.4 for the basis of this identification).

Areas identified as potential continuing sources of groundwater contamination have different remedial action objectives from areas not so identified. In the former case, the objective of alternative development is to protect groundwater, and a wide range of process options was retained in Section 2.0 (from no action to soil removal actions followed by treatment or disposal). In the latter case, the objective is to ensure that

existing conditions now protective of human health and the environment remain protective, and a more limited range of process options was retained.

Section 3.2 is organized consistent with the framework described in the above two paragraphs. Section 3.2.1 presents alternatives for the old plant (CPC) landfill and the area west of the former CPC plant. In the initial part of this section, the no-action and institutional action alternatives are developed for the areas together, since these alternatives are similar. Because the two areas are different in their characteristics, alternatives for containment, removal, and treatment options were assembled and screened separately for each area. These alternatives are discussed in Sections 3.2.1.1 and 3.2.1.2. Because of their physical proximity, the old plant (CPC) landfill and the old plant landfill drainage ditch are evaluated together, even though the drainage ditch was not identified as a potential continuing source of groundwater contamination.

Section 3.2.2 presents the development of alternatives for the areas not identified as potential continuing sources of groundwater contamination. The RI data and the evaluation in this report (see Sections 1.3 and 1.4) indicate that soils contained within the sanitary landfills, lime ponds, mercury cell plant and well sand residue area meet RAOs. However, in order to ensure the continued compliance with RAOs, appropriate remedial alternatives for these areas were assembled. Technologies and process options retained to address these areas include a range of monitoring, maintenance and containment process options. Because these areas are similar physically and alternatives are being developed to meet the same RAOs, each alternative is developed for the four SWMUs/AOCs together, utilizing a combination of the retained process options. Five alternatives (including no action) were assembled and their development is presented in Section 3.2.2. Instead of the "normal" screening of these alternatives, Section 3.2.2 defines the most appropriate process option within a general response action, e.g., clay cap verses multimedia cap. Minimizing screening is consistent with EPA guidance (EPA 1988a) when there are a limited number of appropriate alternatives. These process options will all be evaluated in the detailed analysis in Section 4.0.

3.2.1 OU-1 Soil Alternatives for the Old Plant (CPC) Landfill and Area West of the Former CPC Plant

Soil Alternative A - No Action: Old Plant (CPC) Landfill and Area West of the Former CPC Plant

Alternative A is the no action alternative. This alternative would allow the OU-1 soils in the old plant (CPC) landfill area and area west of the former CPC plant area to remain as they currently exist, with no provisions for reduction in contaminant toxicity, mobility or volume. Olin would continue to maintain the clay cap over the old plant (CPC) landfill. They would also continue the existing groundwater monitoring and corrective action programs as required by the RCRA post-closure permit.

Effectiveness:	This alternative does not provide any additional protection to human health and the environment.
Implementability:	Would require no implementation.
Cost:	Would not require any additional capital or O&M costs.
Screening Comments:	The no action alternative was retained for comparison with the other alternatives as required by the NCP.

Soil Alternative B - Institutional Actions: Old Plant (CPC) Landfill and Area West of the Former CPC Plant

Institutional controls related to OU-1 soils in the old plant (CPC) landfill and area west of the former CPC plant areas that already exist at the facility include:

- Access to the plant is restricted by fencing and a guarded main entrance.
- The deed for the McIntosh property has a statement regarding the presence of hazardous waste on-site.

- Quarterly groundwater monitoring is conducted for the RCRA compliance and corrective action programs.

Alternative B would include increased groundwater monitoring in the vicinity of the old plant (CPC) landfill.

Effectiveness:	Does not provide any additional protection to human health and the environment.
Implementability:	Easily implementable.
Cost:	Would require low capital for additional groundwater monitoring wells and low O&M for sampling the wells.
Screening Comments:	Institutional actions were not retained as a separate alternative because they already are being implemented at the site as mentioned above. Additional on-site monitoring was retained as a component of some of the OU-1 soil remedial alternatives.

3.2.1.1 OU-1 Soil Alternatives Specific to the Old Plant (CPC) Landfill

The old plant (CPC) landfill was identified as a potential continuing source of groundwater contamination and alternatives were assembled to address this landfill. The RI indicated that the potential for migration to the Alluvial Aquifer appears to be only from portions of the landfill and from zones below the fill/waste material. Migration of organic constituents into the Alluvial Aquifer from the soil is most likely in the western portion of the landfill, where acid neutralization took place prior to 1972. The acid apparently diminished the attenuation properties of the underlying clay zone. In addition to no action and institutional actions, the remedial alternatives that were assembled focus on controlling contaminant migration from the landfill to depths of 23 feet below ground surface and include actions to reduce the potential for migration from the loose silt/clay zone. The treatment technologies for the assembled alternatives primarily are designed to treat the organics found in the landfill, with consideration also given to the potential for mercury to exist in some of the landfill material.

Soil Alternative C - Old Plant (CPC) Landfill: Containment (Improve Capping)

Alternative C would consist of improving the existing cap (either clay or multimedia) over the old plant (CPC) landfill to reduce the mobility of the constituents. This alternative would also include additional groundwater monitoring in the vicinity of the landfill.

Effectiveness:	Calculations utilizing the Hydrologic Evaluation Landfill Performance (HELP) model (EPA 1992) showed that infiltration through a multimedia cap would be at about 0.040 inches per year and infiltration through the clay cap would be at 1.2 inches per year. Evaluation of current conditions indicated an infiltration rate of about 2.2 inches per year. These calculations are provided in Appendix E. Alternative C would therefore be effective at reducing infiltration and the subsequent mobility of constituents to the Alluvial Aquifer. Alternative C would not reduce the toxicity or volume of the contaminants.
Implementability:	Alternative C would be readily implementable with standard equipment and construction practices.
Cost:	Low-to-moderate capital cost. Low O&M costs for the additional groundwater monitoring and post-closure monitoring.
Screening Comments:	Soil Alternative C was retained for the detailed analysis.

Soil Alternative D - Old Plant (CPC) Landfill: In Situ Stabilization-Solidification/Containment

Alternative D would consist of in situ stabilization/solidification of the landfill fill/waste and underlying affected materials (a total depth of 23 feet based on concentration data in the soils) to decrease the mobility of the constituents. After stabilization, the area would be capped with clay. This alternative would also include additional groundwater monitoring in the vicinity of the landfill.

Effectiveness:	Alternative D would be effective at reducing the mobility of constituents and the potential for migration to the Alluvial Aquifer.

There would be some volume increase due to the addition of the solidification reagents.

Implementability: May be difficult to implement due to debris in the landfill. Bench-scale tests are planned to select the appropriate reagents and mix ratios, as outlined in the treatability study work plan/SAP (WCC 1992). Implementation possibly would require additional characterization of landfill soils and pilot-scale testing. In situ stabilization/solidification would require specialized equipment.

Cost: Moderate-to-high capital cost for stabilization/solidification and construction of the cap. Low O&M costs for additional groundwater monitoring and post-closure monitoring.

Screening Comments: Soil Alternative D was retained for the detailed analysis.

Soil Alternative E - Old Plant (CPC) Landfill: Excavation/Stabilization-Solidification/Containment

Alternative E would consist of excavating the former landfill fill/waste and underlying affected materials to a depth of 15 feet, stabilizing/solidifying the excavated material ex situ, and stabilizing/solidifying to a depth of 23 feet in situ. The ex situ stabilized/solidified material would then be put back in the excavation and the area would be capped with a clay cap. A depth of 15 feet was assumed as the limit of excavation due to the presence of a building, a railroad track, and other access restrictions, and the slope stability considerations for maintaining these structures. The actual limit of excavation would be evaluated in the design phase. This alternative includes in situ stabilization/solidification from 15 to 23 feet because the RI indicated that contaminant migration has a higher potential to occur in portions of the landfill from zones below 15 feet.

Effectiveness: Alternative E would be effective at reducing the mobility of constituents and the potential for migration to the Alluvial Aquifer. There would be some increase in volume due to the addition of the solidification reagents.

Implementability: Based on engineering judgment, this alternative is considered implementable. Excavation of landfill soils would require H&S precautions and may require solids handling to separate landfill debris from soils prior to stabilization/solidification. Bench-scale tests are planned to select the appropriate reagents for solidification/stabilization (WCC 1992). Additional characterization of landfill soils would be required prior to excavation to define excavation limits. In situ stabilization/solidification below 15 feet would require specialized equipment.

Cost: High capital costs for removal/treatment and construction of the cap. Constructability difficulties during excavation could result in increased capital costs. Low O&M for the additional groundwater monitoring and post-closure monitoring.

Screening Comments: Soil Alternative E was retained for the detailed analysis.

Soil Alternative F - Old Plant (CPC) Landfill: Excavation/Off-Site RCRA Disposal

Alternative F would consist of excavating the former landfill fill/waste and underlying affected materials (to an assumed depth of 15 feet) and off-site disposal at a commercial hazardous waste landfill. Similar to Alternative E, this alternative also would include in situ stabilization/solidification from 15 to 23 feet. After removal and solidification/stabilization, the area would be backfilled to natural grade and capped with a clay cap.

Effectiveness: Alternative F would be effective at reducing the mobility of constituents and the potential for migration to the Alluvial Aquifer. There would be a decrease in volume of on-site material, but no overall decrease in volume.

Implementability: Based on engineering judgment, this alternative is considered implementable. Excavation of landfill soils would require H&S precautions. Some solidification or treatment of the loose silt/clay material would be required prior to transportation to the disposal facility. Additional characterization of landfill soils would be required prior to excavation to define excavation limits. In situ

stabilization/solidification below 15 feet would require specialized equipment and procedures.

Cost: Very high capital cost for excavation and disposal. Low O&M costs for the additional groundwater monitoring and post-closure monitoring.

Screening Comments: Soil Alternative F was retained for the detailed analysis.

Soil Alternatives G1 and G2 - Old Plant (CPC) Landfill: Excavation/On-Site Thermal Treatment/Disposal

Alternatives G1 and G2 both consist of excavating the former landfill fill/waste and underlying affected materials and on-site thermal treatment using one of the following process options:

- Circulating Bed Combuster
- Rotary Kiln Incinerator
- Infrared Incinerator
- Thermal Desorption

No prior treatment would be conducted with Alternative G1. Alternative G2 would include prior treatment of the material using acid extraction to separate the mercury. Because contaminant migration may be occurring from depths below 15 feet, this alternative would also include in situ stabilization/solidification from 15 to 23 feet. After removal and solidification/stabilization, the area would be backfilled with the treatment residuals and capped with clay.

Effectiveness: The G1 and G2 alternatives would be effective at reducing the mobility of constituents and contaminant migration to the Alluvial Aquifer. They would also be effective at reducing the toxicity and volume in the upper 15 feet of material. Residuals would remain below 15 feet.

Implementability: Based on engineering judgment, Alternative G1 is considered implementable. Bench- and/or pilot-scale testing would be required to design the appropriate thermal treatment option. Excavation of

landfill soils would require H&S precautions and would require solids handling to separate landfill debris from soils prior to thermal treatment. Additional characterization of landfill soils would be required prior to excavation to define excavation limits. In situ stabilization/solidification below 15 feet would require specialized equipment and procedures and possibly bench- and/or pilot-scale testing.

Alternative G2 would be very difficult to implement due to high clay content of soil. Detailed bench- and pilot-scale testing would be required to determine applicability of acid extraction. Acid extraction would have very low throughput and would produce treatment residuals that would require recycling or further treatment. Based on engineering judgment, the concentration of mercury in the excavated material could be handled with proper design of thermal treatment and air pollution control devices.

Cost: Very high capital cost for excavation and thermal treatment; pretreatment with acid extraction would increase costs considerably. Low O&M costs for the additional groundwater monitoring and post-closure monitoring of cap.

Screening Comments: Alternative G1 was retained for the detailed analysis. Alternative G2 was screened out based on questionable effectiveness (due to high clay content), implementability (i.e., low throughput, treatment of residuals) and cost.

Soil Alternatives H1 and H2 - Old Plant (CPC) Landfill: Excavation/Chemical Extraction or Dechlorination/Disposal

Alternatives H1 and H2 would consist of excavating the former landfill fill/waste and underlying affected materials and treating the materials using one of the following on-site chemical extraction or dechlorination methods:

- BEST®
- Liquified Gas
- LEEP℠
- APEG-PLUS™

Alternative H1 would include acid extraction to separate the mercury prior to the chemical extraction/dechlorination process. Alternative H2 would include disposal of the material from the chemical extraction/dechlorination process without mercury removal. Because contaminant migration may be occurring from depths below 15 feet, these alternatives would also include in situ stabilization/solidification from 15 to 23 feet. After removal and solidification/stabilization, the area would be backfilled to natural grade and capped with clay.

Effectiveness: Applicability to media would require bench- and pilot-scale testing. If implementable, this alternative would be effective at reducing mobility of constituents and contaminant migration to the Alluvial Aquifer. If implementable, it would be effective at reducing toxicity and volume in the upper 15 feet. Residuals would remain below 15 feet.

Implementability: Excavation of landfill soils would require H&S precautions and solids handling to separate landfill debris from soils prior to the treatment processes. Some solidification or treatment of loose silt/clay material would be required. Additional characterization of landfill soils would be required prior to excavation to define excavation limits. Based on engineering judgment, effective implementability of the acid extraction/dechlorination technologies is uncertain. The fines (silt and clay) in the landfill would hinder the settling/separation process involved in the extraction/dechlorination technologies, thereby significantly decreasing the throughput. In addition, multiple extraction steps may be needed. Treatment residuals would be produced for further treatment and/or disposal. Detailed bench- and pilot-scale studies would be required to determine applicability. Based on Olin's and WCC's experience, technologies designed to remove organics may increase the mobility of mercury.

In situ stabilization/solidification below 15 feet would require specialized equipment and procedures.

Cost: Very high capital cost for treatment. Low O&M costs for the additional groundwater monitoring and post-closure monitoring.

Screening Comments: These alternatives were screened out. Implementability and effectiveness are questionable due to the high clay content. Organic and mercury concentrations are too low and material volume is too high for these alternatives to be cost-effective.

Soil Alternatives I1 and I2 - Old Plant (CPC) Landfill: Excavation/Off-Site Incineration

Alternatives I1 and I2 would consist of excavating the former landfill fill/waste and underlying affected materials (to an assumed depth of 15 feet) and transporting the excavated material to an off-site RCRA incinerator. Alternative I1 would include off-site incineration without on-site treatment for mercury. Alternative I2 would include acid extraction prior to incineration. Because contaminant migration may be occurring from depths below 15 feet, these alternatives would also include in situ stabilization/solidification from 15 to 23 feet. After removal and solidification/stabilization, the area would be backfilled to natural grade and capped with clay.

Effectiveness: These alternatives would be effective at reducing the mobility of constituents and contaminant migration to the Alluvial Aquifer. They would also be effective at reducing the toxicity and volume in upper 15 feet. Residuals would remain below 15 feet.

Implementability: Alternative I1 would be difficult to implement due to the high volume of soils and limited off-site incineration capacity. Excavation of landfill soils would require H&S precautions. Some solidification or treatment of loose silt/clay material would be required. Additional characterization of landfill soils would be required prior to excavation to define excavation limits.

Alternative I2 would be very difficult to implement due to the limited off-site incineration capacity and the high clay content of soil. Detailed bench- and pilot-scale testing would be required to determine applicability of acid extraction. Acid extraction would have very low throughput and would produce treatment residuals that would require recycling or further treatment. The concentration of mercury in excavated material from the landfill

could be handled at the off-site incineration facilities that were contacted.

Cost: Very high capital cost for excavation and incineration; addition of acid extraction would increase costs considerably. Low O&M costs for the additional groundwater monitoring and post-closure monitoring.

Screening Comments: Alternatives I1 and I2 were screened out based on the limited off-site incineration capacity and very high cost.

3.2.1.2 OU-1 Soil Alternatives Specific to the Area West of Former CPC Plant

The Phase III sampling data and the fate and transport analysis (Sections 1.3 and 1.4) indicated that there is a potential for semivolatile organic constituents to be carried by infiltration down to the sands above the Alluvial Aquifer, west of the former CPC plant area. Remedial alternatives were assembled to address the upper 14 feet of soils in this area, which would be the source of any constituents that migrated to the Alluvial Aquifer.[1]

Soil Alternative C - Area West of Former CPC Plant: Extend Existing Cap

Alternative C would consist of extending the clay cap that exists over the former CPC plant to the west, reducing infiltration through the contaminated soils.

Effectiveness: Calculations utilizing the Hydrologic Evaluation Landfill Performance (HELP) model (EPA 1992) showed that infiltration through a clay cap would be about 1.2 inches per year. Evaluation of current conditions indicated an infiltration rate of about 3.3 inches per year. These calculations are provided in Appendix E. Alternative C would therefore be effective at reducing infiltration

[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

and the subsequent mobility of constituents to the Alluvial Aquifer. Alternative C would not reduce the toxicity or volume of the contaminants.

Implementability: Alternative C would be readily implementable with standard equipment and construction practices.

Cost: Low-to-moderate capital cost. Low O&M costs for post-closure monitoring of the cap.

Screening Comments: Soil Alternative C was retained for the detailed analysis.

Soil Alternative D - Area West of Former CPC Plant: In Situ Stabilization-Solidification/Containment

Alternative D would consist of in situ stabilization/solidification of the contaminated soils (to an estimated depth of 14 feet) to decrease the mobility of the constituents. After stabilization, the area would be capped with clay.

Effectiveness: Alternative D would be effective at reducing the mobility of constituents and the potential for migration to the Alluvial Aquifer. There would be some volume increase due to the addition of the solidification reagents.

Implementability: Based on engineering judgment, this alternative is considered implementable. Bench-scale tests would be required to select the appropriate reagents and mix ratios. In situ stabilization/solidification may require specialized equipment.

Cost: Moderate-to-high capital cost for stabilization/solidification and construction of the cap. Low O&M costs for post-closure monitoring of the cap.

Screening Comments: Soil Alternative D was retained for the detailed analysis.

Soil Alternative E - Area West of Former CPC Plant: Excavation/Stabilization-Solidification/Containment

Alternative E would consist of excavating the contaminated soils to an estimated depth of 14 feet and stabilizing/solidifying the excavated material ex situ. The ex situ stabilized/solidified material would then be put back in the excavation and the area would be capped with a clay cap.

Effectiveness:	Alternative E would be effective at reducing the mobility of constituents and the potential for migration to the Alluvial Aquifer. There would be some increase in volume due to the addition of the solidification reagents.
Implementability:	Based on engineering judgment, this alternative is considered implementable. Excavation of contaminated soils would require H&S precautions. Bench-scale tests would be required to select the appropriate reagents for solidification/stabilization.
Cost:	Moderate to high capital costs for removal/treatment and construction of the cap. Low O&M for post-closure monitoring of the cap.
Screening Comments:	Soil Alternative E was retained for the detailed analysis.

Soil Alternative F - Area West of Former CPC Plant: Excavation/Off-Site RCRA Disposal

Alternative F would consist of excavating the contaminated soils to an estimated depth of 14 feet and off-site disposal of the excavated material at a commercial hazardous waste landfill. The area would be backfilled to natural grade and capped with a clay cap.

Effectiveness:	Alternative F would be effective at reducing the mobility of constituents and the potential for migration to the Alluvial Aquifer. There would be a decrease in volume of on-site material, but no overall decrease in volume.

Implementability:	Based on engineering judgment, this alternative is considered implementable. Excavation of contaminated soils would require H&S precautions.
Cost:	High to very high capital cost for excavation and disposal. Low O&M costs for post-closure monitoring of the cap.
Screening Comments:	Soil Alternative F was retained for the detailed analysis.

Soil Alternative G - Area West of Former CPC Plant: Excavation/On-Site Thermal Treatment/Disposal

Alternative G would consist of excavating the contaminated soils to an estimated depth of 14 feet and on-site thermal treatment using one of the following process options:

- Circulating Bed Combuster
- Rotary Kiln Incinerator
- Infrared Incinerator
- Thermal Desorption

After removal and thermal treatment, the area would be backfilled with the treatment residuals and capped with clay.

Effectiveness:	Alternative G would be effective at reducing the mobility of constituents and contaminant migration to the Alluvial Aquifer. This alternative would also be effective at reducing the toxicity and volume of constituents.
Implementability:	Based on engineering judgment, this alternative is considered implementable. Bench- and/or pilot-scale testing would be required to design the appropriate thermal treatment option. Excavation of contaminated soils would require H&S precautions.
Cost:	High to very high capital cost for excavation and thermal treatment. Low O&M costs for post-closure monitoring of the cap.
Screening Comments:	Alternative G was retained for the detailed analysis.

Soil Alternative H - Area West of Former CPC Plant: Excavation/Chemical Extraction or Dechlorination/Disposal

Alternative H would consist of excavating the contaminated soils to an estimated depth of 14 feet and treating the excavated material using one of the following on-site chemical extraction or dechlorination methods:

- BEST®
- Liquified Gas
- LEEP℠
- APEG-PLUS™

Alternative H would include disposal of the material from the chemical extraction/dechlorination process. The area would be backfilled to natural grade and capped with a clay cap.

Effectiveness:	Determining applicability to media would require bench- and pilot-scale testing. If implementable, this alternative would be effective at reducing mobility of constituents and contaminant migration to the Alluvial Aquifer. If implementable, it would be effective at reducing toxicity and volume of constituents.
Implementability:	Excavation of contaminated soils would require H&S precautions. Based on engineering judgment, effective implementability of the dechlorination technologies is uncertain. The fines (silt and clay) in the soils would hinder the settling/separation process involved in the extraction/dechlorination technologies, thereby significantly decreasing the throughput. In addition, multiple extraction steps may be needed. Treatment residuals would be produced for further treatment and/or disposal. Detailed bench- and pilot-scale studies would be required to determine applicability.
Cost:	High to very high capital cost for treatment. Low O&M costs for post-closure monitoring of the cap.
Screening Comments:	This alternative was screened out due to implementability and cost considerations. Effectiveness is questionable due to the high clay

content of the soil. Organic concentrations are too low for this alternative to be cost-effective.

Soil Alternative I - Area West of Former CPC Plant (CPC) Landfill: Excavation/Off-Site Incineration

Alternative I would consist of excavating the contaminated soils to an estimated depth of 14 feet and transporting the excavated material to an off-site RCRA incinerator. The area would be backfilled to natural grade and capped with a clay cap.

Effectiveness:	Alternative I would be effective at reducing the mobility of constituents and contaminant migration to the Alluvial Aquifer. It would also be effective at reducing the toxicity and volume of constituents.
Implementability:	Alternative I may be difficult to implement due to the volume of soils and limited off-site incineration capacity. Excavation of contaminated soils would require H&S precautions.
Cost:	Very high capital cost for excavation and incineration. Low O&M costs for post-closure monitoring of the cap.
Screening Comments:	Alternative I was screened out due to the very high cost and possible implementability problems due to limited incineration capacity.

3.2.2 OU-1 Soil Alternatives for the Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area

Five alternatives were assembled from the process options that were retained in Section 2.0. Because of the limited number of appropriate alternatives, screening was not conducted, and all five alternatives will be evaluated in the detailed analysis in Section 4.0

Soil Alternative A - No Action: Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area

Alternative A is the no action alternative. This alternative would allow the soils in these SWMUs/AOCs to remain as they currently exist, with no provisions for reduction in contaminant toxicity, mobility or volume. Olin would continue to maintain the caps with their existing maintenance programs. Olin would also continue the existing groundwater monitoring and corrective action programs as required by the RCRA post-closure permit.

Soil Alternatives B1 and B2 - Institutional Actions: Sanitary Landfills, Lime Ponds, Mercury Cell Plant Area and the Well Sand Residue Area

Institutional actions have already been implemented at the site. Access to the SWMUs/AOCs is restricted by fencing; the deed for the McIntosh property has a statement regarding the presence of hazardous waste on-site, and Olin conducts quarterly groundwater monitoring as part of their RCRA compliance and corrective action programs.

Alternatives B1 and B2 would include implementing additional institutional actions to ensure that conditions at the SWMUs/AOCs remain protective. The institutional actions that were retained in Section 2.0 include:

- Groundwater monitoring in vicinity of the sanitary landfills, lime ponds and mercury cell plant.
- Surface water monitoring for the sanitary landfills.
- Cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant.

Two institutional action alternatives will be evaluated in the detailed analysis as described below:

- Alternative B1 would include cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant, and increased groundwater monitoring in the vicinity of the sanitary landfill.

- Alternative B2 would include cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant; increased groundwater monitoring in the vicinity of the sanitary landfills, lime ponds and the mercury cell plant; and surface water monitoring in the vicinity of the sanitary landfills.

Both institutional action alternatives include cap inspection/maintenance to ensure the long-term integrity of the caps (i.e., conditions remain protective). The two alternatives provide different levels of monitoring. Alternative B1 includes groundwater monitoring in the vicinity of the sanitary landfill, because this is an area which has limited hydraulic influence from the existing corrective action system, and it is not within the area monitored by the RCRA compliance and corrective action wells. Alternative B2 provides a much more extensive groundwater and surface water monitoring program. The institutional action alternatives will be designed to coordinate with Olin's existing groundwater and surface water monitoring programs and use existing monitor wells, where appropriate.

Soil Alternatives C1 and C2 - Containment/Institutional Actions: Sanitary Landfills, Lime Ponds, Mercury Cell Plant Area and the Well Sand Residue Area

Alternative C1 would include a combination of containment and institutional actions. Containment process options that were retained for the sanitary landfill, the lime ponds and the well sand reside area include:

- Sanitary landfills - multimedia and clay caps
- Lime ponds - multimedia and clay caps
- Well sand residue area - clay cap and soil cover

The institutional actions for alternatives C1 and C2 would be similar to those described in Alternative B1: cap inspection/maintenance for the sanitary landfills, lime ponds,

mercury cell plant, and increased groundwater monitoring in the vicinity of the sanitary landfills.

Alterative C1 would include containment of the sanitary landfills and the two lime ponds. For the purpose of the detailed analysis, a clay cap will be assumed for the sanitary landfills. The fate and transport analysis in Section 1.4 indicated that the sanitary landfills are not continuing sources of groundwater contamination and this analysis was conducted without consideration of the cap. Therefore, the objective of the cap would be to provide a permanent barrier over the contaminated soils to prevent contact by humans or releases to the environment via air or surface water. A multimedia cap would provide marginal, if any, increased effectiveness over clay at meeting this objective. A multimedia cap that would include a clay layer, a drainage layer and vegetative topsoil is assumed for the lime ponds. The primary objective of containment in the lime ponds is to reduce the infiltration and thus reduce or eliminate the perched water layer. A multimedia cap would be more effective and reliable than clay at meeting this objective.

Alterative C2 would be the same as C1 with the addition of consolidation and containment of the well sand residue material in the sanitary landfills. Excavation and on-site disposal process options were retained in Section 2.0 for this purpose. A clay cap and soil cover were retained for containment of the well sand. This alternative specifies a clay cap because the material would be contained in the sanitary landfills where clay is more appropriate.

3.3 OU-2 SEDIMENT ALTERNATIVES

The baseline risk assessment indicated that the basin and ditch sediments are not a significant pathway for human health receptors. Further, the groundwater migration pathway in these sediments is not considered to be significant. Therefore, the assembled alternatives for the wastewater ditch were developed to prevent contaminated sediment transport down the wastewater ditch where exposure to fish and other biota could occur. The basin alternatives were developed to reduce exposure to fish and other biota.

The OU-2 sediment treatment technologies were designed to treat organics and mercury. The organics are the primary constituents in the wastewater ditch; mercury is the primary constituent in the basin.

Sediment Alternative A: No Action

Alternative A is the no action alternative. This alternative would allow the OU-2 sediments to remain as they currently exist, with no provisions for reduction in toxicity, mobility or volume of the contaminants. Evaluation of the no action alternative provides a baseline for comparison with the other alternatives.

Effectiveness:	Alternative A does not provide any additional protection to human health and the environment.
Implementability:	Implementation not required.
Cost:	Would not require any additional capital or O&M costs.
Screening Comments:	The no action alternative was retained for comparison with the other alternatives as required by the NCP.

Sediment Alternative B: Institutional Actions

Alternative B would include implementation of institutional controls to monitor conditions and to reduce human exposure to fish and sediments. Monitoring would include collecting samples of sediment surface and fish for chemical analysis and measuring sedimentation rates. The existing fencing would be extended to limit access, and there would be increased enforcement of fishing restrictions.

Effectiveness:	This alternative would reduce the risk to human health, which already meets the remedial action objective, because it would restrict fish consumption. There would be no reduction in toxicity, mobility or volume of constituents.
Implementability:	Easily implementable.

Cost:	Low capital costs for construction, low O&M costs for fish/sediment monitoring and additional patrolling of the area.
Screening Comments:	Alternative B was retained for the detailed analysis.

3.3.1 OU-2 Sediment Alternatives Specific to the Basin

Basin Sediment Alternative C: Backfilling

Alternative C would include containment of contamination in the basin sediments by backfilling the basin with soil from the adjacent upland area. The area would then be monitored and managed as wetlands.

Effectiveness:	Alternative C would be effective at reducing the mobility of constituents. There would be no reduction in toxicity or volume. The alternative would be protective of the environment by reducing exposure of biota to contaminants.
Implementability:	This alternative would be moderately difficult to implement due to the high volume of material to be moved and the administrative factors related to work within wetlands and adjacent to a navigable waterway.
Cost:	Moderate-to-high capital cost for construction. Low-to-no O&M costs for managing the wetlands.
Screening Comments:	Alternative C was retained for detailed analysis.

Basin Sediment Alternative D: Dredging/Covering (Contained Aquatic Disposal)

Alternative D would involve dredging the shallow areas of the basin (approximately two-thirds) and placing the dredged materials into the deep depression in the western-northwestern part of the basin. The material would then be covered by placing additional dredged material from the unaffected areas of the basin over the top of the dredged sediments. Subaqueous covering of contaminated sediments is referred to as contained aquatic disposal (CAD). Monitoring of the integrity of the cap would be required.

Effectiveness: Alternative D would be protective of the environment by reducing exposure of biota to contaminants. This alternative would be effective at reducing the mobility of constituents. No reduction in toxicity or volume would be attained. With any dredging alternative there would be residual contamination in the basin due to resuspension of very fine sediments during the dredging operations.

Implementability: Alternative D would be moderately difficult to implement and monitor. Additional investigation and testing of sediment characteristics would be required to determine whether this alternative could be effectively implemented. Administrative factors related to working in wetlands and next to navigable waters would have to be considered.

Cost: Moderate-to-high cost for construction. Low O&M cost for subsequent monitoring.

Screening Comments: Alternative D was retained for the detailed analysis.

Basin Sediment Alternatives E1 and E2: Dredging/Disposal

Both Alternatives E1 and E2 would include dredging the basin sediments. Alternative E1 would include mechanical dewatering prior to disposal in an on-site or off-site non-RCRA landfill. Alternative E2 would include disposal and dewatering in a confined disposal facility (CDF) that would be constructed on the upland area adjacent to the basin. Sediments would be allowed to dewater in the CDF by settlement, possibly followed by clarification; the accumulated water would be managed and the CDF would eventually be capped. Solidification/stabilization of the material may be required prior to placement of the cap. Both the CDF and the on-site landfill would require groundwater monitoring.

Effectiveness: These alternatives would be effective at reducing the mobility of constituents. No reduction in toxicity would be attained. There would be a reduction in volume of contaminated basin sediments; however, contaminants would be moved rather than destroyed. These alternatives would be protective of the environment by reducing exposure of biota to contaminants. With any dredging alternative there would be residual contamination in the basin due

to resuspension of very fine sediments during the dredging operations.

Implementability: Both E1 and E2 would be difficult to implement due to the high volume of material to be dredged and dewatered. Administrative factors related to working in wetlands and next to navigable waters would have to be considered.

Cost: Very high cost for construction. Low O&M costs for groundwater monitoring and maintaining the cap. O&M costs could be higher for maintenance of CDF depending on difficulties in managing water.

Screening Comments: Alternatives E1 and E2 were retained for the detailed analysis.

Basin Sediment Alternative F: Dredging/Acid Extraction/Disposal

Alternative F would include dredging of the basin sediments and acid extraction to remove the mercury, followed by disposal. Disposal options that would be considered include on-site and off-site RCRA landfills and on-site and off-site non-RCRA landfills. On-site dewatering of the sediments would be required prior to disposal.

Effectiveness: Determining the applicability of acid extraction to the media would require further evaluation. If applicable, Alternative F would potentially be effective at reducing mobility, volume and toxicity of constituents. Effective implementation would be protective of the environment by reducing exposure of biota to contaminants. With any dredging alternative there would be residual contamination in the basin due to resuspension of very fine sediments during the dredging operation.

Implementability: There would be low throughput for a high volume of sediments. In addition, the fines (silts and clay) in the basin would hinder the settling/separation process involved in the extraction procedure, thereby significantly decreasing the throughput. The high organic content in the basin may necessitate high amounts of reagent (acid). Detailed bench- and pilot-scale testing would be required to determine applicability. Treatment residuals would be produced that would require recycling or further treatment. Mercury

concentrations in bulk soils that would be dredged would probably not be high enough to warrant acid extraction. Administrative factors related to working in wetlands and next to navigable waters would have to be considered.

Cost: Very high capital cost for removal/treatment and disposal. Low-to-no O&M costs, depending on whether an on-site disposal option would be utilized.

Screening Comments: Alternative F was screened out based on questionable effectiveness due to the high clay content, implementability (i.e., low throughput and treatment of residuals) and cost considerations.

3.3.2 OU-2 Sediment Alternatives Specific to the Wastewater Ditch

Wastewater Ditch Sediment Alternative C1 and C2: Containment

Alternative C1 would include excavating a new wastewater ditch adjacent to the existing ditch and utilizing the materials from the excavation to cover the existing wastewater ditch. Alternative C2 would include construction of erosion control measures in the existing ditch (e.g., rip rap, erosion control blanket, etc.). Both alternatives would involve rerouting the process water. Monitoring of the integrity of these alternatives would be required.

Effectiveness: Both alternatives would be effective at reducing the downstream mobility of constituents, which is the concern for the wastewater ditch sediments. There would be no reduction in toxicity or volume. These alternatives would be protective of the environment by reducing the potential exposure of biota to contaminants. Based on engineering judgment, Alternative C1 would be more effective than C2 because the backfill cover would be more competent and require less maintenance. An advantage of C1 is that after construction, the water would be permanently diverted to the new ditch, whereas with C2 the water would be routed through the existing wastewater ditch over the erosion control cap.

Implementability: Alternative C2 would be more difficult to implement than C1 because it would require installation of the erosion control

components over sediments that would be periodically inundated by storm water.

Cost: Moderate capital cost for construction. Low O&M costs for monitoring integrity of containment.

Screening Comments: Alternative C1 was retained for the detailed analysis. Alternative C2 was screened out because it would be more difficult to implement than C1, and based on engineering judgment, C1 would be more effective.

Wastewater Ditch Sediment Alternative D: Stabilization-Solidification

Alternative D would include stabilization/solidification of the ditch material, either in situ or by excavation/mixing and placing the material in an on-site landfill. For in situ stabilization/solidification, the material would be capped to prevent erosion.

Effectiveness: Alternative D would be effective at reducing the mobility of constituents, which is the concern for the wastewater ditch sediments. There would be no reduction in toxicity or volume. The alternative would be protective of the environment by reducing the potential exposure of biota to contaminants. Stabilization/solidification technologies are generally designed to reduce leaching and mobility of dissolved constituents, which is an advantage over containment. However, this alternative would provide similar protectiveness as containment because leaching from the ditch sediments is not a significant pathway at the site.

Implementability: Alternative D would be moderately difficult to implement because the ditch is currently used for discharge of the facility process water and also for discharge of natural storm water runoff from the adjacent area. In situ stabilization would also be difficult to implement due to the length of the ditch and its configuration.

Cost: Moderate-to-high capital cost for construction. Low O&M costs for monitoring the integrity of containment.

Screening Comments: Alternative D was screened out because there would be limited increased effectiveness over containment (Alternative C1).

Wastewater Ditch Sediment Alternative E: Excavation/Disposal

Alternative E would include excavation of the wastewater ditch sediments and off-site RCRA disposal.

Effectiveness:	Alternative E would be effective at reducing the mobility of constituents. There would be a reduction in volume of contaminants in the ditch, but the actual volume of sediment would not be reduced. This alternative would be protective of the environment by reducing the potential exposure of biota to contaminants.
Implementability:	Alternative E would be moderately difficult to implement because the ditch is currently used for discharge of the facility process water and also for discharge of natural storm water runoff from the adjacent area.
Cost:	Very high capital cost. Low-to-no O&M cost.
Screening Comments:	Alternative E was retained for the detailed analysis.

Wastewater Ditch Sediment Alternatives F1 and F2: Excavation/Chemical Extraction or Dechlorination/Disposal

Alternatives F1 and F2 would consist of excavating the wastewater ditch sediments and treating the material using one of the following on-site chemical extraction or dechlorination methods:

- BEST®
- Liquified Gas
- LEEPSM
- APEG-PLUS™

Alternative F1 would include acid extraction to separate the mercury prior to the chemical extraction/dechlorination process. Alternative F2 would include disposal of the material from the chemical extraction/dechlorination process without mercury

removal. Both on-site and off-site disposal options would be considered for the treated sediment.

Effectiveness:	Determining the applicability of these treatment processes to the media would require bench- and pilot-scale testing. If applicable, they would be effective at reducing mobility and volume of constituents. However, treatment residuals would require disposal. If applicable, these alternatives would be protective of the environment by reducing the potential exposure of biota to contaminants.
Implementability:	These alternatives would be very difficult to implement given the high volume of material to be treated and low throughput. In addition, the fines (silt and clay) in the ditch would hinder the settling/separation process involved in the extraction procedure. Multiple extractions might be necessary. Treatment residuals would be produced that would require recycling, further treatment or disposal. Extensive bench- and pilot-scale testing would be required. Excavation would be moderately difficult because the ditch is currently used for discharge of the facility process water and also for discharge of natural storm water runoff from the adjacent area.
Cost:	Very high capital cost for treatment and disposal. Low-to-no O&M costs.
Screening Comments:	These alternatives were screened out due to implementability problems (i.e., low throughput and treatment of residuals), cost considerations and because the effectiveness is questionable due to the high clay content.

Wastewater Ditch Sediment Alternatives G1 and G2: Excavation/On-Site Thermal Treatment/Disposal

Alternatives G1 and G2 both consist of excavation of the wastewater ditch sediments and on-site thermal treatment using one of the following process options:

- Circulating Bed Combuster
- Rotary Kiln Incinerator
- Infrared Incinerator
- Thermal Desorption

No prior treatment would be conducted with Alternative G1. Alternative G2 would include prior treatment of the material using acid extraction to separate the mercury.

Effectiveness: Determining the applicability of acid extraction to the media would require bench- and pilot-scale testing. Excavation and thermal treatment would be effective at reducing mobility and toxicity of constituents. These alternatives would be protective of the environment by reducing the potential exposure of biota to contaminants.

Implementability: Based on engineering judgment, Alternative G1 would be implementable. Bench- and/or pilot-scale testing would be required to design the appropriate thermal treatment option. Excavation would be moderately difficult because the ditch is currently used for discharge of the facility process water and also for discharge of natural storm water runoff from the adjacent area.

Alternative G2 would be very difficult to implement due to high silt/clay content of sediments. Detailed bench- and pilot-scale testing would be required to determine applicability of acid extraction. Acid extraction would have very low throughput and would produce treatment residuals that would require recycling or further treatment. Based on engineering judgment, mercury in sediments could be handled with proper design of thermal treatment and air pollution control devices.

Cost: Very high capital cost for excavation and thermal treatment; addition of acid extraction would increase costs considerably. Low-to-no O&M costs.

Screening Comments: Alternative G1 was retained for detailed analysis. Alternative G2 was screened out based on questionable effectiveness due to the high clay content, implementability problems (i.e., low throughput and treatment of residuals) and cost considerations.

Wastewater Ditch Sediment Alternatives H1 and H2: Excavation/Off-site Incineration

Alternatives H1 and H2 would consist of excavating the wastewater ditch sediments and transporting the excavated material to an off-site commercial incinerator. Alternative H1 would include off-site incineration without on-site treatment for mercury. Alternative H2 would include acid extraction prior to incineration.

Effectiveness:	Applicability of acid extraction to media would require bench- and pilot-scale studies. Alternatives H1 and H2 would be effective at reducing the mobility, toxicity and volume of constituents. These alternatives would be protective of the environment by reducing the potential exposure of biota to contaminants.
Implementability:	Off-site incineration would be difficult to implement due to the high volume of sediments and the limited availability of off-site incineration capacity. Both alternatives would require excavation in the ditch, which is currently used for discharge of the facility process water and also for discharge of natural storm water runoff from the adjacent area. Alternative H2 would be very difficult to implement due to the high silt/clay content of the sediments. Detailed bench- and pilot-scale testing would be required to determine the applicability of acid extraction. Acid extraction would have very low throughput and would produce treatment residuals that would require further treatment. Based on engineering judgment, mercury in the sediment and soils could probably be handled at the off-site incinerator.
Cost:	Very high capital cost for excavation and incineration; addition of acid extraction would increase costs considerably. Low-to-no O&M cost.
Screening Comments:	Both alternatives were screened out because of the difficulty to implement (due to limited off-site incineration capacity) and the very high cost.

3.4 SUMMARY OF RETAINED ALTERNATIVES

Table 3-1 summarizes the alternative screening analysis. The alternatives that were retained for the detailed analysis are listed below:

OU-1 GROUNDWATER

Alternative A - No Action With Continuation of Existing RCRA CAP
Alternative C1 - Extraction/Treatment/Discharge (Vertical Extraction Wells)
Alternative C3 - Extraction/Treatment/Discharge (Vertical and Horizontal Extraction Wells)

OU-1 SOIL

Alternative A - No Action

OLD PLANT (CPC) LANDFILL

Alternative C - Containment (Improve Capping)
Alternative D - In Situ Stabilization-Solidification/Containment
Alternative E - Excavation/Stabilization-Solidification/Containment
Alternative F - Excavation/Off-Site RCRA Disposal
Alternative G1 - Excavation/On-Site Thermal Treatment/Disposal

AREA WEST OF FORMER CPC PLANT

Alternative C - Containment (Extend Existing Cap)
Alternative D - In Situ Stabilization-Solidification/Containment
Alternative E - Excavation/Stabilization-Solidification/Containment
Alternative F - Excavation/Off-Site RCRA Disposal
Alternative G - Excavation/On-Site Thermal Treatment/Disposal

SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative B1 - Institutional Actions (Cap Inspection/Maintenance, Groundwater Monitoring near Sanitary Landfills)
Alternative B2 - Institutional Actions (Cap Inspection/Maintenance, Expanded Groundwater and Surface Water Monitoring)
Alternative C1 - Containment (Sanitary Landfills and Lime Ponds)/ Institutional Actions
Alternative C2 - Containment/Consolidation (Sanitary Landfills, Lime Ponds and Well Sand Residue Area)/Institutional Actions

OU-2 SEDIMENT

Alternative A - No Action
Alternative B - Institutional Actions

BASIN

Alternative C - Backfilling
Alternative D - Dredging/Covering (Contained Aquatic Disposal)
Alternative E1 - Dredging/Disposal (Mechanical Dewatering)
Alternative E2 - Dredging/Disposal (Confined Disposal Facility)

WASTEWATER DITCH

Alternative C1 - Containment (Backfill)
Alternative E - Excavation/Disposal
Alternative G1 - Excavation/On-Site Thermal Treatment/Disposal

TABLES

TABLE 3-1

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Groundwater	A: No Action With Continuation of Existing RCRA CAP	This alternative consists of continuation of the existing RCRA Corrective Action Program.	Retained for detailed analysis in Section 4.0. This alternative forms baseline for comparison to other groundwater alternatives.
OU-1 Groundwater	B: Institutional Actions	Institutional controls would include additional groundwater monitoring of on-site and off-site wells, and deed restrictions on surrounding areas that would restrict groundwater usage.	Institutional actions were not retained as a separate alternative due to the limited effectiveness. Additional on-site groundwater monitoring was retained as a component of some of the OU-1 soils remedial alternatives. Providing municipal water to area residents was retained as a contingency measure to be implemented if warranted by future monitoring.
OU-1 Groundwater	C1: Extraction/Treatment/Discharge (Vertical Extraction Wells)	Alternative C1 would consist of installing additional vertical extraction wells in the areas of the old plant (CPC) landfill and the weak brine pond. This alternative would include aboveground treatment to remove organics (air stripping), mercury (carbon adsorption) and possibly TDS (reverse osmosis). Discharge would be through Olin's existing NPDES permit.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Groundwater	C2: Extraction/Treatment/Discharge (Extraction and Injection Wells)	This alternative would include installing injection and extraction wells. Aboveground treatment would be same as outlined for Groundwater Alternative C1.	Alternative C2 was not retained for further analysis based on engineering judgment that it would have limited increased effectiveness over Groundwater Alternative C1 and may increase the potential for off-site migration.
OU-1 Groundwater	C3: Extraction/Treatment Discharge (Vertical and Horizontal Extraction Wells)	This alternative is similar to Groundwater Alternative C1 except that a horizontal well would be installed instead of a vertical well in the area south of the weak brine pond.	Retained for detailed analysis in Section 4.0.
OU-1 Groundwater	D: Enhanced Extraction/Treatment/ Discharge	Enhanced extraction using steam injection in conjunction with the existing CAP, or a modification of the existing CAP. The steam injection system would be installed in localized areas for removal of the organics from the sands of the unsaturated and saturated zones.	Not retained for further analysis. The removal efficiency is expected to be low for the semi-volatile compounds, thus, limiting the effectiveness. Also, the implementability of this alternative is very uncertain.
OU-1 Soils	A: No Action	Existing clay cap over the old plant (CPC) landfill and other SWMUs at the site would be maintained. Existing groundwater monitoring and corrective action programs as required by the RCRA post-closure permit would be continued.	Retained for detailed analysis in Section 4.0. This alternative forms a baseline for comparison to other soil alternatives.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—Old Plant (CPC) Landfill and West of Former (CPC) Plant	B: Institutional Actions	Institutional actions would include increased groundwater monitoring in the vicinity of the old plant (CPC) landfill.	Institutional actions were not retained as a separate alternative because they already are being implemented. Additional on-site groundwater monitoring was retained as a component of some of the OU-1 soils alternatives.
OU-1 Soils—Old Plant (CPC) Landfill	C: Containment (Improve Capping)	Improving the existing cap over the old plant (CPC) landfill with either a clay or multimedia cap.	Retained for detailed analysis in Section 4.0.
OU-1 Soils—Old Plant (CPC) Landfill	D: In Situ Stabilization - Solidification/Containment	In situ stabilization/solidification of the landfill fill/waste and underlying affected materials (to 23 feet) to decrease the mobility of the constituents. The stabilized area would be capped with clay.	Retained for detailed analysis in Section 4.0.
OU-1 Soils—Old Plant (CPC) Landfill	E: Excavation/Stabilization - Solidification/Containment	Excavation of the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet; stabilizing/solidifying the excavated material ex situ; in situ stabilization/solidification to a depth of 23 feet; backfilling the excavated area with the ex situ stabilized/solidified material; and installation of a clay cap.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—Old Plant (CPC) Landfill	F: Excavation/Off-Site RCRA Disposal	Excavation of the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet; in situ stabilization/solidification from depths of 15 to 23 feet; disposal of the excavated material off-site at a commercial hazardous waste landfill; backfilling the excavated area with imported material; and installation of a clay cap	Retained for detailed analysis in Section 4.0.
OU-1 Soils—Old Plant (CPC) Landfill	G1: Excavation/On-Site Thermal Treatment/Disposal	Excavation of the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet; in situ stabilization/solidification from depths of 15 to 23 feet; thermally treating (e.g., infrared incineration, rotary kiln incineration, thermal description) the excavated material on-site; backfilling the excavated area with the treated material; and installation of a clay cap.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—Old Plant (CPC) Landfill	G2: Excavation/On-Site Thermal Treatment/Disposal (With Acid Extraction)	Same as Soil Alternative G1 except acid extraction would be used to remove mercury prior to thermal treatment.	Not retained for further analysis. This alternative was screened out because of questionable effectiveness due to high clay content, low throughput, management of residuals and very high cost. Based on engineering judgement the concentration of mercury in the excavated material could be handled with thermal treatment and air pollution control devices.
OU-1 Soils—Old Plant (CPC) Landfill	H1: Excavation/Chemical Extraction or Dechlorination/Disposal (With Acid Extraction)	Excavation of the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet; in situ stabilization/solidification from depths of 15 to 23 feet; treatment of excavated material with chemical-extraction or dechlorination; backfilling the excavated area with the treated material; and installation of a clay cap. This alternative would also include acid extraction of mercury prior to the chemical extraction/dechlorination process for removal of organics.	Not retained for further analysis. The alternative was screened out because of questionable effectiveness due to the high clay content, low throughput, and management of residuals. Organic and mercury concentrations are too low and material volume is too high for this alternative to be cost effective.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—Old Plant (CPC) Landfill	H2: Extraction/Chemical Extraction or Dechlorination/Disposal	Same as Soil Alternative H1 except that no acid extraction step would be included.	Not retained for further analysis. The alternative was screened out because of questionable effectiveness due to the high clay content low throughput and management of residuals. Organic and mercury concentrations are too low and material volume is too high for this alternative to be cost effective.
OU-1 Soils—Old Plant (CPC) Landfill	I1: Excavation/Off-Site Incineration	Excavation of the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet; in situ stabilization/solidification from depths of 15 to 23 feet; the excavated material would be transported for incineration at an off-site RCRA incineration.	Not retained for further analysis due to on limited off-site incineration capacity and very high cost.
OU-1 Soils—Old Plant (CPC) Landfill	I2: Extraction/Off-Site Incineration (With Acid Extraction)	Same as Soil Alternative I1 except this alternative would include acid extraction on-site, prior to off-site incineration.	Not retained for further analysis due to the limited off-site incineration capacity and very high cost. Also, the questionable effectiveness and implementation difficulties of acid extraction were further reasons for screening out this alternative.
OU-1 Soils—West of Former CPC Plant	C: Containment (Extend Existing Cap)	Extending the clay cap that exists over the former CPC plant to the west, containing the contaminated soils.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—West of Former CPC Plant	D: In Situ Stabilization - Solidification/Containment	In situ stabilization/solidification of the contaminated soils (to an estimated depth of 14 feet) to decrease the mobility of the constituents. The stabilized area would be capped with clay.	Retained for detailed analysis in Section 4.0.
OU-1 Soils—West of Former CPC Plant	E: Excavation/Stabilization - Solidification/Containment	Excavation of the contaminated soils to an estimated 14 feet; stabilizing/solidifying the excavated material ex situ; backfilling the excavated area with the ex situ stabilized/solidified material; and installation of a clay cap.	Retained for detailed analysis in Section 4.0.
OU-1 Soils—West of Former CPC Plant	F: Excavation/Off-Site RCRA Disposal	Excavation of the contaminated soils (to an estimated depth of 14 feet); disposal of the excavated material off-site at a commercial hazardous waste landfill; backfilling the excavated area with imported material; and installation of a clay cap	Retained for detailed analysis in Section 4.0.
OU-1 Soils—West of Former CPC Plant	G: Excavation/On-Site Thermal Treatment/Disposal	Excavation of the contaminated soils (to an estimated depth of 14 feet); thermally treating (e.g., infrared incineration, rotary kiln incineration, thermal description) the excavated material on-site; backfilling the excavated area with the treated material; and installation of a clay cap.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—West of Former CPC Plant	H: Excavation/Chemical Extraction or Dechlorination/Disposal (With Acid Extraction)	Excavation of the contaminated soils (to an estimated depth of 14 feet); treatment of excavated material with chemical-extraction or dechlorination; backfilling the excavated area with the treated material; and installation of a clay cap.	Not retained for further analysis. The alternative was screened out because of questionable effectiveness due to the high clay content, low throughput, and management of residuals. Organic concentrations are too low for this alternative to be cost effective.
OU-1 Soils—West of Former CPC Plant	I: Excavation/Off-Site Incineration	Excavation of the contaminated soil (to an estimated depth of 14 feet); the excavated material would be transported for incineration at an off-site RCRA incineration.	Not retained due to very high cost and limited off-site incineration capacity.
OU-1 Soils—Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area	B1: Institutional Actions (Cap Inspection/Maintenance, Groundwater Monitoring near Sanitary Landfills)	Cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant, and increased groundwater monitoring in the vicinity of the sanitary landfill.	Retained for detailed analysis in Section 4.0.
OU-1 Soils—Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area	B2: Institutional Actions (Cap Inspection/Maintenance, Expanded Groundwater and Surface Water Monitoring)	Cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant; groundwater monitoring in the vicinity of the sanitary landfills, lime ponds and mercury cell plant, and surface water monitoring in the vicinity of the sanitary landfills.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-1 Soils—Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area	C1: Containment (Sanitary Landfills and Lime Ponds)/Institutional Actions	Construction of a clay cap over the sanitary landfills and a multimedia cap over the lime ponds. Cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant, and increased groundwater monitoring in the vicinity of the sanitary landfill.	Retained for detailed analysis in Section 4.0.
OU-1 Soils—Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area	C2: Containment/Consolidation (Sanitary Landfills, Lime Ponds and Well Sand Residue Area)/Institutional Actions	Consolidation of well sand material in sanitary landfill. Construction of a clay cap over the sanitary landfills a multimedia cap over the lime ponds. Cap inspection/maintenance for the sanitary landfills, lime ponds and mercury cell plant, and increased groundwater monitoring in the vicinity of the sanitary landfill.	Retained for detailed analysis in Section 4.0.
OU-2 Sediments	A: No Action	No action.	Retained for detailed analysis in Section 4.0. This alternative forms baseline for comparison to other sediment alternatives.
OU-2 Sediments	B: Institutional Actions	Extension of existing fencing to limit access, increased basin patrolling, and fish and sediment quality monitoring.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-2 Basin Sediments	C: Backfilling	Backfilling the basin with soil materials from the adjacent upland area to contain the contaminated sediments.	Retained for detailed analysis in Section 4.0.
OU-2 Basin Sediments	D: Dredging/Covering (Contained Aquatic Disposal)	Dredging the contaminated sediments in the shallow areas of the basin and placing the dredged material into the deep depression in the western-northwestern part of the basin; covering the dredged material by placing additional dredged material from the unaffected areas of the basin; monitoring integrity of the cover.	Retained for detailed analysis in Section 4.0.
OU-2 Basin Sediments	E1: Dredging/Disposal (Mechanical Dewatering)	Dredging the basin sediments to the upland area west of the basin; dewatering the dredged sediments mechanically; disposal of the dewatered sediments in an on-site or off-site non-RCRA landfill.	Retained for detailed analysis in Section 4.0.
OU-2 Basin Sediments	E2: Dredging/Disposal (Confined Disposal Facility)	Dredging the basin sediments to the upland area west of the basin; disposal and dewatering in a confined disposal facility (CDF) that would be constructed on the upland area; possible stabilization/solidification of the consolidated material in the CDF; installation of clay cap; and post-closure monitoring.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-2 Basin Sediments	F: Dredging/Acid Extraction/Disposal	Dredging the basin sediments; acid extraction to remove the mercury; disposal at an on-site/off-site RCRA/non-RCRA landfill. On-site dewatering of the sediments would be required prior to disposal.	Not retained for further analysis due to limiting factors pertaining to acid extraction such as very high silt/clay content, low throughput management of residuals and very high cost.
OU-2 Wastewater Ditch Sediments	C1: Containment (Backfill)	Excavating a new wastewater ditch adjacent to the existing ditch and utilizing the materials from the excavation to cap the existing wastewater ditch.	Retained for detailed analysis in Section 4.0.
OU-2 Wastewater Ditch Sediments	C2: Containment (Erosion Control Measures)	Construction of erosion control measures in the wastewater ditch (e.g., rip rap, erosion control blanket, etc.) to reduce downstream mobility of constituents.	Not retained for further analysis. Based on engineering judgement Wastewater Ditch Sediment Alternative C1 would be less difficult to implement and would be more effective.
OU-2 Wastewater Ditch Sediments	D: Stabilization/Solidification	Stabilization/solidification of the ditch sediments either in situ or by excavation/mixing and placement of the material in a landfill constructed on-site. The in situ stabilization option would include capping to prevent erosion.	Not retained for further analysis because there would be limited increased effectiveness over Wastewater Ditch Sediment Alternative C1.
OU-2 Wastewater Ditch Sediments	E: Excavation/Disposal	Excavation of the ditch sediments and off-site RCRA disposal.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-2 Wastewater Ditch Sediments	F1: Excavation/Chemical Extraction or Dechlorination/Disposal (With Acid Extraction)	Excavation of the ditch sediments; acid extraction to remove mercury; chemical extraction or dechlorination to remove organics; on-site or off-site disposal.	Not retained for further analysis. Effectiveness is questionable due to the high clay content. Low throughput and management of treatment residuals would make implementability very difficult. Very high cost.
OU-2 Wastewater Ditch Sediments	F2: Excavation/Chemical Extraction or Dechlorination/Disposal	Same as Wastewater Ditch Sediment Alternative F1 except that no acid extraction step would be included.	Not retained for further analysis. Effectiveness is questionable due to the high clay content. Low throughput and management of treatment residuals would make implementability very difficult. Very high cost.
OU-2 Wastewater Ditch Sediments	G1: Excavation/On-Site Thermal Treatment/Disposal	Excavation and on-site thermal treatment (e.g., infrared or rotary kiln incineration, thermal desorption); on-site disposal in a non-RCRA landfill.	Retained for detailed analysis in Section 4.0.

TABLE 3-1 (Continued)

SUMMARY OF ALTERNATIVE SCREENING ANALYSIS

Area/Media	Alternative	Description	Screening Comments
OU-2 Wastewater Ditch Sediments	G2: Excavation/On-Site Thermal Treatment/Disposal	Same as Wastewater Ditch Sediment Alternative G1 except that it would include acid extraction.	Not retained for further analysis due to implementability, effectiveness and cost. Effectiveness is questionable due to the high clay content. Low throughput and management of treatment residuals would make implementability very difficult. Very high cost. Based on engineering judgement, mercury in the sediments could be handled with proper design of thermal treatment and air pollution control devices.
OU-2 Wastewater Ditch Sediments	H1: Excavation/Off-Site Incineration	Excavation of the ditch sediment; transportation and off-site RCRA incineration.	Not retained for further analysis due to limited off-site incineration capacity and very high cost.
OU-2 Wastewater Ditch Sediments	H2: Excavation/Off-Site Incineration	Same as Wastewater Ditch Sediment Alternative H1 except that it would include acid extraction prior to incineration.	Not retained for further analysis due to limited off-site incineration capacity and very high costs. Also, the questionable effectiveness and implementation difficulties were further reasons for screening out this alternative.

Section 4

4.0
DETAILED ANALYSIS OF ALTERNATIVES

4.1 INTRODUCTION

The purpose of the following detailed analysis is to evaluate the retained alternatives and provide a basis for selection of the most appropriate alternative for each medium. The analysis was performed using the following evaluation criteria as set forth in the RI/FS guidance document:

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

Consideration of state and community acceptance are typically deferred to the issuance of the Record-of-Decision (ROD) and receipt of public comments. The remaining seven criteria are described in the following paragraphs, and the evaluation of each alternative (with respect to the criteria) is presented in Section 4.2.

The first two criteria (overall protection of human health and the environment and compliance with ARARs) are designated as threshold criteria because in most cases, these criteria must be met by the selected alternative. After evaluating compliance with the threshold criteria, the alternatives were analyzed using the next five criteria to determine how they compare to one another and to identify possible compromises between them.

Overall Protection of Human Health and the Environment

This criterion addresses whether the remedy is protective of human health and the environment considering the site's characteristics. The remedy's long-term effectiveness and permanence, short-term effectiveness, and reduction of toxicity, mobility, and volume affect the overall protection of human health and the environment. How each alternative achieves protection over time and whether site risks are eliminated, reduced, or controlled are also analyzed.

Compliance with ARARs

Section 2.2.2 provides a discussion of the potential ARARs for the site. Unless a waiver is obtained for a particular ARAR, the remedy must comply with all location-, action-, and chemical-specific ARARs. The detailed analysis provides a discussion of the appropriate action-specific ARARs that would be critical in the design and implementation of the remedial alternatives.

Long-Term Effectiveness and Permanence

This criterion relates to the long-term effectiveness of the alternative in maintaining protection of human health and the environment after response objectives have been met. The focus is on any residual risk remaining at the site after completion of the remedial action and the reliability of engineering and institutional controls and monitoring to manage hazardous substances remaining at the site.

Reduction of Toxicity, Mobility, and Volume

This evaluation criterion addresses the general preference for treatment methods that would result in the reduction of toxicity, mobility, or volume of a waste. The specific factors to be considered are the amount of waste to be destroyed or treated; the expected degree of reduction in toxicity, mobility, or volume; the degree to which the remediation would be irreversible; and the nature and quantity of treatment residuals that would remain on-site.

Short-Term Effectiveness

This criterion relates to the potential for adverse effects to the community or environment during construction and implementation of the remedy. The length of time required to achieve protection, the short-term reliability of the technology, and protection of the community and of workers during remediation are considered.

Implementability

This criterion relates to the technical and administrative feasibility of the remedial alternative. The specific factors to be considered are ability to construct, operate, and maintain the technology; ability to monitor the effectiveness of the remedy; and the ability to obtain approvals from other agencies.

Cost

The cost estimates presented in this report are typically in the +50 percent to -30 percent accuracy range. The estimates were based on a variety of information, including estimates from technology vendors, generic unit costs, conventional cost estimating guides, prior experience, and information from other Superfund sites. The estimates have been prepared for guidance in the alternative evaluation from the information available at the time of the estimate. The actual costs of the project would depend on true labor and material costs, actual site conditions, final project scope, the implementation schedule, competitive market conditions, and other variable factors. A significant uncertainty that would affect the cost is the actual volumes of contaminated soil, sediment, and groundwater. Contingencies have been applied to each alternative to take into consideration assumptions and uncertainties associated with the current project scope and unforeseen circumstances. A 30 percent contingency allowance was used to reflect uncertainties unless otherwise noted.

Capital and operation and maintenance (O&M) costs were estimated for each alternative and were used to calculate present net worth. Capital costs include the direct and indirect expenditures required to implement a remedial action. Direct costs include construction costs or expenditures for equipment, labor, and materials required

to implement a remedial action. Indirect costs include those associated with engineering services, permitting (as required) and legal services, construction services, and other services necessary to carry out a remedial action.

Annual O&M costs include operation labor, maintenance materials, maintenance labor, energy, and other costs needed for continued post-construction operation and maintenance. For purposes of comparing the long-term remedial actions, 30 years of operation, maintenance and monitoring were typically utilized in the present net worth calculations at a five percent discount rate.

The estimated present worth costs for the major components of each alternative are summarized in this section. Appendix G includes spread sheets that provide more detail on the individual cost items within these major components (e.g., clearing and grubbing, transportation, etc.) and a more detailed description of the basis of these costs. The estimated costs presented in this document are based on the volume estimates in Section 2.0. Some of the soil and the sediment alternative costs would vary significantly with volume. The volumes for the old plant (CPC) landfill, the basin and the wastewater ditch are not well defined; therefore, a sensitivity analysis was performed for these three areas. These analyses are also presented in Appendix G.

4.2 INDIVIDUAL ANALYSIS OF ALTERNATIVES

The narrative discussion in this section describes and assesses each alternative using the criteria described above (with the exception of state and community acceptance). The individual analysis for OU-1 groundwater is summarized in Table 4-1. Tables 4-2 and 4-3 summarize the individual analyses for OU-1 soils in the old plant (CPC) landfill and the area west of the former CPC plant, respectively. Table 4-4 summarizes the individual analysis for the OU-1 soil alternatives addressing the sanitary landfills, lime ponds, mercury cell plant and well sand residue area. The OU-2 basin and wastewater ditch sediment individual analyses are summarized in Tables 4-5 and 4-6, respectively.

4.2.1 OU-1 Groundwater Alternatives

Flow diagrams showing the major components of the retained OU-1 groundwater alternatives are presented in Figure 4-1. Table 4-1 summarizes the individual analysis of the OU-1 groundwater alternatives.

4.2.1.1 Groundwater Alternative A: No Action With Continuation of Existing RCRA CAP

The no action alternative would consist of continued operation of the five corrective action wells and the associated treatment systems. (The corrective action well locations are shown in Figure 1-4.) Olin would also continue the quarterly compliance and corrective action monitoring programs.

Overall Protection of Human Health and the Environment

The no action alternative is protective of human health and the environment because Olin is committed by the legally enforceable RCRA post-closure permit to operate the ongoing corrective action program until the established cleanup standards are achieved. The RCRA CAP is effective at controlling off-site migration of the plume and at preventing exposure of surrounding residents to contaminated groundwater.

Compliance with ARARs

The no action alternative complies with the ARARs. Olin is required to attain chemical-specific ARARs (the RCRA permit limits based on MCLs). Olin currently operates the CAP in conformance with all state and federal regulations that would be considered action-specific ARARs. There are no known location-specific ARARs for OU-1 groundwater.

Long-Term Effectiveness and Permanence

The CAP would be effective over the long term by continuous operation and maintenance until the cleanup objectives specified in the post-closure permit are

achieved. Olin is legally committed by their post-closure permit to long-term operation of the CAP. The wells and treatment systems are operated and maintained as integral parts of the facility's manufacturing operations, and during the past 5 years Olin has demonstrated their commitment to maintaining the systems. Permanence is dependent on residual contamination after post-closure objectives are achieved.

Reduction of Toxicity, Mobility, and Volume

There is a reduction in toxicity, mobility, and volume of contaminants in the aquifer with removal of contaminants by the ongoing CAP. Contaminants are transferred to other media with treatment (i.e., air and carbon). The carbon requires disposal at a hazardous waste landfill, which reduces mobility.

Short-Term Effectiveness

There would be no short-term adverse effects because the alternative has already been implemented. The predicted cleanup period is 25 to 27 years, as described in the RCRA post-closure permit.

Implementability

The alternative has already been implemented.

Cost

There would be no additional costs.

Contingency Measure

The RCRA CAP is effective at controlling off-site migration of the plume and at preventing exposure of surrounding residents to contaminated groundwater. Providing municipal water to area residents is retained as a contingency measure to be implemented if future monitoring indicates off-site migration to drinking water wells. McIntosh city water is available to area residents, including all those within a 3-mile

radius of the facility. The source of the water is two wells that are screened in the Miocene Aquifer - one well about 2 miles northwest and another well about 5 miles southwest of the Olin facility. Residents can be easily connected to this municipal water supply for a connection cost of about $ 250 and a monthly fee that is dependent on water usage.

4.2.1.2 Groundwater Alternative C1: Extraction/Treatment/Discharge (Vertical Extraction Wells)

Alternative C1 would consist of additional extraction wells for contaminated groundwater, with treatment and discharge of the treated water. Figure 4-2 shows potential locations for two additional extraction wells in the areas that are potential continuing sources of groundwater contamination. One extraction well would be installed through the center of the old plant (CPC) landfill to accelerate removal of organics. The other extraction well would be installed to the south of the brine ponds (the area of interpreted mercury-containing dense brine accumulation). Three additional monitor wells would be installed in the vicinity of the old plant (CPC) landfill to assess the effectiveness of this alternative. These monitor wells would be added to Olin's ongoing RCRA quarterly monitoring program.

The two extraction wells would be installed in a manner similar to the existing corrective action wells, with 10-inch-diameter PVC casing screened across the full saturated thickness of the Alluvial Aquifer. Two vertical extraction wells were selected for this alternative based on the areal extent of the target areas and the radius of influence created by the existing CAP wells. The alternative is based on installing one of the vertical wells through the center of the old plant (CPC) landfill - the suspected source area. The Phase III sampling data indicate that is practical because contaminant migration appears to be occurring from areas below the waste/fill material through the unsaturated sands. A well installed through the landfill would maximize recovery and reduce the lateral spread of contaminants within the aquifer. A well installed outside of the landfill area could cause increased lateral spread of contaminants. Soil remedial alternatives for the old plant (CPC) landfill could be implemented in conjunction with Groundwater Alternative C1. Construction of some of the soil remedial alternatives could affect installation of the well through the center of the landfill. In that case, the

well would either be installed after construction of the soil alternative, or the vertical extraction well could alternatively be installed directly to the north of the landfill. The pumping rate is estimated to be about 100 gpm for each well.

The treatment systems would consist of air stripping to remove volatile and some semivolatile organics, followed by carbon adsorption, primarily for mercury removal but also as a polishing step for the organics. A pH adjustment may be required prior to discharge. The treatment components would be sized and designed similar to the existing system. Depending on the flow rate and brine concentrations, reduction of TDS may be required to meet the NPDES permit limits. For the purpose of this FS, it was assumed that TDS treatment would be with reverse osmosis (RO). Preliminary discussions with vendors have indicated that RO would be very expensive (about 20 to 30 million dollars present worth cost over a 30-year operation period). Olin is continuing to evaluate other options, such as recycling the discharge from the carbon adsorber and the air stripper to the brine system of the chlorine plant. Treatability testing would be required for the selection and design of the appropriate TDS treatment process. Figure 4-3 shows a conceptual process flow diagram of the groundwater treatment system.

Overall Protection of Human Health and the Environment

Alternative C1 would be protective of human health and the environment. The additional extraction wells would add to the protectiveness of the CAP by accelerating contaminant removal. Alternative C1 would be effective at controlling off-site migration of the plume and preventing exposure of surrounding residents to contaminated groundwater.

Compliance with ARARs

This alternative would reduce the time period for groundwater cleanup and compliance with the groundwater chemical-specific ARARs. The system would be designed to meet all action-specific ARARs. The appropriate action-specific ARARS are discussed below:

- The air emissions caused by operation of the air strippers would have to comply with the Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations. Based on Olin's current emissions and the requirements for the air strippers operating for the existing CAP, it is anticipated that off-gas treatment will not be required.

- The treated water would be discharged through Olin's existing NPDES treatment system, which may require a permit modification. As discussed above, brine concentrations may be too high to allow for direct discharge, and treatment (prior to discharge) to reduce the brine concentrations may be required. Olin is continuing to evaluate options to reduce the TDS in their wastewater effluent stream.

There are no known location-specific ARARs for OU-1 groundwater.

Long-Term Effectiveness and Permanence

The CAP's long-term effectiveness would be increased with accelerated contaminant removal. Permanence would depend on the effectiveness of groundwater extraction at remediating the potential source areas. This effectiveness would be assessed using data from the expanded groundwater monitoring program.

Reduction of Mobility, Toxicity, and Volume

Toxicity, mobility, and volume of contaminants would be reduced within the aquifer with removal by the extraction wells. Contaminants would be transferred to other media with treatment (i.e., air and carbon). The carbon requires disposal at a hazardous waste landfill, which would reduce mobility.

Short-Term Effectiveness

Short-term adverse effects would be minimal. The potential for short-term exposure of remedial workers during installation could be managed with proper health and safety

procedures. There would be minor increases in volatile emissions as compared to no action, and groundwater sampling and recovery operations would increase the potential for worker exposure during the sampling program. However, the associated increases in human health risk should be negligible. It is estimated that Alternative C1 could be implemented within 12 months from the start of construction. The predicted time to meet remedial action objectives has not been determined, but there should be a reduction in the cleanup period as compared to the no action alternative.

Implementability

Vertical extraction wells are readily implementable, as demonstrated by the existing CAP. Treatability studies would have to be conducted to evaluate the appropriate technology for reducing the TDS concentrations to meet the existing NPDES permitting standards (i.e., if treatment for TDS is required).

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Groundwater Alternative C1 Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Vertical Well with Treatment System No. 1[1]	1	638,000	1,325,000	1,963,000
Vertical Well with Treatment System No. 2[1]	1	638,000	1,325,000	1,963,000
TOTAL		1,276,000	2,650,000	3,926,000

NOTE:

[1] Treatment for TDS may be required to meet the NPDES permit limits. The cost for reverse osmosis is not included at this time. Preliminary discussions with vendors have indicated it would be very expensive (about 20 to 30 million dollars present worth cost over a 30-year operation period). Olin is continuing to evaluate other options such as recycling the discharge from the carbon adsorber and the air stripper to the brine system of the chlorine plant.

4.2.1.3 Alternative C3: Extraction/Treatment/Discharge (Vertical and Horizontal Extraction Wells)

Alternative C3 would include extraction from a horizontal well and a vertical well and treatment of the extracted groundwater. The horizontal extraction well would be installed in the area to the south of the weak brine pond area (the area of dense brine accumulation). The vertical extraction well would be installed through the center of the old plant (CPC) landfill. Figure 4-4 shows potential locations of these wells. Three additional monitor wells would be installed in the vicinity of the old plant (CPC) landfill to assess the effectiveness of this alternative. These monitor wells would be added to Olin's ongoing RCRA quarterly monitoring program.

The vertical extraction well would be installed in a manner similar to the existing corrective action wells, with 10-inch-diameter PVC casing screened across the full saturated thickness of the Alluvial Aquifer. The alternative is based on installing the vertical extraction well through the center of the old plant (CPC) landfill - the suspected source area. The Phase III sampling data indicate that is practical because contaminant migration appears to be occurring from areas below the waste/fill material through the unsaturated sands. A well installed through the landfill would maximize recovery and reduce the lateral spread of contaminants within the aquifer that could be caused by a well installed outside of the landfill area could cause increased lateral spread of contaminants. Soil remedial alternatives for the old plant (CPC) landfill could be implemented in conjunction with Groundwater Alternative C3. Construction of some of the soil remedial alternatives could affect installation of the well through the center of the landfill. In that case, the well would either be installed after construction of the soil alternative, or the vertical extraction well could alternatively be installed directly to the north of the landfill. The horizontal well would be installed using directional drilling techniques. The horizontal section of the well would be situated at the base of the Alluvial Aquifer (the top of the Miocene clay) in the area where dense mercury-containing brine is believed to have accumulated. Figure 4-5 shows a typical cross section of a horizontal well. Since the purpose of the well would be to recover the mercury-containing brine, testing would be performed after installation to determine the appropriate pumping rate to maximize mercury removal. For the purpose of this FS, the pumping rates are assumed to be about 100 gpm for both the horizontal and vertical

wells. The treatment systems would consist of air stripping to remove volatile and some semivolatile organics, followed by carbon adsorption, primarily for mercury removal but also as a polishing step for the organics. A pH adjustment also may be required. The treatment components would be sized and designed similar to the existing system. Depending on the flow rate and brine concentrations, reduction of TDS may be required to meet the NPDES permit limits. For the purpose of this FS, it was assumed that TDS treatment would be with reverse osmosis (RO). Preliminary discussions with vendors have indicated that RO would be very expensive (about 20 to 30 million dollars present worth cost over a 30-year operation period). Olin is continuing to evaluate other options, such as recycling the discharge from the carbon adsorber and the air stripper to the brine system of the chlorine plant. Treatability testing would be required for the selection and design of the appropriate TDS treatment process. Figure 4-3 shows a conceptual process flow diagram of the groundwater treatment system.

Overall Protection of Human Health and the Environment

Alternative C3 would be protective of human health and the environment. The additional extraction wells would add to the protectiveness of the CAP by accelerating contaminant removal. Alternative C3 would be effective at controlling off-site migration of the plume and preventing exposure of surrounding residents to contaminated groundwater.

Compliance with ARARs

This alternative would reduce the time period for groundwater cleanup and compliance with the chemical-specific ARARs that are required by the CAP. The system would be designed to meet all action-specific ARARs. The appropriate action-specific ARARS are discussed below:

- The air emissions caused by operation of the air strippers would have to comply with the Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations. Based on Olin's current emissions and the requirements for the air strippers operating

for the existing CAP, it is anticipated that off-gas treatment will not be required.

- The treated water would be discharged through Olin's existing NPDES treatment system, which may require a permit modification. As discussed above, brine concentrations may be too high to allow for direct discharge, and treatment (prior to discharge) to reduce the brine concentrations may be required. Olin is continuing to evaluate other options to reduce the TDS in their wastewater effluent stream.

There are no known location-specific ARARs for OU-1 groundwater.

Long-Term Effectiveness and Permanence

The CAP's long-term effectiveness would be increased with accelerated contaminant removal. Permanence would depend on the effectiveness of the groundwater extraction program at remediating the potential source areas. This effectiveness would be assessed using data from the expanded groundwater monitoring program.

Reduction of Toxicity, Mobility, and Volume

Toxicity, mobility, and volume of contaminants would be reduced within the aquifer with removal by the extraction wells. Contaminants would be transferred to other media with treatment (i.e., air and carbon). The carbon would require disposal at a hazardous waste landfill, which would reduce mobility.

Short-Term Effectiveness

Short-term adverse effects would be minimal. The potential for short-term exposure of remedial workers during implementation could be managed with proper health and safety procedures. There would be minor increases in volatile emissions as compared to no action, and groundwater sampling and recovery operations would increase the potential for worker exposure during the sampling program. However, the associated increases in human health risk would be negligible. It is estimated that alternative C3

could be implemented within 12 months from the start of construction. The predicted time to meet the remedial action objectives has not been determined, but there should be a reduction in the cleanup period as compared to the no action alternative.

Implementability

Vertical extraction wells are readily implementable. Although horizontal well installation is currently conducted by only a few contractors and the technology is still in development, these systems are becoming more common for groundwater remediation. Based on discussions with the horizontal well contractors, the system would be implementable. Additional characterization prior to design must be conducted to obtain a better definition of the brine layer and thus define the appropriate location and length of the horizontal well. Treatability studies would have to be conducted to evaluate the appropriate technology for reducing the TDS concentrations to meet the existing NPDES permitting standards (i.e., if treatment for TDS is required).

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Groundwater Alternative C3 Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Vertical Well with Treatment System[1]	1	638,000	1,325,000	1,963,000
Horizontal Well with Treatment System[1]	2	1,282,000	1,325,000	2,607,000
TOTAL		1,920,000	2,650,000	4,570,000

NOTE:

1 Treatment for TDS may be required to meet the NPDES permit limits. The cost for reverse osmosis is not included at this time. Preliminary discussions with vendors have indicated it would be very expensive (about 20 to 30 million dollars present worth cost over a 30-year operation period). Olin is continuing to evaluate other options such as recycling the discharge from the carbon adsorber and the air stripper to the brine system of the chlorine plant.

OU-1 Groundwater Alternative C3

4.2.2 OU-1 Soil Alternatives for the Old Plant (CPC) Landfill

The evaluation of retained OU-1 soil alternatives for the old plant (CPC) landfill is presented in this section and summarized in Table 4-2. Figure 2-1 depicts the existing conditions in this area. Flow diagrams showing the major components of the assembled alternatives are presented in Figure 4-6. The primary objective of the alternatives is protection of groundwater. The no action alternative for soils in the old plant (CPC) landfill area would be the same with regard to the screening criteria as the no action alternative for OU-1 groundwater, which is discussed in Section 4.2.1. A separate detailed analysis of no action is therefore not presented in this section.

As discussed in Section 2.3.2.3, soils from the location of the old plant landfill drainage ditch are included in the alternatives assembled for the old plant (CPC) landfill. The RI sampling data indicate that remedial action of these soils would not be required to meet the remedial action objectives and based on the PSALs developed for the adjacent landfill (Table 2-8), remediation would not be required for protection of groundwater. The exposure point concentrations used in the baseline risk assessment that showed no unacceptable risk to industrial workers from exposure to surface soils (via ingestion, direct contact and inhalation) were at or above the concentrations detected in the two samples obtained from the former drainage ditch area (see Section 1.3). The maximum mercury concentration detected in these two samples was 10.2 mg/kg. A preliminary remediation goal (PRG) of 89 mg/kg for mercury (Table 2-3) was developed based on ingestion of surface soils by the hypothetical resident (child) receptor. (Using PRGs from the hypothetical future resident is very conservative. Olin asserts that the potential for parts of the site to become residential are virtually nonexistent.)

4.2.2.1 <u>Soil Alternative C - Old Plant (CPC) Landfill: Containment (Improvement Capping)</u>

Alternative C would consist of upgrading the existing cap over the old plant (CPC) landfill and performing additional groundwater monitoring in the vicinity of the landfill. Both clay and multimedia caps were considered. The detailed analysis is based on a multimedia cap.

OU-1 Soil Alternative C - Old Plant (CPC) Landfill

The estimated area to be capped is 3.0 acres, based on the approximate dimensions of the landfill (300 x 400 feet). The existing topsoil and some of the existing clay would be stripped and stockpiled. It was assumed that approximately 1,000 cubic yards of soil (300 feet long by 20 feet wide by 5 feet deep) would be excavated from the area of the former old plant (CPC) landfill drainage ditch and placed in the landfill. The upgraded cap would consist of the following elements (in ascending order):

- Two feet of a compacted clay barrier layer with a permeability not to exceed 1 x 10^{-7} cm/s. (The potential for using the existing clay cap material as part of this layer would be evaluated.)

- One 60-mil high-density polyethylene (HDPE) liner.

- One composite geonet (i.e., drainage layer).

- Two feet of cover layer, including one foot of topsoil and one foot of compacted native soil material with a slope not to exceed 5 percent. The topsoil would be seeded and mulched. (The top soil removed from the existing cap may be used.)

Figure 4-7 shows the multimedia cap configuration for Alternative C. Three monitor wells would be installed in the vicinity of the landfill to evaluate the upgraded cap's effectiveness at reducing contaminant migration to the Alluvial Aquifer. These wells would be added to Olin's existing groundwater monitoring program.

<u>Overall Protection of Human Health and the Environment</u>

This alternative would be protective of human health and the environment. It would minimize further release of contaminants to the groundwater by limiting future infiltration through the cap. Based on the HELP model, the infiltration rate through the multimedia cap is estimated to be 0.04 inches per year, or a 98 percent reduction over the 2.2 inches per year estimated for existing conditions. This calculation is presented in Appendix E. Residual contamination would be present in the fill/waste material and the subsurface soils after the alternative is implemented, and some

leaching to the groundwater may continue at a lower rate than currently exists. Based on the PSALs presented in Table 2-8, which are near the maximum concentrations detected in the soil without consideration of the cap, the clay cap would be protective of groundwater. Lowering the leaching rate would accelerate contaminant reduction in the Alluvial Aquifer.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative C would be implemented to comply with the action-specific ARARs. The soils from the old plant (CPC) landfill drainage ditch area (an estimated 1,000 cubic yards) would be the only excavated material associated with this alternative. Olin has determined that these soils would not be classified as a listed hazardous waste under 40 CFR 261, and the chemical analyses of the Phase III soil samples from this area (Section 1.3.1.2) indicate that it is very unlikely that they would be classified as a characteristic hazardous waste. Therefore, the minimum technical requirements (MTRs) under 40 CFR 264 and the land disposal restrictions (LDRs) would not be ARARs. However, it was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. Since infiltration of water through the wastes would be reduced, the long-term effect would be reduction in the rate of contaminant infiltration to the groundwater. Permanence would be dependent on cap maintenance.

OU-1 Soil Alternative C - Old Plant (CPC) Landfill

Reduction of Toxicity, Mobility, and Volume

The mobility of constituents would be reduced due to a decrease in infiltration to the groundwater. There would be no reduction in toxicity or volume of the fill/waste or residual contamination. However, containment is considered an appropriate alternative because mobility to the groundwater is the only potential long-term threat posed by OU-1 soils.

Short-Term Effectiveness

There would be little to no short-term adverse effects. The existing clay cover would not be removed completely prior to placing the landfill ditch soils and constructing the cap in order to prevent worker exposure to the underlying landfill fill/waste material. It is estimated that Alternative C could be implemented within 4 months from the start of construction.

Implementability

Alternative C could be readily implemented. The technology is well demonstrated and standard construction equipment and practices could be utilized for implementation. Additional characterization would be required to define the limits of excavation in the old plant (CPC) landfill drainage ditch area.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

OU-1 Soil Alternative C - Old Plant (CPC) Landfill

4 9 0303

Soil Alternative C Old Plant (CPC) Landfill Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Excavation/Transport (Old Plant Landfill Drainage Ditch Soils)	3	58,000	0	58,000
Multimedia Cap	4	1,669,000	437,000	2,106,000
TOTAL		1,727,000	437,000	2,164,000

4.2.2.2 Soil Alternative D - Old Plant (CPC) Landfill: In Situ Stabilization-Solidification/Containment

Alternative D would consist of stabilizing/solidifying the residual fill/waste material in the old plant (CPC) landfill and underlying affected soils, installing a clay cap, and installing additional monitor wells.

Based on the Phase III soil boring investigations for the old plant (CPC) landfill, the maximum depth of the loose silt/clay zone was 22 feet and the vertical extent of contamination was generally limited to the upper 23 feet (with the exception of one of the borings). Therefore, Alternative D was evaluated assuming stabilization/solidification (S/S) to a depth of 23 feet over the 300- x 400-foot landfill (approximately 100,000 cubic yards). The data from the RI indicated that contaminant migration occurs only from certain portions of the landfill area (primarily the western portion). Therefore, prior to implementation, additional characterization would be required to define the horizontal and vertical limits for S/S.

The existing topsoil and some of the existing clay would be stripped and stockpiled prior to S/S. It was assumed that approximately 1,000 cubic yards of soil (300 feet long by 20 feet wide by 5 feet deep) would be excavated from the area of the former old plant (CPC) landfill drainage ditch and placed in the landfill.

Various remedial contractors perform in situ S/S using different techniques. For the purpose of this analysis, it was assumed that the in situ mixing would be done with large-diameter augers that would be advanced through the area to be treated. Other in situ S/S technologies such as grout injection may be more appropriate. The

appropriate technology would be determined during the remedial design phase. For the S/S technique presented in this analysis, reagents would be added pneumatically (if dry) or pumped (if fluid). Mixing would be done in overlapping cylinders to ensure that the site was uniformly mixed and solidified. Type I portland cement at 20 percent addition by weight was assumed for this analysis. The vendor estimate was 15 percent addition by weight; 20 percent was assumed to be conservative for developing the cost estimate. The specific type of in situ mixing equipment would be determined during the remedial design phase. The reagent and the mix ratios would be selected based on the bench-scale studies that were outlined in the treatability study work plan/SAP (WCC, 1992).

After completing the S/S, a clay cap would be installed consisting of a 2-foot compacted clay liner, with a permeability not to exceed 1×10^{-7} cm/s, and 1 foot of topsoil. The topsoil would be seeded and mulched to establish vegetation. Three monitor wells would be installed in the vicinity of the landfill to evaluate the alternative's effectiveness at reducing contaminant migration to the Alluvial Aquifer. These wells would be added to Olin's existing groundwater monitoring program. A cross section and plan view of Alternative D is depicted in Figure 4-8.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. In situ S/S would add to the protectiveness of the existing CAP by immobilizing constituents and reducing further degradation of the Alluvial Aquifer. Degradation of the aquifer would also be reduced by reduced infiltration due to the improved cap.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative D would be implemented to comply with the action-specific ARARs. The soils from the old plant landfill drainage ditch area (an estimated 1,000 cubic yards) would be the only excavated material associated with this alternative. Olin has determined that these soils would not be classified as a listed hazardous waste under 40 CFR 261, and the chemical analyses of the Phase III soils samples from this area (Section 1.3.1.2) indicate that it

is very unlikely that they would be classified as a characteristic hazardous waste. Therefore, the MTRs under 40 CFR 264 and the LDRs would not be ARARs. However, it was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required.

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the in situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs. Engineering controls may be required to meet these air quality standards.

There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. As a result of S/S, the contaminants would be essentially immobilized, thereby reducing or eliminating their downward migration to the groundwater. The clay cap over the landfill would minimize future infiltration through the landfill and protect the stabilized/solidified materials from erosion or direct contact. This alternative is considered permanent because the contaminants would remain immobile even if there were an increase in infiltration. In addition, the overall strength of the subsurface materials in the landfill would be enhanced by S/S, providing more stability for the cap.

Reduction of Toxicity, Mobility, and Volume

Contaminants would be permanently immobilized within the S/S matrix. There would be an increase (estimated to be about 20 percent) in the volume of wastes/residual contamination. The 20 percent increase in volume is based on a vendor estimate. A more accurate estimate of the volume increase would be obtained from the bench-scale studies that were outlined in the treatability study work plan/SAP (WCC, 1992). Volume increase would be a major factor in selecting the appropriate mixing reagents

and mix ratios for the S/S process. Most mixing reagents do not significantly reduce toxicity. However, this is considered an appropriate alternative because mobility to the groundwater is the only potential long-term threat posed by OU-1 soils. This alternative satisfies the statutory preference for using treatment as a principal component.

Short-Term Effectiveness

Short-term adverse effects would be related to potential exposure of workers. The S/S process would generate dust during implementation with the potential for exposure to workers and surrounding residents. Dust generation could be managed through the use of engineering controls such as air movers to keep dust away from workers. Reagents are commonly injected below grade to limit dust generation. The S/S procedure is intrusive, and there would be a potential to encounter material in the landfill that could be an exposure hazard to workers. Appropriate health and safety procedures would be required, as well as possible additional characterization to better define the potential hazards. The landfill is located well within boundaries of the facility, and off-site impacts would be minimal. It is estimated that Alternative D could be implemented within 22 months from the start of construction.

Implementability

Based on the existing information, Alternative D could be implemented with moderate-to-high difficulty. Implementation difficulties would be primarily due to debris and other material, such as wood or concrete, encountered during the mixing. Any obstructions present in the landfill would hinder productivity and possibly effectiveness. Specialized equipment may be required for S/S, but the technology is well demonstrated and services of this type are provided by a number of vendors. Bench-scale testing is planned, as outlined in the treatability study work plan/SAP (WCC, 1992). Additional characterization would be required to better define the physical characteristics of the subsurface materials in the landfill and also to better define the potential hazards to remedial workers. Additional characterization would also be required to define the limits of excavation in the old plant landfill drainage ditch area. Because of the occurrence of the loose silt/clay zone, the feasibility of working with heavy mixing equipment on the old plant (CPC) landfill would have to be evaluated. The technology

for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Soil Alternative D Old Plant (CPC) Landfill Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Excavation/Transport (Old Plant Landfill Drainage Ditch Soils)	3	58,000	0	58,000
In Situ S/S (0 to 23 feet)	5	14,661,000	0	14,661,000
Clay Cap	6	999,000	437,000	1,436,000
TOTAL		15,718,000	437,000	16,155,000

The in situ S/S component has a 70 percent contingency because of debris that may be present in the landfill and its unknown effects on schedule (and thereby cost).

4.2.2.3 Soil Alternative E - Old Plant (CPC) Landfill: Excavation/Stabilization-Solidification/Containment

Alternative E would consist of excavating the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet, stabilizing/solidifying the excavated materials, in situ S/S of the subsurface soils from 15 to 23 feet, placement of the excavated and stabilized/solidified material back into the landfill, installation of a clay cap, and installation of additional monitor wells.

A depth of 15 feet was assumed as the practical limit of excavation, as described in Section 2.3.2. Based on the results of soil borings, a 15-foot deep excavation would encompass all of the fill/waste material. For a 300- x 400-foot excavation 15 feet deep, approximately 67,000 cubic yards would be removed for treatment. It is expected that cutoff walls or sheet piles would be required on the western boundary of the excavation

to protect an active railroad. The RI data also indicated that contaminant migration appears to occur from zones below 15 feet. Therefore, this alternative would include in situ S/S from 15 to 23 feet. For this FS, it was assumed that the excavation and S/S procedures would be implemented across the 300- x 400- foot area. However, the data indicated that contaminant migration occurs only from certain portions of this area (primarily the western portion).

The existing topsoil and some of the existing clay would be stripped and stockpiled prior to excavation. It was assumed that during excavation any debris or material not compatible with the treatment process would be screened and sent to an off-site RCRA landfill. Some material could require incineration as described under Compliance with ARARs.

The excavated material would be loaded into trucks and transported to a temporary storage area. After completing the excavation, in situ S/S would be conducted (from 15 to 23 feet bgs). It was assumed that approximately 1,000 cubic yards of soil (300 feet long by 20 feet wide by 5 feet deep) would be excavated from the area of the former old plant landfill drainage ditch and transported to the treatment area.

Various remedial contractors perform in situ S/S using different techniques. For the purpose of this analysis, it was assumed that the in situ mixing would be done with large-diameter augers that would be advanced through the area to be treated. Reagents would be added pneumatically (if dry) or pumped (if fluid). Mixing would be done in overlapping cylinders to ensure that the site was uniformly mixed and solidified. Type I portland cement at 20 percent addition by weight was assumed for this analysis. The vendor estimate was 15 percent addition by weight; 20 percent was assumed to be conservative for developing the cost estimate. The specific type of in situ mixing equipment would be determined in the remedial design phase. The reagent and the mix ratios would be selected based on the bench-scale studies that were outlined in the treatability study work plan/SAP (WCC, 1992).

Ex situ S/S of the excavated material would be performed in a pug mill or mixing box at an on-site treatment area. RCRA standards for temporary storage and treatment of

the excavated materials may be relevant and appropriate depending on the waste characterization.

After ex situ S/S, the treated material would be transported back to the old plant (CPC) landfill, placed in lifts, and compacted using standard compaction equipment. The backfilled S/S material would then be graded to facilitate the construction of a clay cap. The clay cap would consist of a 2-foot compacted clay liner with a permeability not to exceed 1×10^{-7} cm/s, and 1 foot of topsoil. The topsoil would be seeded and mulched to establish vegetation. Three monitor wells would be installed in the vicinity of the landfill to evaluate the alternative's effectiveness at reducing contaminant migration to the Alluvial Aquifer. These wells would be added to Olin's existing groundwater monitoring program. A cross section depicting Alternative E is presented in Figure 4-9.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. Stabilization/solidification would add to the protectiveness of the existing CAP by immobilizing constituents and reducing further degradation of the Alluvial Aquifer. Degradation of the aquifer would also be reduced by reduced infiltration due to the improved cap.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative E would be implemented to comply with the action-specific ARARs. Olin has determined that the material contained in the landfill would not be classified as a listed hazardous waste under 40 CFR 261. Olin submitted a plan {the treatability study work plan/SAP (WCC, 1992)} for testing the landfill fill/waste to determine whether it would be a characteristic hazardous waste. EPA is still reviewing this plan. However, based on knowledge of the material (i.e., dominantly low-solubility constituents in clayey matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. Therefore LDRs and MTRs would not be relevant and appropriate. It is also very

unlikely that the excavated soils from the old plant landfill drainage ditch would be a hazardous waste. Depending on the final remedy selected, Olin anticipates that its RCRA permit would be amended to designate an appropriate area, such as the landfill, as a CAMU, allowing hazardous wastes to be excavated, treated and redeposited within the landfill area without triggering the LDRs or MTRs.

As discussed above, off-site RCRA land disposal is assumed for any debris or other material that is not compatible with the ex situ process. If any of this material failed the TCLP test, LDRs would apply and the applicable treatment standards would have to be met prior to land disposal. If such material is encountered, off-site RCRA incineration would probably be the appropriate contingency disposal method. The cost for contingency incineration has not been included.

It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required.

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the ex situ and in situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs. Engineering controls may be required to meet these air quality standards.

State and federal regulations applicable to transportation of hazardous waste (ADEM Administrative Code R.335-14-4 and 40 CFR 263) would be ARARs for any hazardous waste transported off-site and the U. S. Department of Transportation rules would be ARARs for transporting hazardous materials (49 CFR 107).

There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. As a result of S/S, the

contaminants would be essentially immobilized, thereby reducing or eliminating their downward migration to the groundwater. The clay cap over the landfill would minimize future infiltration through the landfill and protect the stabilized/solidified materials from erosion or direct contact. This alternative is considered permanent because the contaminants would remain immobile even if there were an increase in infiltration. In addition, the overall strength of the subsurface materials in the landfill would be enhanced by S/S, providing stability for the clay cap.

Reduction of Toxicity, Mobility, and Volume

Contaminants would be permanently immobilized within the S/S matrix. There would be an increase in the volume of wastes/residual contamination (estimated to be 20 percent). The 20 percent increase in volume is based on a vendor estimate. A more accurate estimate of the volume increase would be obtained from the bench-scale studies that were outlined in the treatability study work plan/SAP (WCC, 1992). Volume increase would be a major factor in selecting the appropriate mixing reagents and mix ratios for the S/S process. Most mixing reagents do not significantly reduce toxicity. However, this is considered an appropriate alternative because mobility to the groundwater is the only potential long-term threat posed by OU-1 soils. This alternative satisfies the statutory preference for using treatment as a principal component.

Short-Term Effectiveness

The short-term adverse effects under this alternative would be generally related to the potential for exposure of workers and the environment during excavation and handling of the excavated material. These short-term effects could be managed through proper excavation techniques (e.g., sloping, shoring) and health and safety monitoring. The S/S process would generate dust during implementation, but this could be managed through the use of engineering controls such as air movers to keep dust away from workers. For in-situ S/S the reagents are commonly injected below grade to limit dust generation. The excavation and treatment areas would be well within the boundaries of the facility, and off-site effects should be minimal. It is estimated that this alternative could be implemented within 26 months from the start of construction.

OU-1 Soil Alternative E - Old Plant (CPC) Landfill

Implementability

Alternative E would be moderately difficult to implement. Excavation may be difficult because of debris such as wood and concrete expected to be present in the landfill, and because of surrounding structures (e.g., railroad track). Screening of the excavated material may be required prior to treatment. The surrounding structures would have to be protected either through shoring, sloping or sheet piling and the presence of such structures may limit the depth of excavation. Specialized equipment may be required for S/S, but the technology is well demonstrated and services of this type are provided by a number of vendors. Bench-scale tests are planned, as outlined in the treatability study work plan/SAP (WCC, 1992), to select the appropriate reagents and mixtures for in situ and ex situ S/S. Based on the existing data, ex situ S/S could be implemented after screening out any unacceptable material. Additional characterization would be required to define the excavation and in situ S/S limits. Additional characterization would also be required to define the limits of excavation in the old plant landfill drainage ditch area. The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Soil Alternative E Old Plant (CPC) Landfill Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Excavation/Transport (Old Plant Landfill Drainage Ditch Soils)	3	58,000	0	58,000
Excavation/Backfill	7	17,148,000	0	17,148,000
Ex Situ S/S (0 to 15 feet)	8	7,560,000	0	7,560,000
In Situ S/S (15 to 23 feet)	9	3,887,000	0	3,887,000
Clay Cap	6	999,000	437,000	1,436,000
TOTAL		29,652,000	437,000	30,089,000

OU-1 Soil Alternative E - Old Plant (CPC) Landfill

4 9 0358

The excavation component has a 70 percent contingency because of debris that may be present in the landfill and its unknown effect on schedule (and thereby cost).

4.2.2.4 Soil Alternative F - Old Plant (CPC) Landfill: Excavation/Off-Site RCRA Disposal

Alternative F would consist of excavating the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet, disposing of the excavated materials off-site at a commercial hazardous waste landfill, stabilizing/solidifying in situ from 15 to 23 feet, backfilling the landfill with imported backfill material, installing a cap, and installing additional monitor wells.

A depth of 15 feet was assumed as the practical limit of excavation, as described in Section 2.3.2. Based on the results of soil borings, a 15-foot deep excavation would encompass all of the fill/waste material. For a 300- x 400-foot excavation 15 feet deep, approximately 67,000 cubic yards would be removed for treatment. The RI data also indicated that contaminant migration appears to occur from zones below 15 feet. Therefore, this alternative would include in situ S/S from 15 to 23 feet. For this FS, it was assumed that the excavation and S/S procedures would be implemented across the 300- x 400- foot area. However, the data indicated that contaminant migration occurs only from certain portions of this area (primarily the western portion). It was also assumed that approximately 1,000 cubic yards of soil (300 feet long by 20 feet wide by 5 feet deep) would be excavated from the area of the former old plant landfill drainage ditch and transported off-site for disposal.

The existing topsoil and some of the existing clay would be stripped and stockpiled prior to excavation. It is expected that cutoff walls or sheet piles would be required on the western boundary of the excavation to protect an active railroad. The excavated material would be transported via trucks and disposed of at a permitted off-site disposal facility, and the excavation would be backfilled with imported fill material. Figure 4-10 shows a cross section of the old plant (CPC) landfill for Alternative F.

OU-1 Soil Alternative F - Old Plant (CPC) Landfill

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. Excavation and off-site disposal would add to the protectiveness of the existing CAP by removal of constituents, reducing further degradation of the Alluvial Aquifer. Degradation of the aquifer would also be reduced by reduced contaminant infiltration due to in situ S/S and the improved cap.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative F would be implemented to comply with the action-specific ARARs. Olin has determined that the material contained in the landfill would not be classified as a listed hazardous waste under 40 CFR 261. Olin submitted a plan {the treatability study work plan/SAP (WCC, 1992)} for testing the landfill fill/waste to determine whether it would be a characteristic hazardous waste. EPA is still reviewing this plan. However, based on knowledge of the material (i.e., dominantly low-solubility constituents in clayey matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. A RCRA hazardous waste disposal facility was assumed primarily because of potential problems in obtaining acceptance of a CERCLA waste at a solid waste disposal facility, and Olin's stringent internal policies regarding off-site disposal. In the event that some of the excavated soils would not pass the TCLP test, LDRs would apply, and applicable treatment standards would have to be met. If such material is encountered, off-site RCRA incineration would probably be the only off-site contingency disposal method available without prior treatment, although the cost for off-site contingency incineration has not been included in this FS.

It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required.

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the in situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs. Engineering controls may be required to meet these air quality standards.

State and federal regulations applicable to transportation of hazardous waste (ADEM Administrative Code R.335-14-4 and 40 CFR 263) would be ARARs for any hazardous waste transported off-site and the U. S. Department of Transportation rules would be ARARs for transporting hazardous materials (49 CFR 107).

There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. It would provide long-term effectiveness and permanence by removing contaminants (i.e., the excavated fill/waste material) from the site. As a result of S/S, the residual contaminants from 15 to 23 feet would be immobilized, thereby reducing or eliminating their downward migration to the groundwater. The clay cap over the landfill would minimize future infiltration through the landfill. In addition, the overall strength of the subsurface materials in the landfill would be enhanced by S/S, providing stability for the clay cap.

Reduction of Toxicity, Mobility, and Volume

The overall volume of the wastes/residual contamination on-site would be reduced as a result of removal and off-site disposal, which would reduce mobility. Contaminants from 15 to 23 feet would be permanently immobilized within the S/S matrix. Most mixing reagents do not significantly reduce toxicity. Off-site landfilling would not reduce the toxicity of the material.

OU-1 Soil Alternative F - Old Plant (CPC) Landfill

Short-Term Effectiveness

The short-term adverse effects under this alternative would be generally related to the potential for exposure of workers and the environment during excavation and handling of the excavated material. These short-term effects could be managed through proper excavation techniques (e.g., sloping, shoring) and health and safety monitoring. The S/S process would generate dust during implementation but this could be managed through the use of engineering controls such as air movers to keep dust away from workers. Reagents are commonly injected below grade to limit dust generation. In addition, there would be potential short-term risks to the public from spills during off-site transportation and disposal. It is estimated that this alternative could be implemented within 24 months from the start of construction.

Implementability

Alternative F would be moderately difficult to implement. Excavation may be difficult because of debris such as wood and concrete expected to be present in the landfill, and because of surrounding structures (e.g., railroad track). Screening of the excavated material may be required prior to treatment. The surrounding structures would have to be protected either through shoring, sloping or sheet piling and the presence of such structures may limit the depth of excavation. Additional characterization would be required to better define the excavation and in situ S/S limits. Additional characterization would also be required to define the limits of excavation in the old plant (CPC) landfill drainage ditch area. Specialized equipment may be required for S/S, but the technology is well demonstrated and services of this type are provided by a number of vendors. Bench-scale tests are planned, as outlined in the treatability study work plan/SAP (WCC, 1992), to select the appropriate reagents and mixtures for in situ S/S. Off-site transportation and disposal could be readily implemented. The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

OU-1 Soil Alternative F - Old Plant (CPC) Landfill

4 9 0310

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Soil Alternative F Old Plant (CPC) Landfill Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Total Present Worth Total Cost ($)
Excavation/Transport (Old Plant Landfill Drainage Ditch Soils)	3	58,000	0	58,000
Excavation/Backfill	10	20,744,000	0	20,744,000
Off-Site RCRA Disposal (0 to 15 feet)	11	47,222,000	0	47,222,000
In Situ S/S (15 to 23 feet)	9	3,887,000	0	3,887,000
Clay Cap	6	999,000	437,000	1,436,000
TOTAL		72,910,000	437,000	73,347,000

The excavation component has a 70 percent contingency because of debris that may be present in the landfill and its unknown effect on schedule (and thereby cost).

4.2.2.5 Soils Alternative G1 - Old Plant (CPC) Landfill: Excavation/On-Site Thermal Treatment/Disposal

Alternative G1 would consist of excavation of the old plant (CPC) landfill fill/waste and underlying affected materials to a depth of 15 feet, thermal treatment of the excavated materials, in situ S/S of the subsurface soils from 15 to 23 feet, placement of the thermally treated material back into the landfill, installation of a clay cap, and installation of additional monitor wells.

A depth of 15 feet was assumed as the practical limit of excavation as described in Section 2.3.2. Based on the results of soil borings, a 15-foot deep excavation would encompass all of the fill/waste material. For a 300- x 400-foot excavation 15 feet deep, approximately 67,000 cubic yards would be removed for treatment. The RI data also indicated that contaminant migration appears to occur from zones below 15 feet.

OU-1 Soil Alternative G1 - Old Plant (CPC) Landfill

Therefore, this alternative would include in situ S/S from 15 to 23 feet. For this FS, it was assumed that the excavation and S/S procedures would be implemented across the 300- x 400- foot area. However, the data indicated that contaminant migration occurs only from portions of this area (primarily the western portion). It is expected that cut-off walls or sheet piles would be required on the west boundary of the excavation to protect an active railroad. It was assumed that approximately 1,000 cubic yards of soil (300 feet long by 20 feet wide by 5 feet deep) would be excavated from the area of the former old plant (CPC) landfill drainage ditch and transported off-site for disposal.

The existing topsoil and some of the existing clay would be stripped and stockpiled prior to excavation. Thermal treatment would be performed using either a mobile incinerator (infrared or rotary kiln) or a thermal desorber. An on-site infrared incinerator was considered for this analysis. The specific type of thermal treatment technology would be determined in the remedial design phase. The treatability study work plan/SAP (WCC, 1992) outlines tests that will be conducted to evaluate the thermal properties of the material. The results of these tests and additional bench-scale studies would be considered along with other factors such as cost and availability in the selection of an appropriate thermal technology.

A transportable incinerator would be mobilized, operated, and demobilized according to the relevant and appropriate requirements of RCRA. Incineration of soils contaminated with organic compounds is a proven technology. At an estimated feed rate of 5 tons per hour, it would take about two years to incinerate the estimated 67,000 cubic yards of material. Specific operating practices to meet the performance objectives would be determined through a trial burn at the site after installation of the incinerator.

It was assumed that a wet scrubber system would be used for emissions control. It was also assumed that the sludge generated from treatment of scrubber water would be disposed of at an off-site RCRA disposal facility, and stabilization/solidification at the disposal facility would be required.

The residual soil and ash (thermally treated material) should be nonhazardous and thus could be disposed of as a solid waste. Relevant and appropriate RCRA standards may

have to be met for temporary storage and treatment of the excavated materials. Figure 4-11 depicts the old plant (CPC) landfill after implementation of Alternative G1.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. Excavation and on-site thermal treatment would add to the protectiveness of the existing CAP by destruction of constituents, reducing further degradation of the Alluvial Aquifer. Degradation of the aquifer would also be reduced by reduced contaminant infiltration due to in situ S/S and the improved cap.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative G1 would be implemented to comply with the action-specific ARARs. Olin has determined that the material contained in the landfill would not be classified as a listed hazardous waste under 40 CFR 261. Olin submitted a plan {the treatability study work plan/SAP (WCC, 1992)} for testing the landfill fill/waste to determine whether it would be a characteristic hazardous waste. EPA is still reviewing this plan. However, based on knowledge of the material (i.e., dominantly low-solubility constituents in clayey matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. Depending on the final remedy selected, Olin anticipates that its RCRA permit would be amended to designate an appropriate area, such as the landfill, as a CAMU, allowing hazardous wastes to be excavated, treated and redeposited within the landfill area without triggering the LDRs or MTRs.

Standards related to the incinerators in 40 CFR 264 Subpart O would be relevant and appropriate. As a CERCLA remedial action, a permit would not be obtained, but the substantive requirements of a permit would have to be met.

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the thermal

treatment unit and in situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs. It was assumed that the thermal treatment unit emissions would be treated with a scrubber. If the sludge that is generated from treatment of scrubber water is a hazardous waste, off-site disposal (which is assumed) would trigger LDRs and the applicable treatment standards would have to be met. It may be feasible to stabilize the sludge on-site and manage it within the CAMU. Bench-scale tests would be required to define the appropriate disposal methods for this sludge.

State and federal regulations applicable to transportation of hazardous waste (ADEM Administrative Code R.335-14-4 and 40 CFR 263) would be ARARs for any hazardous waste transported off-site and the U. S. Department of Transportation rules would be ARARs for transporting hazardous materials (49 CFR 107).

It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. It would provide long-term effectiveness and permanence by removing contaminants (i.e., the excavated fill/waste material) from the site. As a result of S/S, the residual contaminants from 15 to 23 feet would be immobilized, thereby reducing or eliminating their downward migration to the groundwater. The clay cap over the landfill would minimize future infiltration through the landfill. In addition, the overall strength of the subsurface materials in the landfill would be enhanced by S/S, providing stability for the clay cap.

Reduction of Toxicity, Mobility and Volume

This alternative would reduce the toxicity, mobility, and volume of fill/waste and residual materials by thermal treatment. Contamination from 15 to 23 feet bgs would be permanently immobilized in the S/S matrix. Most mixing reagents do not

significantly reduce toxicity. This alternative satisfies the statutory preference for using treatment as a principal component.

Short-Term Effectiveness

There would be short-term adverse effects related to the potential for exposure of workers and the environment during excavation and handling of the excavated material. These short-term effects could be managed through proper excavation techniques (e.g., sloping, shoring) and health and safety monitoring. The S/S process would generate dust during implementation but this could be managed through the use of engineering controls such as air movers to keep dust away from workers. Reagents are commonly injected below grade to limit dust generation. There would also be potential risks to workers through operating an incinerator (because of high operational temperatures and complexity of the equipment). These short-term effects would be mitigated through the proper use of safety protocols, proper drainage controls, and restrictions on access to contaminated areas. Although emissions from the incinerator would comply with all air quality regulations, potential accidental releases could temporarily affect air quality in the vicinity of the site. Air monitoring and possible dust and volatile emissions controls would be implemented at the site, primarily during excavation and incineration activities. It is estimated that this alternative could be implemented within 48 months from the start of construction.

Implementability

This alternative would be difficult to implement. Excavation may be difficult because of debris such as wood and concrete expected to be present in the landfill, and because of adjacent structures (e.g., railroad track). Screening of the excavated material may be required prior to treatment. The surrounding structures would have to be protected either through shoring, sloping or sheet piling and the presence of such structures may limit the depth of excavation. Additional characterization would be required to better define the excavation and in situ S/S limits. Additional characterization would also be required to define the limits of excavation in the old plant (CPC) landfill drainage ditch area. Specialized equipment may be required for S/S, but the technology is well demonstrated and vendors are available. Bench-scale tests are planned, as outlined in

the treatability study work plan/SAP (WCC, 1992), to select the appropriate reagents and mixtures for in situ S/S. Operation of an incinerator is mechanically complex and has stringent monitoring requirements to assure proper performance. The incinerator therefore needs highly trained and skilled staff and substantial attention. A long lead time may be required for equipment installation and for trial test burns after installation at the site. In addition, it might be necessary to postpone implementation until a suitable mobile incinerator is available. The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Soil Alternative G1 Old Plant (CPC) Landfill Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Excavation/Transport (Old Plant Landfill Drainage Ditch Soils)	3	58,000	0	58,000
Excavation/Backfill	12	16,444,000	0	16,444,000
On-Site Thermal Treatment (0 to 15 feet)	13	87,083,000	0	87,083,000
In Situ S/S (15 to 23 feet)	9	3,887,000	0	3,887,000
Clay Cap	6	999,000	437,000	1,436,000
TOTAL		108,471,000	437,000	108,908

The excavation component has a 70 percent contingency because of debris that may be present in the landfill and its unknown effect on schedule (and thereby cost).

4.2.3 OU-1 Soil Alternatives for Area West of Former CPC Plant

Note: As explained below, this section presents remedial alternatives that may not be required based on refined modeling of the potential for this area to affect groundwater.

Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The recommended PSAL for 1,2,4-trichlorobenzene was slightly above the maximum concentration detected in the soils. For development of the remedial alternatives in this FS report, the estimated dimensions of the area west of the former CPC plant were refined based on more accurate topographic maps. The PSALs were then recalculated with these updated dimensions. When using the more accurate dimensions, all of the calculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils. (See Table 2-9). In the draft FS report it was assumed for all OU-1 soil alternatives that the area west of the CPC plant would be capped with a clay cap. This was considered appropriate because the potential for groundwater contamination from these soils was low and the cap would reduce this potential even more and protect from direct contact to the soils. EPA Specific Comment 19 to the draft FS report stated that additional alternatives, including treatment alternatives and no action, must be evaluated for the area west of the former CPC plant. The following sections provide an analysis of remedial alternatives for the area west of the former CPC plant in response to EPA's comment, although the recalculated PSALs indicate that remedial action is not required for protection of groundwater.

The evaluation of retained OU-1 soil alternatives for the area west of the CPC plant is summarized in Table 4-3. Figure 2-2 depicts the existing conditions in this area. Flow diagrams showing the major components of the assembled alternatives are presented in Figure 4-12. For the old plant (CPC) landfill, the primary objective of the alternatives is protection of groundwater. The no action alternative for soils west of the old plant (CPC) would be the same with regard to the screening criteria as the no action alternative for OU-1 groundwater, which is discussed in Section 4.2.1. A separate detailed analysis of no action is therefore not presented in this section.

4.2.3.1 Soil Alternative C - Area West of Former CPC Plant: Containment (Extend Existing Cap)

Alternative C would consist of extending the clay cap that exists over the former CPC plant to the west, capping the contaminated soils.

The estimated area to be capped is about 15,000 square feet (See Figure 2-2). The cap would consist of a 2-foot compacted clay liner, with a permeability not to exceed 1×10^{-7} cm/s, and 1 to 1.5 feet of topsoil. The topsoil would be graded to match the grade of the existing cap, and then seeded and mulched to establish vegetation. The drainage from the cap would be directed to Olin's existing NPDES permitted outfall.

Figure 4-13 shows the clay cap configuration for Alternative C.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The concentrations in the soils in the area west of the former CPC plant were below the recommended PSALs developed for protection of groundwater (Table 2-9) and this alternative would provide added protection to groundwater[1]. The cap would reduce infiltration and further minimize migration of contaminants to the groundwater. Based on the HELP model, the infiltration rate through the clay cap is estimated to be 1.2 inches per year or about a 62 percent reduction over the 3.2 inches per year estimated for existing conditions. The HELP model calculations are presented in Appendix E. The cap would also provide a barrier as protection from human contact, air emissions and surface water runoff.

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[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative C would be implemented to comply with the action-specific ARARs. There would be no excavation or placement and therefore MTRs under 40 CFR 264 and the LDRs would not be ARARs. It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. Since infiltration of water through the contaminated soils would be reduced, the long-term effect would be reduction in the rate of contaminant infiltration to the groundwater. Permanence would be dependent on cap maintenance.

Reduction of Toxicity, Mobility, and Volume

The mobility of constituents would be reduced due to a decrease in infiltration to the groundwater. There would be no reduction in toxicity or volume of the fill/waste or residual contamination.

Short-Term Effectiveness

There would be little to no short-term adverse effects. There would be no excavation of contaminated soils. It is estimated that Alternative C could be implemented within 2 months from the start of construction.

OU-1 Soil Alternative C - Area West of Former CPC Plant

Implementability

Alternative C could be readily implemented. The technology is well demonstrated and standard construction equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

Soil Alternative C Area West of Former CPC Plant Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Clay Cap	14	173,000	206,000	379,000

4.2.3.2 Soil Alternative D - Area West of Former CPC Plant: In Situ Stabilization-Solidification/Containment

Alternative D would consist of stabilizing/solidifying the upper 14 feet of soils in the area west of the former CPC plant and capping the area with a clay cap.

Various remedial contractors perform in situ S/S using different techniques. For the purpose of this analysis, it was assumed that the in situ mixing would be done with large-diameter augers that would be advanced through the area to be treated. Other in situ S/S technologies such as excavating and mixing with a backhoe may be more appropriate. The appropriate technology would be determined during the remedial design phase. For the S/S technique presented in this analysis, reagents would be added pneumatically (if dry) or pumped (if fluid). Mixing would be done in overlapping cylinders to ensure that the site was uniformly mixed and solidified. Type I portland cement at 20 percent addition by weight was assumed for this analysis. The vendor estimate was 15 percent addition by weight; 20 percent was assumed to be conservative for developing the cost estimate. The specific type of in situ mixing equipment would be determined during the remedial design phase. The reagent and the mix ratios would

be selected based on bench-scale treatability studies similar to those that were are planned for old plant (CPC) landfill and outlined in the treatability study work plan/SAP (WCC, 1992). The work would be done in a relatively confined area. Protection of an adjacent railroad would have to be considered. For the purpose of this FS, it is assumed that the in situ S/S can be implemented without sheet piles or cut off walls.

After completing the S/S, a clay cap would be installed consisting of a 2-foot compacted clay liner, with a permeability not to exceed 1×10^{-7} cm/s, and 1 to 1.5 feet of topsoil. The topsoil would be graded to match the grade of the existing cap, and then seeded and mulched to establish vegetation. A 20 percent increase in volume was assumed causing a steeper grade than the clay cap alternative (Alternative C). The drainage from the cap would be directed to Olin's existing NPDES permitted outfall. A cross section and plan view of Alternative D is depicted in Figure 4-14

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The concentrations in the soils in the area west of the former CPC plant were below the recommended PSALs developed for protection of groundwater (Table 2-9) and this alternative would provide added protection to groundwater[1]. In situ S/S would cause immobilization of constituents and reduce the potential for migration to the Alluvial Aquifer. The protection to groundwater would be further increased by reduced infiltration due to the clay cap. The cap would also provide a barrier against human contact, air emissions and surface water runoff.

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[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

OU-1 Soil Alternative D - Area West of Former CPC Plant

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative D would be implemented to comply with the action-specific ARARs. There would be no excavation or placement and therefore MTRs under 40 CFR 264 and the LDRs would not be ARARs. It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. As a result of S/S, the contaminants would be essentially immobilized, thereby reducing or eliminating their downward migration to the groundwater. The clay cap would minimize future infiltration through the contaminated soils and protect the stabilized/solidified materials from erosion or direct contact. This alternative is considered permanent because the contaminants would remain immobile even if there were an increase in infiltration.

Reduction of Toxicity, Mobility, and Volume

Contaminants would be permanently immobilized within the S/S matrix. There would be an increase (estimated to be about 20 percent) in volume. The 20 percent increase in volume is based on a vendor estimate. A more accurate estimate of the volume increase would be obtained from bench-scale studies similar to those that are planned for the old plant (CPC) landfill, as outlined in the treatability study work plan/SAP (WCC, 1992). Volume increase would be a major factor in selecting the appropriate mixing reagents and mix ratios for the S/S process. Most mixing reagents do not significantly reduce toxicity. This alternative satisfies the statutory preference for using treatment as a principal component.

Short-Term Effectiveness

Short-term adverse effects would be related to potential exposure of workers. The S/S process would generate dust during implementation, with the potential for exposure to workers and surrounding residents. Dust generation could be managed through the use of engineering controls such as air movers to keep dust away from workers. Reagents are commonly injected below grade to limit dust generation. The S/S procedure is intrusive, and there would be a potential for exposure to soils that could be hazardous to workers. Appropriate health and safety procedures would be required. The CPC plant is located well within the boundaries of the facility, and off-site impacts would be minimal. It is estimated that Alternative D could be implemented within 4 to 6 months from the start of construction.

Implementability

Based on the existing information, Alternative D could be implemented with moderate difficulty. The work would involve intrusive work in a relatively confined area, and protection of an adjacent railroad would have to be considered. Specialized equipment may be required for S/S, but the technology is well demonstrated and services of this type are provided by a number of vendors. Bench-scale testing would be required similar to those planned for the old plant (CPC) landfill and outlined in the treatability study work plan/SAP (WCC, 1992). The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

OU-1 Soil Alternative D - Area West of Former CPC Plant

Soil Alternative D Area West of Former CPC Plant Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
In Situ S/S (0 to 14 feet)	15	928,000	0	928,000
Clay Cap	14	173,000	206,000	379,000
TOTAL		1,101,000	206,000	1,307,000

4.2.3.3 Soil Alternative E - Area West of Former CPC Plant: Excavation/ Stabilization-Solidification/Containment

Alternative E would consist of excavating the contaminated soils in the area west of the former CPC plant, stabilizing/solidifying the excavated materials, placing the stabilized/solidified material back into the excavation and installing a clay cap.

A depth of 14 feet was assumed as the depth of excavation based on the vertical extent of contamination and the depth of the upper clay layer. For a 15,000-square-foot area, approximately 8,000 cubic yards would be removed for treatment. Cutoff walls or sheet piles may be required on the northern boundary of the excavation to protect a railroad. Alternatively, the railroad spur could be removed. It is assumed for cost estimating purposes that sheet piles would be used.

The excavated material would be loaded into trucks and transported to a temporary storage area. Ex situ S/S of the excavated material would be performed in a pug mill or mixing box at an on-site treatment area. RCRA standards for temporary storage and treatment of the excavated materials may be relevant and appropriate depending on the waste characterization.

After ex situ S/S, the treated material would be transported back to the excavation, placed in lifts, and compacted using standard compaction equipment. The backfilled S/S material would then be graded to facilitate the construction of a clay cap. The clay cap would consist of a 2-foot compacted clay liner with a permeability not to exceed 1 x 10^{-7} cm/s, and 1 to 1.5 feet of topsoil. The topsoil would be graded to match the grade of the existing cap, and then seeded and mulched to establish vegetation. A 20 percent

increase in volume was assumed, causing a steeper grade than the clay cap alternative (Alternative C). The drainage from the cap would be directed to Olin's existing NPDES permitted outfall. A cross section and plan view of Alternative E is depicted in Figure 4-15.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The concentrations in the soils in the area west of the former CPC plant were below the recommended PSALs developed for protection of groundwater (Table 2-9) and this alternative would provide added protection to groundwater[1]. Ex situ S/S would cause immobilization of constituents and reduce the potential for migration to the Alluvial Aquifer. The protection to groundwater would be further increased by reduced infiltration due to the clay cap. The cap would also provide a barrier against human contact, air emissions and surface water runoff.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative E would be implemented to comply with the action-specific ARARs. Olin has determined that the contaminated soils would not be classified as a listed hazardous waste under 40 CFR 261. Based on knowledge of the material, (i.e., dominantly low-solubility constituents in clayey matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. Therefore LDRs and MTRs would not be relevant and appropriate. Depending on the final remedy selected, Olin anticipates that its RCRA permit would be amended to designate an appropriate area as a CAMU, allowing hazardous wastes

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[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

to be excavated, treated and redeposited within the excavation without triggering the LDRs or MTRs. It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required.

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the ex situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs. Engineering controls may be required to meet these air quality standards.

There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. As a result of S/S, the contaminants would be essentially immobilized, thereby reducing or eliminating their downward migration to the groundwater. The clay cap would minimize future infiltration through the contaminated soils and protect the stabilized/solidified materials from erosion or direct contact. This alternative is considered permanent because the contaminants would remain immobile even if there were an increase in infiltration.

Reduction of Toxicity, Mobility, and Volume

Contaminants would be permanently immobilized within the S/S matrix. There would be an increase (estimated to be about 20 percent) in volume. The 20 percent increase in volume is based on a vendor estimate. A more accurate estimate of the volume increase would be obtained from bench-scale studies similar to those that are planned for the old plant (CPC) landfill, as outlined in the treatability study work plan/SAP (WCC, 1992). Volume increase would be a major factor in selecting the appropriate mixing reagents and mix ratios for the S/S process. Most mixing reagents do not significantly reduce toxicity. This alternative satisfies the statutory preference for using treatment as a principal component.

OU-1 Soil Alternative E - Area West of Former CPC Plant

Short-Term Effectiveness

Short-term adverse effects would be related to potential exposure of workers. The S/S process would generate dust during implementation with the potential for exposure to workers and surrounding residents. Dust generation could be managed through the use of engineering controls such as air movers to keep dust away from workers. The S/S procedure is intrusive, and there would be a potential for exposure to soils that could be hazardous to workers. Appropriate health and safety procedures would be required. The CPC plant is located well within boundaries of the facility, and off-site impacts would be minimal. It is estimated that Alternative E could be implemented within 6 to 8 months from the start of construction.

Implementability

Based on the existing information, Alternative E would be moderately difficult to implement. Excavation may be difficult because the work would be in a relative confined area and an adjacent railroad track would have to be either removed or protected. Bench-scale testing would be required similar to that planned for the old plant (CPC) landfill, as outlined in the treatability study work plan/SAP (WCC, 1992). The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

OU-1 Soil Alternative E - Area West of Former CPC Plant

Soil Alternative E Area West of Former CPC Plant	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Excavation/Backfill	16	829,000	0	829,000
Ex Situ S/S (0 to 14 feet)	17	1,140,000	0	1,140,000
Clay Cap	14	173,000	206,000	379,000
TOTAL		2,142,000	206,000	2,348,000

4.2.3.4 Soil Alternative F - Area West of Former CPC Plant: Excavation/Off-Site RCRA Disposal

Alternative F would consist of excavating the contaminated soils in the area west of the former CPC plant, disposing of the excavated materials off-site at a commercial hazardous waste landfill, backfilling the excavation with imported fill material and installing a clay cap.

A depth of 14 feet was assumed as the depth of excavation based on the vertical extent of contamination and the depth of the upper clay layer. For a 15,000-square-foot area, approximately 8,000 cubic yards would be removed for disposal. Cutoff walls or sheet piles may be required on the northern boundary of the excavation to protect a railroad. Alternatively, the railroad spur could be removed. It is assumed for cost estimating purposes that sheet piles would be used.

The excavated material would be transported via trucks and disposed of at a permitted off-site disposal facility. The excavation would then be backfilled with imported fill material. The clay cap would consist of a 2-foot compacted clay liner with a permeability not to exceed 1×10^{-7} cm/s, and 1 to 1.5 feet of topsoil. The topsoil would be graded to match the grade of the existing cap, and then seeded and mulched to establish vegetation. The drainage from the cap would be directed to Olin's existing NPDES permitted outfall. A cross section and plan view of Alternative F is depicted in Figure 4-16.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The concentrations in the soils in the area west of the former CPC plant were below the recommended PSALs developed for protection of groundwater (Table 2-9)[1]. Excavation and off-site disposal would add to the protection of groundwater by removal of the contaminated soils, thus eliminating them as a potential source. The protection to groundwater would be further increased by reduced infiltration due to the clay cap in the event that residual contamination remained below the limits of the excavation. The human contact, air emission and surface water runoff pathways would be eliminated with removal of the contaminated soils.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative F would be implemented to comply with the action-specific ARARs. Olin has determined that the contaminated soils would not be classified as a listed hazardous waste under 40 CFR 261. Based on knowledge of the material, (i.e., dominantly low-solubility constituents in clayey matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. Therefore, LDRs and MTRs would not be relevant and appropriate. A RCRA hazardous waste disposal facility was assumed primarily because of potential problems of obtaining acceptance of a CERCLA waste at a solid waste disposal facility, and Olin's stringent internal policies regarding off-site disposal. In the event that some of the excavated soils would not pass the TCLP test, LDRs would apply, and applicable treatment standards would have to be met. If such material is encountered, off-site RCRA incineration would probably be the only available contingency off-site disposal

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[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

method without prior treatment, although the cost for contingency off-site incineration has not been included in this FS because it is believed that incineration would not be required.

There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would be effective over the long term with maintenance of the vegetative layer and repair of any erosional damage to the cap. It would provide long-term effectiveness and permanence by removing the contaminated soils from the site.

Reduction of Toxicity, Mobility, and Volume

The overall volume of the contaminated soil on-site would be reduced as a result of removal and off-site disposal, which would reduce mobility. Off-site landfilling would not reduce the toxicity of the material.

Short-Term Effectiveness

The short-term adverse effects under this alternative would be generally related to the potential for exposure of workers and the environment during excavation and handling of the excavated material. These short-term effects could be managed through proper excavation techniques (e.g., sloping, shoring) and health and safety monitoring. Engineering controls may be required to reduce worker exposure. In addition, there would be potential short-term risks to the public from spills during off-site transportation and disposal. It is estimated that this alternative could be implemented within 6 to 8 months from the start of construction.

Implementability

Based on the existing information, Alternative F would be moderately difficult to implement. Excavation may be difficult because the work would be in a relative confined area and an adjacent railroad track would have to be either removed or

protected. The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Soil Alternative F Area West of Former CPC Plant Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Total Present Worth Total Cost ($)
Excavation/Backfill	18	1,150,000	0	1,150,000
Off-Site RCRA Disposal (0 to 15 feet)	19	6,031,000	0	6,031,000
Clay Cap	14	173,000	206,000	379,000
TOTAL		7,354,000	206,000	7,560,000

4.2.3.5 Soils Alternative G - Area West of Former CPC Plant: Excavation/On-Site Thermal Treatment/Disposal

Alternative G would consist of excavating the contaminated soils in the area west of the former CPC plant, thermally treating the excavated materials, placing the thermally treated material back into the excavation, and installing a clay cap.

A depth of 14 feet was assumed as the depth of excavation based on the vertical extent of contamination and the depth of the upper clay layer. For a 15,000-square-foot area, approximately 8,000 cubic yards would be removed for disposal. Cutoff walls or sheet piles may be required on the northern boundary of the excavation to protect a railroad. Alternatively, the railroad spur could be removed. It is assumed for cost estimating purposes that sheet piles would be used.

Thermal treatment would be performed using either a mobile incinerator (infrared or rotary kiln) or a thermal desorber. An on-site infrared incinerator was considered for

this analysis. The specific type of thermal treatment technology would be determined in the remedial design phase. The results of bench-scale tests similar to those planned for the old plant (CPC) landfill material, and outlined in the treatability study work plan/SAP (WCC, 1992), would be used along with other factors such as cost and availability in the selection of an appropriate thermal technology.

A transportable incinerator would be mobilized, operated, and demobilized according to the relevant and appropriate requirements of RCRA. Incineration of soils contaminated with organic compounds is a proven technology. At an estimated feed rate of 5 tons per hour, it would take more than 100 days to incinerate the estimated 8,000 cubic yards of material. Specific operating practices to meet the performance objectives would be determined through a trial burn at the site after installation of the incinerator.

It was assumed that a wet scrubber system would be used for emissions control. It was also assumed that the sludge generated from treatment of scrubber water would be disposed of at an off-site RCRA disposal facility, and stabilization/solidification at the disposal facility would be required.

The residual soil and ash (thermally treated material) should be nonhazardous and thus could be disposed of as a solid waste. Relevant and appropriate RCRA standards may have to be met for temporary storage and treatment of the excavated materials.

The clay cap would consist of a 2-foot compacted clay liner with a permeability not to exceed 1×10^{-7} cm/s, and 1 to 1.5 feet of topsoil. The topsoil would be graded to match the grade of the existing cap and then seeded and mulched to establish vegetation. The drainage from the cap would be directed to Olin's existing NPDES-permitted outfall. A cross section and plan view of Alternative G is depicted in Figure 4-17.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The concentrations in the soils in the area west of the former CPC plant were below the recommended PSALs developed for protection of groundwater (Table 2-9)[1]. Excavation and on-site thermal treatment would add to the protection of groundwater by destruction of constituents, thus minimizing or eliminating them as a potential source. The protection to groundwater would be further increased by reduced infiltration due to the clay cap in the event that residual contamination remained below the limits of the excavation. The human contact, air emission and surface water runoff pathways would be eliminated with removal of the contaminated soils.

Compliance with ARARs

Implemented in conjunction with the RCRA groundwater CAP, this alternative would comply with the chemical-specific ARARs for the groundwater. Alternative G would be implemented to comply with the action-specific ARARs. Olin has determined that the contaminated soils would not be classified as a listed hazardous waste under 40 CFR 261. Based on knowledge of the material (i.e., dominantly low-solubility constituents in clayey matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. Therefore, LDRs and MTRs would not be relevant and appropriate. Depending on the final remedy selected, Olin anticipates that its RCRA permit would be amended to designate an appropriate area as a CAMU, allowing hazardous wastes to be excavated, treated and redeposited within the excavation without triggering the LDRs or MTRs. It was assumed that maintenance of the cap and the groundwater monitoring activities would be incorporated into Olin's RCRA post-closure monitoring programs, and a permit modification would be required.

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1 Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

OU-1 Soil Alternative G - Area West of Former CPC Plant

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the thermal treatment unit and in situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs. It was assumed that the thermal treatment unit emissions would be treated with a scrubber. If the sludge that is generated from treatment of scrubber water is a hazardous waste, off-site disposal (which is assumed) would trigger LDRs and the applicable treatment standards would have to be met. It may be feasible to stabilize the sludge on-site and manage it within the CAMU. Bench-scale tests would be required to define the appropriate disposal methods for this sludge.

Standards related to the incinerators in 40 CFR 264 Subpart O would be relevant and appropriate. As a CERCLA remedial action, a permit would not be obtained, but the substantive requirements of a permit would have to be met.

State and federal regulations applicable to transportation of hazardous waste (ADEM Administrative Code R.335-14-4 and 40 CFR 263) would be ARARs for any hazardous waste transported off-site, and the U. S. Department of Transportation rules would be ARARs for transporting hazardous materials (49 CFR 107).

There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

This alternative would provide long-term effectiveness and permanence by destroying contaminants (i.e., in the excavated material) by thermal treatment.

Reduction of Toxicity, Mobility and Volume

This alternative would reduce the toxicity, mobility, and volume of fill/waste and residual materials by thermal treatment. This alternative satisfies the statutory preference for using treatment as a principal component.

Short-Term Effectiveness

There would be short-term adverse effects related to the potential for exposure of workers and the environment during excavation and handling of the excavated material. These short-term effects could be managed through proper excavation techniques (e.g., sloping, shoring) and health and safety monitoring. Engineering controls may be required to reduce worker exposure. There would also be potential risks to workers through operating an incinerator (because of high operational temperatures and complexity of the equipment). These short-term effects would be mitigated through the proper use of safety protocols, proper drainage controls, and restrictions on access to contaminated areas. Although emissions from the incinerator would comply with all air quality regulations, potential accidental releases could temporarily affect air quality in the vicinity of the site. Air monitoring and possible dust and volatile emissions controls would be implemented at the site, primarily during excavation and incineration activities. It is estimated that this alternative could be implemented within 8 to 12 months from the start of construction.

Implementability

Based on the existing information, Alternative G would be moderately difficult to implement. Excavation may be difficult because the work would be in a relative confined area and an adjacent railroad track would have to be either removed or protected. The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation. Operation of an incinerator is mechanically complex and has stringent monitoring requirements to assure proper performance. The incinerator therefore needs highly trained and skilled staff and substantial attention. A long lead time may be required for equipment installation and for trial test burns after installation at the site. In addition, it might be necessary

to postpone implementation until a suitable mobile incinerator is available. The technology for the clay cap is well demonstrated and standard equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Soil Alternative G Area West of Former CPC Plant Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Excavation/Backfill	20	775,000	0	775,000
On-Site Thermal Treatment (0 to 15 feet)	21	13,023,000	0	13,023,000
Clay Cap	14	173,000	206,000	379,000
TOTAL		13,971,000	206,000	14,177,000

4.2.4 OU-1 Soil Alternatives for the Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

Appropriate remedial alternatives were assembled for the old plant landfill drainage ditch, the lime ponds, the sanitary landfills, the mercury cell plant, and the well sand residue area to provide protection to human health and the environment. The soils within these SWMUs/AOCs contain hazardous constituents. The RI data indicate that these SWMUs/AOCs are not direct contact, ingestion or inhalation hazards based on the OU-1 soil exposure pathways expressed in the baseline risk assessment. The fate and transport analysis (Section 1.4) indicates that they are not continuing sources of groundwater contamination when judged by their effect on groundwater relative to MCLs. The objective for these SWMUs/AOCs is to assemble appropriate alternatives that ensure that conditions remain protective (i.e., the RAOs would not be exceeded) under reasonable future conditions. The evaluation of retained OU-1 soil alternatives for the sanitary landfills, lime ponds, mercury cell plant and the well sand residue area is summarized in Table 4-4.

4.2.4.1 Soils Alternative A - No Action: Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area

Alternative A would allow the soils in the four SWMUs/AOCs to remain as they currently exist, with no provisions for reduction in contaminant toxicity, mobility or volume. Olin would continue to maintain the caps over these areas with their existing maintenance programs and would continue the existing groundwater monitoring and corrective action programs as required by their RCRA post-closure permit.

Overall Protection of Human Health and the Environment

The no action alternative is protective of human health and the environment. The fate and transport analysis presented in Section 1.4 shows that these SWMUs/AOCs are not continuing sources of groundwater contamination, and there were not any unacceptable human health risks identified in the baseline risk assessment from exposure to soils as they exist at the site. Protection of human health and the environment for each of the four SWMUs/AOCs is discussed in more detail below. Since the baseline risk assessment indicated no carcinogenic risks higher than 10^{-4} and no noncarcinogenic risks with a hazard index higher than 1.0, the discussion below focuses on future risks. The concern is that future risks from these SWMUs/AOCs remain acceptable. In order to assess these potential future risks using the most conservative approach, it was assumed that the existing caps over these SWMUs/AOCs would have been breached or partially removed. (This assumption was not made for the lime pond as explained below.) This same conservative assumption, i.e., that the caps would have been removed from these SWMUs/AOCs (except the lime pond), was made for the fate and transport analysis (Section 1.4) of hazardous substances in these units to groundwater. The discussion below is supported by risk calculations, which are presented in Appendix H.

Sanitary Landfills

The fate and transport analysis described in Section 1.4 shows that the sanitary landfills are not a continuing source of groundwater contamination. The analysis is conservative because it was conducted without consideration of the existing caps over the landfills.

OU-1 Soil Alternative A - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

The analysis indicates that no further action in the landfills is required to ensure protection of groundwater.

The sanitary landfills are currently capped and there are no complete exposure pathways for ingestion, direct contact or inhalation of the landfill soils. For the purpose of evaluating continued protection to human health, risk calculations were conducted conservatively assuming no cap and some potential for contact with contaminated soils. The maximum concentration of each constituent detected in the three sanitary landfill samples was used as the exposure point concentration for these calculations.

The future industrial worker and the hypothetical future resident (child) were selected as the potential receptor populations. It was assumed that the future industrial worker who works at the site 8 hours per day, 250 days per year for 25 years would be exposed to the landfill soils through ingestion, dermal and inhalation pathways 10 percent of the time during the course of the 25-year exposure period. The calculated carcinogenic risks and noncarcinogenic hazard indices for this receptor are summarized below:

Receptor	Pathway	Lifetime Excess Cancer Risk	Noncarcinogenic Hazard Index
Industrial Worker	Dermal Contact with Surface Soil	2.89E-07	1.87E-03
	Ingestion of Surface Soil	1.56E-06	1.03E-02
	Inhalation of Soil VOC Inhalation	0.00E+00	7.20E-02
	Inhalation of Soil Particulates	1.10E-09	1.15E-04
	TOTAL	1.85E-06	8.43E-02

Even without consideration of future cap maintenance, the calculated carcinogenic risks and noncarcinogenic hazard indices do not exceed the risk-based RAOs (i.e., 1×10^{-4} excess lifetime cancer risk and 1.0 hazard index).

For the hypothetical future resident (child) it was assumed that a child would be exposed to the landfill soils through ingestion, dermal and inhalation pathways 24 hours per day, 350 days per year for 20 years. These are very unrealistic (conservative) assumptions, particularly since Olin asserts that the hypothetical future resident is an

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unlikely receptor, considering that the potential for parts of the site to become residential is virtually nonexistent. The calculated risk values are summarized below:

Receptor	Pathway	Lifetime Excess Cancer Risk	Noncarcinogenic Hazard Index
Hypothetical Child Resident	Dermal Contact with Surface Soil	7.71E-06	6.24E-02
	Ingestion of Surface Soil	8.58E-05	7.10E-01
	Inhalation of Soil VOC Inhalation	0.00E+00	5.72E+00
	Inhalation of Soil Particulates	6.97E-08	9.13E-03
	TOTAL	9.36E-05	6.50+00

Even with these unrealistic assumptions, the only pathway that exceeds the risk-based RAO is inhalation of volatile constituents, primarily from chlorobenzene, which was detected in one sample at 5.7 mg/kg. Other chlorobenzene detections were 0.1 and 0.037 mg/kg. Therefore, the exposure point concentration would likely be lower than was used in these calculations. In addition, volatiles in the soil would dissipate over time and using the existing concentrations for a 20-year exposure period is very conservative.

If the cap were gone, there would be a potential for surface water runoff from contaminated soils in the sanitary landfill area. Olin is required by their stormwater permit to monitor the surface water drainage from the site on a quarterly frequency. One of the sampling points is located where the drainage to the south from the sanitary landfills enters the wastewater ditch. Any unacceptable runoff from the sanitary landfills would be detected by this monitoring.

Lime Ponds

The fate and transport analysis described in Section 1.4 showed that the lime ponds are not a continuing source of groundwater contamination. The analysis was based on calculated infiltration rates through the clay caps. Unlike the other three SWMUs/AOCs it was not assumed that the clay caps were absent. The Phase III sampling showed that water is perched above the lime waste layers, indicating that the

lime waste has an infiltration rate less than the overlying cap. If it had been assumed that the clay caps were absent, the infiltration rate would have been calculated for the lower permeability lime waste, resulting in a less conservative analysis. Based on the analysis in Section 1.4 no further action for the lime ponds is required to ensure continued protection of groundwater.

The lime waste is buried beneath 0.5 to 6 feet of clay and about 10 feet of ash and the potential for direct contact to the lime is very unlikely. In any event, the mercury concentrations in the lime waste were very low (maximum of 1.3 mg/kg) and the lime waste is not a direct contact hazard.

Drainage from the lime ponds is ultimately to Olin's wastewater ditch, which is monitored by their existing NPDES sampling. Any unacceptable runoff from the lime ponds would be detected by this sampling.

Mercury Cell Plant

The fate and transport analysis described in Section 1.4 shows that the soils in the mercury cell plant are not a continuing source of groundwater contamination. The analysis is very conservative because it was conducted by evaluating infiltration through 6 feet of silty/sandy clay, without consideration of the asphalt or Durbigum® covers. Based on this analysis no further action in the mercury cell plant area is required to ensure continued protection of groundwater.

The mercury cell plant has an asphalt cover and currently there are not any complete exposure pathways for ingestion, direct contact and inhalation of the underlying soils. For the purpose of evaluating continued protection of human health, risk calculations were conducted assuming no asphalt cover and some potential for contact with the underlying soils. These risk calculations are presented in Appendix H. The analysis was conducted assuming a mercury concentration of 164 mg/kg, the highest concentration detected in the soils beneath the mercury cell plant. This assumption is also very conservative as the other five samples range from non detectable to 3.4 mg/kg.

The industrial worker and the hypothetical future resident (child) were selected as potential receptor populations using the same conservative exposure assumptions that were used for the sanitary landfills. (The lifetime excess cancer risk was not calculated because mercury is not considered a carcinogenic compound.) The hazard index calculations are summarized below for the industrial worker who works at the site 8 hours per day, 250 days per year for 25 years and is assumed to be exposed to the contaminated soils by dermal, ingestion and inhalation pathways 10 percent of the time:

Receptor	Pathway	Noncarcinogenic Hazard Index
Industrial Worker	Dermal Contact with Surface Soil	5.35E-04
	Ingestion of Surface Soil	2.67E-02
	Inhalation of Soil Particulates	3.02E-06
	TOTAL	2.73E-02

Even without consideration of the asphalt cover, the calculated noncarcinogenic hazard index did not exceed the risk-based RAOs of 1.0.

For the hypothetical future resident (child) it was assumed that a child would be exposed to the mercury cell plant soils through dermal, ingestion and inhalation pathways 24 hours per day, 350 days per year for 20 years. As stated above, these are very unrealistic (conservative) assumptions, particularly since Olin asserts that the hypothetical future resident is an unlikely receptor considering that the potential for parts of the site to become residential is virtually nonexistent. The calculated risk values are summarized below:

Receptor	Pathway	Noncarcinogenic Hazard Index
Hypothetical Child Resident	Dermal Contact with Surface Soil	1.79E-02
	Ingestion of Surface Soil	1.84E+00
	Inhalation of Soil Particulates	2.40E-04
	TOTAL	1.86E+00

OU-1 Soil Alternative A - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

The hazard index of 1.8 only slightly exceeds the risk-based RAO of 1.0, even using unrealistic assumptions of no asphalt cover and dermal contact, ingestion and inhalation of the contaminated soils in the mercury cell plant by a child receptor whose existence at the site in the future is very unlikely.

Drainage from the mercury cell plant is to Olin's wastewater ditch, which is monitored by their existing NPDES sampling. Any unacceptable runoff from the mercury cell plant area would be detected by this sampling.

Well Sand Residue Area

Mercury was found not to leach from the well sand material (based on the TCLP test) and therefore the well sand residue area is not considered a continuing source of groundwater contamination. For the purpose of evaluating continued protection to human health, risk calculations were conducted assuming contact to the well sand material. These risk calculations are presented in Appendix H. The analysis was conducted assuming a mercury concentration of 20.1 mg/kg, the concentration detected in the Phase III well sand sample.

Again, the industrial worker and the hypothetical future resident (child) were selected as the potential receptor populations using similar exposure assumptions as used previously for the sanitary landfills and the mercury cell plant. The hazard index calculations are summarized below for the industrial worker who works at the site 8 hours per day, 250 days per year for 25 years and is assumed to be exposed to the well sand 10 percent of the time:

Receptor	Pathway	Noncarcinogenic Hazard Index
Industrial Worker	Dermal Contact with Surface Soil	6.85E-05
	Ingestion of Surface Soil	3.28E-03
	Inhalation of Soil Particulates	3.26E-07
	TOTAL	3.35E-03

Even under these conservative exposure conditions, the calculated hazard index did not exceed the risk-based RAO of 1.0.

For the hypothetical future resident (child) it was assumed that a child would be exposed to the well sand residue area through ingestion, dermal and inhalation pathways 24 hours per day, 350 days per year for 20 years. As stated above, these are very unrealistic (conservative) assumptions, particularly since Olin asserts that the hypothetical future resident is an unlikely receptor considering that the potential for parts of the site to become residential is virtually nonexistent. The calculated risk values are summarized below:

Receptor	Pathway	Noncarcinogenic Hazard Index
Hypothetical Child Resident	Dermal Contact with Surface Soil Ingestion of Surface Soil Inhalation of Soil Particulates	2.29E-03 2.26E-01 2.59E-05
	TOTAL	2.28E-01

The hazard index does not exceed the risk-based RAO of 1.0.

One of Olin's existing stormwater permit sampling points is approximately 1,500 feet downgradient of the well sand residue area. Olin is required by their stormwater permit to monitor this sampling point for mercury on a quarterly frequency. Any unacceptable discharge from the well sand residue area would be detected by this monitoring.

Compliance with ARARs

The no action alternative complies with the ARARs. Olin is required to attain chemical-specific ARARs (the RCRA permit limits based on MCLs) with the CAP. Olin currently maintains the SWMUs/AOCs in conformance with all state and federal regulations that would be considered action-specific ARARs. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

Alternative A is considered to provide long-term effectiveness and permanence because no unacceptable risks to human health and the environment were identified under current and likely future exposure scenarios, and even without the existing institutional actions (e.g., caps and monitoring) conditions should remain protective.

Reduction of Toxicity, Mobility, and Volume

There would be no additional reduction in toxicity, mobility, or volume of contaminants associated with this alternative.

Short-Term Effectiveness

There would be no short-term adverse effects.

Implementability

Implementation is not required.

Cost

There would be no additional costs.

4.2.4.2 Soils Alternative B1 - Institutional Actions (Cap Inspection/Maintenance, Groundwater Monitoring near Sanitary Landfills).

For Alternative B1, the existing clay caps over the sanitary landfills and the lime ponds, the asphalt cover over the mercury cell plant, and the fencing around the well sand residue area would be routinely inspected. The findings of the inspections would be documented. If an inspection noted problem areas such as erosional areas, cracks in the asphalt, or insufficient cap depth, maintenance or corrective measures would be required. Maintenance and corrective measures would also be documented.

OU-1 Soil Alternative B1 - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

This alterative would also include additional groundwater monitoring in the vicinity of the sanitary landfills. Groundwater monitoring is not included in Alternative B1 for the other SWMUs/AOCs, because they are within boundaries of Olin's current RCRA compliance monitoring. The groundwater monitoring would be conducted with eight downgradient monitor wells situated around the landfill at the approximate locations shown on Figure 4-18. Where appropriate, the existing sanitary landfill (SL) wells would be used. For cost estimate purposes, it was assumed that six new monitor wells would be installed. The eight wells would be added to Olin's existing RCRA quarterly groundwater monitoring program. In the event that groundwater monitoring indicated releases from the sanitary landfills, additional corrective action measures might be required.

The maintenance/inspection and additional groundwater monitoring programs would be added to the provisions of Olin's post-closure hazardous waste permit. Any corrective measures warranted as a result of these programs would be conducted as part of the ongoing RCRA activities.

Overall Protection of Human Health and the Environment

Alternative B1 would be protective of human health and the environment. It would provide added protection (over no action) because it would ensure continued maintenance of the caps. The existing caps would be upgraded as necessary through the inspection and maintenance procedures. Groundwater monitoring would be extended to the sanitary landfill area where currently there is no routine monitoring.

Compliances with ARARs

Alternative B1 would comply with ARARs. Olin is required to attain chemical-specific ARARs (the RCRA permit limits based on MCLs) with the CAP. All maintenance, cap upgrade and groundwater monitoring would be carried out in compliance with action-specific ARARs and incorporated into Olin's existing hazardous waste post-closure permit. There are no known location-specific ARARs.

OU-1 Soil Alternative B1 - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

Long-Term Effectiveness and Permanence

Alternative B1 would provide some added long-term effectiveness (over no action) with the monitoring/maintenance programs by ensuring that conditions do not change (i.e., risks do not increase). The alternative is considered permanent even though it includes long-term maintenance and monitoring programs because no unacceptable risks to human health and the environment were identified for current and likely future conditions with the no action alternative.

Reduction of Toxicity, Mobility and Volume

There would be no additional reduction in toxicity, mobility, and volume of contaminants associated with this alternative. However, the cap maintenance programs would ensure that the mobility of constituents would not increase.

Short-Term Effectiveness

There would be no short-term adverse effects, with the possible exception of minimal effects associated with well installation. It is estimated that well installation could be completed within 1 month from the start of construction.

Implementability

Implementation would be easily accomplished by setting up a routine cap inspection plan and documenting that the plan was being followed and that corrective action was being taken when problems such as erosion areas were discovered. Installation of groundwater monitoring wells and incorporation of these wells into the existing sampling programs would be easily implementable.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

Soil Alternative B1 Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Institutional Actions	22	244,000	2,619,000	2,863,000

4.2.4.3 Soils Alternative B2 - Institutional Actions (Cap Inspection/Maintenance, Expanded Groundwater and Surface Water Monitoring)

For Alternative B2, the existing clay caps over the sanitary landfills and the lime ponds, the asphalt cover over the mercury cell plant, and the fencing around the well sand residue area would be routinely inspected. The findings of the inspections would be documented. If an inspection noted problem areas such as erosional areas, cracks in the asphalt, or insufficient cap depth, maintenance or corrective measures would be required. Maintenance and corrective measures would also be documented.

This alterative would also include expanded groundwater and surface water monitoring in the vicinity of the SWMUs/AOCs. Groundwater monitoring would be conducted with the eight downgradient wells around the sanitary landfills that were included in Alternative B1. Additional groundwater monitoring would be done near the lime ponds and the mercury cell plant area, as shown in Figure 4-19. At total of sixteen monitor wells would be added to Olin's quarterly groundwater monitoring programs. For cost estimate purposes, it was assumed that 13 new wells would be installed and three existing wells would be used. An additional stormwater monitoring location would be added to Olin's existing stormwater sampling program at the location shown on Figure 4-19.

OU-1 Soil Alternative B2 - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

Overall Protection of Human Health and the Environment

Alternative B2 would be protective of human health and the environment. It would provide added protection (over no action) because it would ensure continued maintenance of the caps. The existing caps would be upgraded as necessary through the inspection and maintenance procedures. Additionally, groundwater monitoring would be extended to the sanitary landfill area where currently there is no routine monitoring. Monitoring at other SWMUs/AOCs and the additional surface water monitoring may provide added protection, although the effectiveness of this monitoring is questionable as described below under long-term effectiveness and permanence.

Compliances with ARARs

Alternative B2 would comply with ARARs. Olin is required to attain chemical-specific ARARs (the RCRA permit limits based on MCLs) with the CAP. All maintenance, cap upgrade and groundwater monitoring would be carried out in compliance with action-specific ARARs and incorporated into Olin's existing hazardous waste post-closure permit. The surface water monitoring would be incorporated into Olin's stormwater sampling program. There are no known location-specific ARARs.

Long-Term Effectiveness and Permanence

Alternative B2 would provide some added long-term effectiveness (over no action) with the monitoring/maintenance programs by ensuring that conditions do not change (i.e., risks do not increase). Groundwater monitoring in the vicinity of the lime ponds and the mercury cell plant would have minimal effectiveness. There is existing contamination in the Alluvial Aquifer beneath the facility, predominantly due to past releases from process units and some of the SWMUs/AOCs that are no longer releasing contaminants, e.g., the weak brine pond. The corrective action program (five corrective action wells located to contain and remove the contaminant plume) has increased the lateral migration of contaminants and changed the historical groundwater flow directions beneath the site. It would be very difficult to distinguish contamination due to past releases from a continuing release resulting from the lime ponds or the mercury cell

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plant area. Regardless, the mercury cell plant and lime ponds are already within the compliance boundaries of the existing RCRA monitoring programs.

The additional surface water sampling would also have limited effectiveness because a sample is already collected downstream, prior to the runoff entering the wastewater ditch. The alternative is considered permanent even though it includes long-term maintenance and monitoring programs because no unacceptable risks to human health and the environment were identified for current and likely future conditions with the no action alternative.

Reduction of Toxicity, Mobility and Volume

There would be no additional reduction in toxicity, mobility, or volume of contaminants associated with this alternative. However, the cap maintenance programs would ensure that the mobility of constituents would not increase.

Short-Term Effectiveness

There would be no short-term adverse effects, with the possible exception of minimal effects associated with well installation. It is estimated that well installation could be completed within 2 months from start of construction.

Implementability

Implementation would be easily accomplished by setting up a routine cap inspection plan and documenting that the plan was being followed and that corrective action was being taken when problems such as erosion areas were discovered. Installation of groundwater monitoring wells and incorporation of these wells into the existing sampling programs would be easily implementable. The surface water sampling could also be easily implemented.

OU-1 Soil Alternative B2 - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

Soil Alternative B2 Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Expanded Institutional Actions	23	527,000	3,219,000	3,746,000

4.2.4.4 Soils Alternative C1 - Containment (Sanitary Landfills and Lime Ponds)/Institutional Actions

Alternative C1 would consist of constructing a clay cap over the sanitary landfills and a multimedia cap over the lime ponds. The newly installed caps, the asphalt cover over the mercury cell plant, and the fencing around the well sand residue area would be routinely inspected. The findings of the inspections would be documented. If an inspection noted problem areas such as erosional areas, cracks in the asphalt, or insufficient cap depth, maintenance or corrective measures would be required. Maintenance and corrective measures would also be documented.

This alterative would also include additional groundwater monitoring in the vicinity of the sanitary landfills. Groundwater monitoring would be conducted with eight downgradient monitor wells situated around the landfill at the approximate locations shown on Figure 4-18. Where appropriate, the existing sanitary landfill (SL) wells would be used. For cost estimate purposes, it was assumed that six new monitor wells would be installed. The eight wells would be added to Olin's existing RCRA quarterly groundwater monitoring program. In the event that groundwater monitoring indicated releases from the sanitary landfills, additional corrective action measures might be required.

The estimated area of the sanitary landfills to be capped is about 12 acres. The existing topsoil and some of the existing clay would be stripped and stockpiled for possible use in constructing the cap or for providing fill material. The landfill area then would be graded. Additional fill material may be required to attain the appropriate grade for construction of the cap. The sanitary landfill cap would consist of a 2-foot compacted clay liner, with a permeability not to exceed 1 x 10^{-7} cm/s, and 1 foot of topsoil. The topsoil would be seeded and mulched to establish vegetation.

The estimated area of the east lime pond is 51,000 square feet, and the estimated area of the west lime pond is 18,000 square feet. The existing topsoil and some of the existing clay would be stripped and stockpiled for possible use in constructing the cap. The multimedia cap would consist of the following elements (in ascending order):

- One 40-mil, high-density polyethylene (HDPE) liner.
- Two feet of a compacted clay barrier layer with a permeability not to exceed 1 x 10^{-7} cm/s. (The potential for using the existing clay cap material as part of this layer would be evaluated.)
- One composite geonet.
- Two feet of cover layer including one foot of topsoil and one foot of compacted native soil material with a slope not to exceed 5 percent. The topsoil would be seeded and mulched. (The top soil removed from the existing cap may be used.)

Figure 4-20 shows the multimedia cap configuration for the lime ponds.

Overall Protection of Human Health and the Environment

Alternative C1 would be protective of human health and the environment. It would provide added protection (over no action) with a more competent physical barrier over the sanitary landfill soils. The multimedia caps over the lime ponds would also provide

a more competent barrier and reduce infiltration, which would satisfy the objective of reducing the perched water layer. The inspection/maintenance program would ensure continued protection. Additionally, groundwater monitoring would be extended to the sanitary landfill area where currently there is no routine monitoring.

Compliance with ARARs

Alternative C1 would comply with ARARs. Olin is required to attain chemical-specific ARARs (the RCRA permit limits, MCLs) with the CAP. All maintenance, cap upgrade and groundwater monitoring would be carried out in compliance with action-specific ARARs and incorporated into Olin's existing hazardous waste post-closure permit.

Long-Term Effectiveness and Permanence

This alternative would provide some added long-term effectiveness (over no action) with construction of the caps and the monitoring/maintenance programs by ensuring that conditions do not change (i.e., risks do not increase). The alternative is considered permanent even though it includes long-term maintenance and monitoring programs because no unacceptable risks to human health and the environment were identified for current and likely future conditions with the no action alternative.

Reduction of Toxicity, Mobility and Volume

The mobility of constituents would be reduced due to the improved caps. There would be no reduction in toxicity or volume of contamination.

Short-Term Effectiveness

There would be no short-term adverse effects, with the possible exception of minimal effects associated with well installation and cap construction. It is estimated that this alternative could be implemented within 6 to 8 months from the start of construction.

Implementability

Alternative C1 could be readily implemented. The technology is well demonstrated and standard construction equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

Soil Alternative C1 Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Sanitary Landfills (Clay Cap)	25	3,003,000	0	3,003,000
Lime Ponds (Multimedia Cap)	24	930,000	0	930,000
Institutional Actions	22	244,000	2,619,000	2,863,000
TOTAL		4,177,000	2,619,000	6,796,000

4.2.4.5 Soils Alternative C2 - Consolidation/Containment (Sanitary Landfills, Lime Ponds and Well Sand Residue Area)/Institutional Actions

Alternative C2 would consist of consolidating the well sand material in the sanitary landfills, constructing a clay cap over the landfills and constructing a multimedia cap over the lime ponds. The newly installed caps and the existing asphalt cover over the mercury cell plant would be routinely inspected. The findings of the inspections would be documented. If an inspection noted problem areas such as erosional areas, cracks in the asphalt, or insufficient cap depth, maintenance corrective measures would be required. Maintenance and corrective measures would also be documented.

This alterative would also include additional groundwater monitoring in the vicinity of the sanitary landfills. Groundwater monitoring would be conducted with eight

downgradient monitor wells situated around the landfill at the approximate locations shown on Figure 4-18. Where appropriate, the existing sanitary landfill (SL) wells would be used. For cost estimate purposes, it was assumed that six new monitor wells would be installed. The eight wells would be added to Olin's existing RCRA quarterly groundwater monitoring program. In the event that groundwater monitoring indicated releases from the sanitary landfills, additional corrective action measures might be required.

The well sands, which consist of about 5,000 cubic yards of material, would be loaded into trucks at the well sand residue area and transported to the sanitary landfill. Prior to placement of the well sand material, the existing topsoil and some of the existing clay on the landfills would be stripped and stockpiled for possible use in constructing the cap or for providing fill material. The well sand material would be placed and the landfill would be graded to attain the appropriate slope for construction of the cap. The sanitary landfill cap would consist of a 2-foot compacted clay liner, with a permeability not to exceed 1×10^{-7} cm/s, and 1 foot of topsoil. The topsoil would be seeded and mulched to establish vegetation.

The estimated area of the east lime pond is 51,000 square feet, and the estimated area of the west lime pond is 18,000 square feet. The existing topsoil and some of the existing clay would be stripped and stockpiled for possible use in constructing the cap. The multimedia cap would consist of the following elements (in ascending order):

- One 40-mil, high-density polyethylene (HDPE) liner.
- Two feet of a compacted clay barrier layer with a permeability not to exceed 1×10^{-7} cm/s. (The potential for using the existing clay cap material as part of this layer would be evaluated.)
- One composite geonet.
- Two feet of cover layer including one foot of topsoil and one foot of compacted native soil material with a slope not to exceed 5 percent.

The topsoil would be seeded and mulched. (The top soil removed from the existing cap may be used.)

Figure 4-20 shows the multimedia cap configuration for the lime ponds.

Overall Protection of Human Health and the Environment

Alternative C2 would be protective of human health and the environment. It would provide added protection (over no action) with a more competent physical barrier over the sanitary landfill soils and a barrier over the well sand material. The multimedia caps over the lime ponds would also provide a more competent barrier and reduce infiltration, which would satisfy the objective of reducing the perched water layer. The inspection/maintenance program would ensure continued protection. Additionally, groundwater monitoring would be extended to the sanitary landfill area where currently there is no routine monitoring.

Compliance with ARARs

This alternative would comply with ARARs. Olin is required to attain chemical-specific ARARs (the RCRA permit limits based on MCLs) with the CAP. All maintenance, cap upgrade and groundwater monitoring would be carried out in compliance with action-specific ARARs and incorporated into Olin's existing hazardous waste post-closure permit.

Long-Term Effectiveness and Permanence

This alternative would provide some added long-term effectiveness (over no action) with construction of the caps and the monitoring/maintenance programs by ensuring that conditions do not change (i.e., risks do not increase). The alternative is considered permanent even though it includes long-term maintenance and monitoring programs because no unacceptable risks to human health and the environment were identified for current and likely future conditions with the no action alternative.

OU-1 Soil Alternative C2 - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and the Well Sand Residue Area

Reduction of Toxicity, Mobility and Volume

The mobility of constituents would be reduced due to the improved caps. There would be no reduction in toxicity or volume of contamination.

Short-Term Effectiveness

There would be no short-term adverse effects, with the possible exception of minimal effects associated with well installation and cap construction. It is estimated that this alternative could be implemented within 6 to 8 months from the start of construction.

Implementability

Alternative C2 could be readily implemented. The technology is well demonstrated and standard construction equipment and practices could be utilized for implementation.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth costs. The referenced cost tables are presented in Appendix G.

Soil Alternative C2 Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Sanitary Landfills (Clay Cap)	25	3,003,000	0	3,003,000
Lime Ponds (Multimedia Cap)	24	930,000	0	930,000
Well Sand Residue Area (Consolidation)	26	273,000	0	273,000
Institutional Actions	22	244,000	2,619,000	2,863,000
TOTAL		4,450,000	2,619,000	7,069,000

4.2.5 OU-2 Sediment Alternatives

The evaluation of retained OU-2 sediment alternatives is presented in this section and summarized in Tables 4-5 and 4-6 for the basin and wastewater ditch sediments, respectively. Flow diagrams showing the major components of the alternatives are presented in Figure 4-21.

4.2.5.1 Sediment Alternative A: No Action

The no action alternative would allow the OU-2 basin and wastewater ditch sediments to remain as they currently exist, with no provisions to reduce toxicity, mobility or volume. No additional institutional actions would be implemented beyond the current access restrictions.

Overall Protection of Human Health and the Environment

Since the sources of the site constituents of concern have been effectively eliminated, maximal impacts and risks have probably already occurred and the OU-2 ecosystems are in a state of natural recovery. Fish ingestion would remain the primary contributor to human health risk. However, risks should not exceed the 1.0 hazard index for noncarcinogenic risks or the 10^{-4} excess lifetime cancer risk thresholds (i.e., the remedial action objectives). As discussed in Section 1.6, the overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. In view of the dietary exposure calculations (Table 1-12), it is improbable that any terrestrial or amphibious higher vertebrate populations in OU-2 are adversely affected by exposures to site constituents via the ingestion pathway. Since the ingestion pathway is generally considered the most important for exposures of higher vertebrates to bioaccumulative chemicals, the risks associated with other pathways (e.g., dermal contact with water or soil) in OU-2 are judged to be inconsequential. Limited evidence was found of stresses to the lower trophic levels, as represented by benthic macroinvertebrate community structure, although no clear causal relationship to site constituents of concern was established. Based on theoretically possible exposures and published lowest observed effects levels (LOELs), it was noted that there could be a potential for sublethal effects on certain sensitive aquatic organisms (e.g., limitations on reproduction and/or growth).

OU-2 Sediment Alternative A

The no action alternative is considered protective. It is noted that the baseline risk assessment was developed from a single sampling event, and monitoring (fish and sediment) may be required to confirm protectiveness and establish that no unexpected future increase in risks would occur.

Compliance with ARARs

Compliance with chemical-specific ARARs is uncertain. Constituent concentrations in surface water may exceed federal and state water quality criteria. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. The no action alternative does comply with the identified location-specific ARARs, although none are critical in its implementation.

Long-Term Effectiveness and Permanence

Long-term risks would be dependent on the effectiveness and rate of natural recovery and the potential for mobilization (i.e., resuspension, bioavailability) of the largely sediment-bound constituents of concern. Hydrodynamic studies were conducted from February through May, 1993 to develop data to address sediment transport into and out of the basin (i.e., determine whether the basin is subject to net sediment erosion or deposition). These studies indicate that even during flood conditions, current speeds are insufficient to result in erosion of basin sediments. It was concluded that the basin is a depositional area, although no attempt was made to determine the rate of deposition. The hydrodynamic studies are summarized in Section 1.4.2. The complete hydrodynamic study report was included in the RI report (WCC, 1993). Based on the results of these studies, risks are unlikely to increase and are expected to gradually decrease as a result of natural recovery. Collection of data for estimation of sedimentation rates is included under Alternative B.

Reduction of Toxicity, Mobility, and Volume

There would be no reduction in volume or inherent toxicity with no action. But effective toxicity (availability) would gradually diminish as mobility is decreased by

natural sedimentation. (See discussion of sediment deposition under long-term effectiveness and permanence.)

Short-Term Effectiveness

There would be no short-term adverse effects associated with this alternative.

Implementability

No implementation is required.

Cost

There is no cost associated with this alternative.

4.2.5.2 Sediment Alternative B: Institutional Actions

Sediment Alternative B would include continuation of the existing fishing restrictions in the basin. A fence would be constructed across the wastewater ditch to further reduce access to the area, and the basin would be patrolled more frequently to reduce trespassing. Field monitoring would be conducted to estimate the rate of sediment deposition in the basin as a component of the institutional action alternative. Sedimentation pins would be used to measure erosion (and/or deposition) in relatively shallow areas along the perimeter of the basin. Sediment traps would be used to collect ambient sediment depositional data within deeper areas of the basin. A program of annual collection of sediment, surface water and fish for chemical analyses would be implemented to assess any changes in potential risks.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The calculated human health risks were below the remedial action objectives ($1x10^{-4}$ lifetime cancer risk and 1.0 hazard index). As discussed in Section 1.6, the overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. Fish ingestion and the associated

human health risks would be controlled (i.e., limited) by the access restrictions and frequent patrolling. The monitoring program would provide any indication of changes in risks. The basin ecosystem is in natural recovery and therefore potential risks to the ecosystem are unlikely to increase. The sediment sampling, benthic macroinvertebrate studies and fish tissue sampling conducted during the RI have established a baseline which would be used in conjunction with periodic monitoring to assess the effectiveness of this alternative and rate of recovery of the system.

Compliance with ARARs

Compliance with chemical-specific ARARs is uncertain. Natural recovery should result in a reduction in constituent concentrations in the surface water. However, concentrations may exceed federal and state water quality criteria. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. None of the location-specific ARARs identified for the site would pertain to Alternative B. This alternative would be implemented to comply with any action-specific ARARs, although none are critical in its implementation.

Long-Term Effectiveness and Permanence

The long-term effectiveness and permanence of the institutional actions would be dependent on continued implementation by Olin. Similar to the no action alternative, long-term risks would also be dependent on the effectiveness and rate of natural recovery and the potential for mobilization (i.e., resuspension, bioavailability) of the largely sediment-bound constituents of concern. The hydrodynamic studies indicate that even during flood conditions, current speeds are insufficient to result in erosion of basin sediments. It was concluded that the basin in a predominantly depositional area, although no attempt was made to determine the rate of deposition. The hydrodynamic studies are summarized in Section 1.4.2. The complete hydrodynamic study report was included in the RI report (WCC, 1993). Based on the results of these studies, risks are unlikely to increase and are expected to gradually decrease as a result of natural recovery. The sedimentation studies for this alternative would be used to estimate sedimentation rates and assess the effectiveness of natural recovery.

OU-2 Sediment Alternative B

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Reduction of Toxicity, Mobility, and Volume

There would be no reduction in volume or inherent toxicity with institutional actions. But effective toxicity (availability) would gradually diminish as mobility is decreased by natural sedimentation. (See discussion of sediment deposition under long-term effectiveness and permanence.)

Short-Term Effectiveness

There would be little-to-no short-term adverse effects associated with this alternative. This alternative could be implemented in 2 to 3 months. It was assumed for the purposes of this FS that the monitoring program would be continued for a period of 30 years.

Implementability

This alternative could be readily implemented.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Sediment Alternative B Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Institutional Actions	27	211,000	2,736,000	2,947,000

4.2.5.3 Basin Sediment Alternative C: Backfilling

For basin sediment Alternative C, the upland bluff area to the west of the basin would be cleared and grubbed and then excavated. The excavated material would be used as backfill to be placed in the basin. The basin would be filled to the approximate basin

water level at low river stage (about 2 feet msl). It is estimated for this FS that backfilling the basin would require about one million cubic yards of material. If the remedial action was extended to the two small ponds to the north of the basin, it is estimated that about 150,000 cubic yards would be required. The volume of backfill could be considerably greater than these estimates, depending on the volume of sediments displaced during backfilling. As discussed in Section 2.3.2, the area and volume estimates are based on remediation of the basin.

The work would have to be done during low river stage, and it was assumed that it would require two dry seasons (or two years) to complete backfilling. The excavation and backfilling activities would be done with dozers and scrapers. It is estimated that about four miles of access roads would be constructed to move the equipment and materials. There is a potential that some soft material currently at the bottom of the basin could be pushed ahead of the filling activities rather than being covered. To prevent this, some of the fill material could be hauled to eastern side of the basin and filling could be conducted both from the west and from the east, pushing the soft material into the deep depression. Another option is to partition the basin with the access roads and isolate areas for filling. Figure 4-22 shows the areas that would be cut for the backfilling operation.

After backfilling is complete, the former basin area would be contoured to provide a depression for open water habitat. The remaining low-lying area would become a wetland. It is assumed based on the absence of significant wetland emergent plants under natural conditions that some "human intervention" would be required to successfully establish hydrophytes in the remediated area. There would be several major considerations for establishing aquatic vegetation in addition to natural colonization. First, plants that grow naturally within the region should be selected. Secondly, plants which have extensive root growth should be considered since they would stabilize the soils or sediments under all hydrologic situations. Representatives of the sedge family (Cyperaceae), cattails (Typhaceae), grasses (Gramineae), and rushes (Juncaceae) are all good candidates to the extent that they occur naturally in the region. Selection of plant species would be coordinated with the Alabama Department of Conservation and the U.S. Fish and Wildlife Service.

Since water level control is critical for establishment and survival of the desired emergent aquatic plants, only the areas less than 18 inches deep during the predominant growing season should be considered newly created "wetlands." Roots of emergent plants must be kept wet and the plants will not survive if they are completely covered with water for extended periods, especially during the growing season. Therefore, the present weir or a new one would have to be evaluated for maximizing and sustaining the wetland area in the context of Basin Sediment Alternative C.

Depending upon the plants selected, planting or seeding may be required to establish the initial mixture desired. If required, such planting/seeding is not expected to add significantly to the overall cost of the alternative. The wetland area would be connected to the Tombigbee River via the current drainageway, through which the area is subject to flooding during portions of the year.

The upland area would be graded to match the natural contour of the land and reforested.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The calculated human health risks were below the remedial action objectives ($1x10^{-4}$ lifetime cancer risk and 1.0 hazard index). As discussed in Section 1.6, the overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. This alternative would provide added protectiveness of human health by eliminating exposure of fish to the basin sediments. The fish ingestion pathway was identified as the greatest contributor to human health risks. The existing basin ecosystem would be severely disrupted. Most of the contaminated sediments would be isolated from the biota, reducing the potential for ecological risks from site constituents. Much of the filled area would eventually establish a habitat similar to the adjacent wetlands area in OU-2.

Compliance with ARARs

Compliance with chemical-specific ARARs is uncertain. Constituent concentrations would likely exceed federal and state water quality criteria during the construction

period. After implementation, this alternative would greatly reduce or eliminate exposure of contaminated basin sediments to surface water and would reduce the potential for exceeding these criteria. Because 100 percent coverage of contaminated sediments may be impossible (see implementability below), occasional exceedances could still occur. A waiver may be justified, as it may not be technically practical to meet the water quality criteria.

The alternative could be implemented to comply with the action-specific and location-specific ARARs. Since the OU-2 basin is natural and not manmade for the purpose of Waste Management or Wastewater Treatment, and since it is contiguous with the Tombigbee River, it is outside the probable scope for exemption from Clean Water Act Section 404 permitting under CERCLA (Mobile District, Army Corps of Engineers, personal communication, September 21, 1993). Therefore, a Department of the Army (U.S. Corps of Engineers) permit will be required according to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA). Water quality certification under Section 401 of the CWA will be required by the state of Alabama. All government interagency and interdepartmental coordination, as well as the 30-day public notice and comment period, would be included in the permitting activity.

OU-2 currently does not fall within coastal zone jurisdiction. However, the elevation of OU-2 is less than 10 feet (MSL) and subject to tidal influence and thus may qualify for coastal zone management jurisdiction by 1995. All activities proposed within the state coastal zone management boundary require a "certificate for consistency" from the state Coastal Zone Management Agency. Section 401 and the certificate for consistency are coordinated with the state by the U.S. Corps of Engineers (concurrent with Section 404 action), as well as with the U.S. Fish and Wildlife Service, EPA, and other federal agencies.

For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

OU-2 Basin Sediment Alternative C

Of the 22 endangered species noted in the RI, only the American alligator *(Alligator mississippiensis)* is definitely known to live in OU-2. A single juvenile (1.5 meters total length) was observed along the south shoreline of the OU-2 basin on several occasions during the RI field work. Although the alligator has been delisted and is neither endangered or threatened, for law enforcement purposes they are classified as threatened due to similarity of appearance to the American crocodile, which is an endangered species. Since the site is west of Florida and well outside the habitat for the American crocodile, consultation under the Endangered Species Act (16 U.S.S. 1531 et seq.) may not be required. However, the U.S. Fish and Wildlife Service and the state of Alabama would make that determination.

The RI report (WCC, 1993) stated that there was a lack of suitable habitat in OU-2 for two threatened species, the eastern indigo snake *(Drymarchon corais couperi)* and the gopher tortoise *(Gopherus polyphemus)* and their probability of occurrence was low. The bluff area, however, does contain suitable habitat with a higher probability for these species to be present. Based on post RI observations made in 1993 several mussel species were observed in OU-2. Habitat requirements for a threatened species, the inflated headsplitter *(Potamilus inflatus)*, appears to be present as described in the Recovery Plan (U.S. Fish and Wildlife, 1992). Additional studies would be conducted prior to construction to define whether threatened or endangered species would be affected by implementing Alternative C. If threatened or endangered species were identified, either during these studies or during construction, consultation and permitting as specified by Section 7 of the Endangered Species Act would be required prior to "taking" any such species.

In the environmental impact assessment for construction of the diaphragm cell chlor-alkali plant (Betz and Converse, 1977), archaeological and historic resources were identified along the McIntosh bluff area. In the opinion of the archaeologist, the bluff is an "important historic site" and would undoubtedly qualify for the National Register of Historic Places. Requirements may include compliance with the National Historic Preservation Act of 1988 as amended; Archaeology and Historical Preservation: Secretary of Interior's Standards and Guideline; 36 CFR 80; 36 CFR 81; and 36 CFR 296, as a minimum.

OU-2 Basin Sediment Alternative C

Long-Term Effectiveness and Permanence

The fish ingestion pathway from the basin would be greatly reduced. With the establishment of new wetlands habitat over the long term, there should be a healthy ecosystem, with minimal potential effects from site constituents. Contaminated sediments would be covered with a nominal 1 to 4 feet of backfill. Based on data from the hydrodynamic studies, this alternative is considered permanent. The basin is interpreted to be a depositional system, and it would take an unexpected change in the hydrodynamic conditions to cause erosion of the backfill. An analysis would have to be done to determine how backfilling would influence hydrodynamic conditions.

Reduction of Toxicity, Mobility, and Volume

The basin sediments would be contained, thus decreasing the mobility and bioavailability of contaminants. There would be no reduction in inherent toxicity or volume. Containment to isolate contaminants is considered an appropriate alternative because the potential for exposure of biota to constituents was the only potential long-term threat identified for the basin sediments.

Short-Term Effectiveness

There would be extensive short-term adverse effects. The deep water habitat of the basin and the upland habitat of the bluff would be completely altered. The filling activities would mobilize contaminated sediments to the water column. The water in the basin would either have to be treated or diverted to the river. Uncontaminated suspended solids could be released to the river during contouring. For the purpose of this feasibility study, it was assumed that the water would not require any treatment. It is estimated that this alternative could be completed within 24 months from the start of construction. However, the actual time could be considerably greater because of uncertain flood conditions and more volume could be required for backfill than was estimated.

Implementability

The basin sediments are very soft and the thickness of these soft sediments has not been defined. With the backfilling operation, some of this soft sediment would likely be pushed ahead of the filling activities, forming a "mud wave." In some areas, the mud wave may reach an elevation near the final grade of the backfilling activities, and 100 percent coverage of the sediments may not be possible. Pilot-scale testing of the backfilling operation would be required prior to construction to evaluate the feasibility of this alternative. The timing of construction would be dependent on uncertain flood patterns of the Tombigbee River.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

Basin Sediment Alternative C Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated[1] Present Worth Total Cost ($)
Backfilling	28	13,871,000	0	13,871,000

This alternative has a 50 percent contingency. This contingency is primarily due to the uncertainty associated with the amount of backfill material needed for the basin and uncertain flood patterns of the adjacent Tombigbee River. The pilot-scale test may show that the required backfill would be significantly greater than estimated (i.e., greater than the 50 percent contingency), and the cost of this alternative would have to be re-evaluated.

[1] The cost estimate is based on implementing the remedy for the basin. If the remedy were extended to the two small ponds to the north of the basin, it is estimated that the cost would increase by about 15 percent.

4.2.5.4 Basin Sediment Alternative D: Dredging/Covering (Contained Aquatic Disposal)

For basin sediment Alternative D, the sediment would be dredged at non-flood conditions from areas of the basin that are less than about 8 feet deep and then deposited in the deep depression. The sediments in the depression would be allowed to consolidate and the area would be covered with clean, dredged sediment. This technique is referred to as contained aquatic disposal (CAD) by the U. S. Army Corps of Engineers (USACE) (Truitt, 1987).

It is estimated that approximately 240,000 cubic yards of in-place sediment would be dredged into the depression from the remaining portion of the basin. This volume is based on removing 2 feet of material from the areas of the basin shallower than 8 feet deep and removing an additional 2 feet in the southern one-third of the basin, where contaminated sediment was found to a greater depth. If the remedial action was extended to the two small ponds to the north of the basin, it is estimated that an additional 26,000 cubic yards would be dredged and placed in the depression, based on removal of an estimated 1 foot from the ponds. An additional 150,000 cubic yards of in-place sediment (dredged from the basin after removal of the contaminated sediments) is estimated for covering the depression. The cover volume is based on placing 4 feet of material over the dredged contaminated sediments. It was assumed that there would be about 1 foot of consolidation resulting in a final 3-foot cover. Figures 4-23 and 4-24 show typical cross sections across the depression in the basin before and after covering, respectively. Detailed bathymetric profiles and additional sediment sampling would be required to define the dredge and fill areas.

It was assumed that the sediment in the basin would be removed by a barge-mounted hydraulic dredge and transported to the depression (via a floating and flexible pipeline). A combination of a barge and a vertical pipe with a baffle or a diffuser at the end may be used for placement of the material. The diffuser would reduce the velocity of flow (possibly by an order of magnitude) yet maintain the same discharge rate of the hydraulic dredge. This mechanism allows the dredged material to be placed in the depression with minimum resuspension. The covered area would be monitored by periodic bathymetric profiles of the basin. After implementation, this alternative would

also include periodic monitoring of sediments and fish tissue concentrations to evaluate the adequacy of the cover and the recovery rate of the aquatic system. A 10-year monitoring period was assumed.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The calculated human health risks were below the remediation objectives ($1x10^{-4}$ lifetime cancer risk and 1.0 hazard index). As discussed in Section 1.6, the overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. This alternative would provide added protectiveness to human health by reducing exposure of fish to the basin sediments. The fish ingestion pathway was identified as the greatest contributor to human health risks. Most of the contaminated sediments would be isolated from the biota, reducing the potential for ecological risks from site constituents. The existing basin ecosystem would be severely disrupted. The potential long-term ecological benefits compared to no action are questionable, as described below under long-term effectiveness and permanence.

Compliance with ARARs

Compliance with ARARs is uncertain. With any dredging operation there would be residual contamination due to resuspension. Water quality criteria, particularly for mercury, may still be exceeded after the alternative is implemented. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. (See discussion under implementability.)

The alternative could be implemented to comply with the action-specific and location-specific ARARs. Since the OU-2 basin is natural and not manmade for the purpose of Waste Management or Wastewater Treatment, and since it is contiguous with the Tombigbee River, it is outside the probable scope for exemption from Clean Water Act Section 404 permitting under CERCLA (Mobile District, Army Corps of Engineers, personal communication, September 21, 1993). Therefore, a Department of the Army (U.S. Corps of Engineers) permit will be required according to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA). Water

quality certification under Section 401 of the CWA will be required by the state of Alabama. All government interagency and interdepartmental coordination, as well as the 30-day public notice and comment period, would be included in the permitting activity.

OU-2 currently does not fall within coastal zone jurisdiction. However, the elevation of OU-2 is less than 10 feet (MSL) and subject to tidal influence and thus may qualify for coastal zone management jurisdiction by 1995. All activities proposed within the state coastal zone management boundary require a "certificate for consistency" from the state Coastal Zone Management Agency. Section 401 and the certificate for consistency are coordinated with the state by the U.S. Corps of Engineers (concurrent with Section 404 action), as well as with the U.S. Fish and Wildlife Service, EPA, and other federal agencies.

For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

Of the 22 threatened and endangered species noted in the RI, only the American alligator *(Alligator mississippiensis)* is definitely known to live in OU-2. A single juvenile (1.5 meters total length) was observed along the south shoreline of the OU-2 basin on several occasions during the RI field work. Although the alligator has been delisted and is neither endangered or threatened, for law enforcement purposes they are classified as threatened due to similarity of appearance to the American crocodile, which is an endangered species. Since the site is west of Florida and well outside the habitat for the American crocodile, consultation under the Endangered Species Act (16 U.S.S. 1531 et seq.) may not be required. However, the U.S. Fish and Wildlife Service and the state of Alabama would make that determination.

Alternative D would not include the disruption of the bluff or the likely habitat of the eastern indigo snake *(Drymarchon corais couperi)* and the gopher tortoise *(Gopherus polyphemus),* two threatened species that could occur along the bluff. Based on post RI observations made in 1993 several mussel species were observed in OU-2. Habitat requirements for a threatened species, the inflated headsplitter *(Potamilus inflatus),*

appears to be present as described in the Recovery Plan (U.S. Fish and Wildlife, 1992). Additional studies would be conducted prior to construction to define whether threatened or endangered species would be affected by implementing Alternative C. If threatened or endangered species were identified, either during these studies or during construction, consultation and permitting as specified by Section 7 of the Endangered Species Act would be required prior to "taking" any such species.

In the environmental impact assessment for construction of the diaphragm cell chlor-alkali plant (Betz and Converse, 1977), archaeological and historic resources were identified along the McIntosh bluff area. In the opinion of the archaeologist, the bluff is an "important historic site" and would undoubtedly qualify for the National Register of Historic Places. Alternative D should not include disruption of these resources.

Long-Term Effectiveness and Permanence

There should be a long-term, permanent decrease in fish tissue concentrations. However, long-term benefits to the ecosystem may not occur. The net result of this alternative would be a significant change in the overall bathymetric profile of the basin. There would no longer be shallower, marginal areas or a deep depression (in effect, a moderately deep, steep-sided or boxlike configuration would result). This would eliminate the shallow water habitat that is required by many of the amphibious (e.g., bird species) and aquatic (e.g., mussel species) that use OU-2. Depth was shown to be the predominant limiting factor for the benthic macroinvertebrates, as the most diverse and productive benthic samples were associated with shallow marginal areas of the basin. It is therefore possible that a long-term net loss in benthic macroinvertebrate productivity could occur.

The results of the hydrodynamic study indicated that the basin is generally a depositional area. Therefore, it is estimated that the cover would be subject to disruption only if there were a future change in hydrodynamic conditions (either gradual or catastrophic). Long-term effectiveness and permanence would be evaluated with the monitoring program.

OU-2 Basin Sediment Alternative D

Reduction of Toxicity, Mobility, and Volume

The basin sediments would be contained, thus decreasing the mobility and bioavailability of contaminants. There would be no reduction in inherent toxicity or volume. After implementation, there may be some mobile constituents present that were suspended/dissolved during the dredging activities.

Short-Term Effectiveness

There would be extensive short-term adverse effects. The entire benthic community would be removed. A large percentage of the aquatic organisms would be destroyed by the dredging, and contaminant concentrations in tissues of the remaining fish would probably increase because of mobilization and dissolution of constituents. Dredging would also increase the potential for contaminant migration out of the basin to the adjacent Tombigbee River. It is estimated that this alternative could be completed within 12 months from the start of construction. The actual time would depend on flood conditions and obstructions encountered during dredging.

Implementability

The subaqueous covering operations would require specialized contractors and equipment. The basin sediments are very fine-grained and flocculent. Resuspension of contaminated sediment and settling out over areas that have already been dredged may limit the effectiveness of this alternative at meeting the surface water ARARs. Residual contamination would exist from resuspension of sediment and dissolution as a result of the dredging operations. During the RI, selected sediment samples were analyzed by the elutriate mercury test, a test developed by the USACE to simulate dredging and test disposal processes. The test consisted of mixing the sediments with surface water from the site and agitating the mixture. The water fraction was then analyzed for dissolved mercury. Nineteen samples were collected from the basin: 15 grab samples (0 to 6 inches) and 4 core samples (2 to 4 feet). The elutriate mercury results and the test methods are presented in Appendix I. Mercury was not detected in any of the grab samples at a detection limit of 2 μg/l. Mercury was detected in 2 of the 4 core samples (both at 153 μg/l). These results indicate that there is a potential

for dissolution of mercury in the water during the dredging activities. There appears to be a greater potential for dissolution from deeper sediments, possibly because the surficial sediments are already in equilibrium with the water column.

Pilot-scale testing would be required during the design phase to define the appropriate equipment and procedures for dredging and covering. Detailed bathymetric profiles and additional sediment characterization would be required to define dredge and fill areas. Underwater obstructions would interfere with dredging operations. It is possible that large, sunken cyprus logs may be present in the basin. Olin was told by a local resident that logs were stored in the basin area as part of timber operations conducted prior to construction of the Olin facility and that some logs sunk and remain in the basin. Investigations would be required to determine the location of any logs prior to dredging. Timing of construction would be dependent on uncertain flood patterns of the Tombigbee River.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost table is presented in Appendix G.

Basin Sediment Alternative D Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated[1] Present Worth Total Cost ($)
Dredging/Covering (CAD)	29	13,740,000	1,243,000	14,983,000

This alternative has a contingency of 50 percent. This contingency is due to the uncertainties associated with flood patterns of the Tombigbee River and the possibility of obstructions to the dredging.

[1] The cost estimate is based on implementing the remedy for the basin. If the remedy were extended to the two small ponds to the north of the basin, it is estimated that the cost would increase by about 10 percent.

4.2.5.5 Basin Sediment Alternative E1: Dredging/Disposal (Mechanical Dewatering)

Basin sediment Alternative E1 would consist of dredging the affected sediments from the basin, mechanical dewatering of the dredged sediments, disposal in an on-site solid waste landfill, installation of monitor wells, and post-closure monitoring.

For the purpose of estimating volumes, it was assumed that dredging would be conducted 2 feet deep across the entire basin, with an additional 2 feet in the southern one-third, where contaminated sediments were found to a greater depth. Based on these assumptions, the estimated volume of in-place sediment to be removed is 340,000 cubic yards. If the remedial action were extended to the two small ponds to the north of the basin, it is estimated that an additional 26,000 cubic yards would be dredged, for a total of 366,000 cubic yards. If a dredging alternative is implemented, the limits of dredging would have to be better defined through further sediment characterization.

It was assumed that removal of sediment would be conducted with a barge-mounted hydraulic dredge. Based on a review of the sediment characteristics and the scope of the alternative, a cutterhead or augerhead dredge would probably be appropriate. Discussions with contractors indicated that the best approach may be to customize a dredge. The type of dredge would be selected during the design phase based on characteristics of the sediments and possibly through pilot-scale testing.

The dredged sediments would be transported via a pipeline to the dewatering area, located on the adjacent bluff to the west of the basin. Site preparation would include clearing, grubbing and grading the dewatering area. It was assumed that final dewatering would be done with belt filter presses. Because of the lower production rates of the mechanical dewatering devices as compared to the rate of sediment dredging, the material from the basin would be dredged into a temporary holding pond to provide storage and a constant feed to the belt filter presses. The holding pond would also act as a clarifier to increase the solids content of the material to be dewatered. The sediment from the holding pond would be dredged (or pumped) to mix tanks, where polymer would be added. After mixing, the material would be fed to the belt presses. Decant water from the temporary holding pond and effluent from the filter presses would be directed back to the basin. The area in the basin where the effluent

would be discharged would be the last area dredged. The type of dewatering equipment and additives (e.g., polymers) would be selected during the design phase based on bench-scale treatability studies.

It has been assumed that the filter cake would be placed into trucks by conveyor belts and transported to an on-site landfill. The landfill dimensions would be approximately 1,000 x 1,000 x 10 feet deep. The material would be placed in lifts and compacted using standard compaction equipment or low ground pressure equipment. The cap would consist of 2 feet of compacted soils of less than 1×10^{-7} laboratory permeability and one foot of topsoil that would be vegetated. The landfill would require groundwater monitor wells and post-closure monitoring.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The calculated human health risks were below the remedial action objectives (1×10^{-4} lifetime cancer risk and 1.0 hazard index). As discussed in Section 1.6, the overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. This alternative would provide added protectiveness to human health by reducing exposure of fish to the basin sediments. The fish ingestion pathway was identified as the greatest contributor to human health risks. The basin ecosystem would be completely disrupted. Most of the contaminated sediments would be removed, reducing the potential for ecological risks from site constituents. The potential long-term ecological benefits are questionable, as described below under long-term effectiveness and permanence.

Compliance with ARARs

Compliance with ARARs is uncertain. With any dredging operation there would be residual contamination due to resuspension. Water quality criteria, particularly for mercury, may still be exceeded after the alternative is implemented. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. (See discussion under implementability.)

OU-2 Basin Sediment Alternative E1

The alternative could be implemented to comply with the action-specific and location-specific ARARs. Since the OU-2 basin is natural and not manmade for the purpose of Waste Management or Wastewater Treatment, and since it is contiguous with the Tombigbee River, it is outside the probable scope for exemption from Clean Water Act Section 404 permitting under CERCLA (Mobile District, Army Corps of Engineers, personal communication, September 21, 1993). Therefore, a Department of the Army (U.S. Corps of Engineers) permit will be required according to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA). Water quality certification under Section 401 of the CWA will be required by the state of Alabama. All government interagency and interdepartmental coordination, as well as the 30-day public notice and comment period, would be included in the permitting activity.

OU-2 currently does not fall within coastal zone jurisdiction. However, the elevation of OU-2 is less than 10 feet (MSL) and subject to tidal influence and thus may qualify for coastal zone management jurisdiction by 1995. All activities proposed within the state coastal zone management boundary require a "certificate for consistency" from the state Coastal Zone Management Agency. Section 401 and the certificate for consistency are coordinated with the state by the U.S. Corps of Engineers (concurrent with Section 404 action), as well as with the U.S. Fish and Wildlife Service, EPA, and other federal agencies.

For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

Of the 22 threatened and endangered species noted in the RI, only the American alligator *(Alligator mississippiensis)* is definitely known to live in OU-2. A single juvenile (1.5 meters total length) was observed along the south shoreline of the OU-2 basin on several occasions during the RI field work. Although the alligator has been delisted and is neither endangered or threatened, for law enforcement purposes they are classified as threatened due to similarity of appearance to the American crocodile, which is an endangered species. Since the site is west of Florida and well outside the habitat for the American crocodile, consultation under the Endangered Species Act (16 U.S.S. 1531

et seq.) may not be required. However, the U.S. Fish and Wildlife Service and the state of Alabama would make that determination.

The RI report (WCC, 1993) stated that there was a lack of suitable habitat in OU-2 for two threatened species, the eastern indigo snake *(Drymarchon corais couperi)* and the gopher tortoise *(Gopherus polyphemus)* and their probability of occurrence was low. Alternative E1 would include piping along the bluff during dredging and mechanical dewatering adjacent to the bluff. These areas do contain suitable habitat for the indigo snake and the gopher tortoise. Based on post RI observations made in 1993 several mussel species were observed in OU-2. Habitat requirements for a threatened species, the inflated headsplitter *(Potamilus inflatus)*, appears to be present as described in the Recovery Plan (U.S. Fish and Wildlife, 1992). Additional studies would be conducted prior to construction to define whether threatened or endangered species would be affected by implementing Alternative E1. If threatened or endangered species were identified, either during these studies or during construction, consultation and permitting as specified by Section 7 of the Endangered Species Act would be required prior to "taking" any such species.

In the environmental impact assessment for construction of the diaphragm cell chlor-alkali plant (Betz and Converse, 1977), archaeological and historic resources were identified along the McIntosh bluff area. In the opinion of the archaeologist, the bluff is an "important historic site" and would undoubtedly qualify for the National Register of Historic Places. Requirements may include compliance with the National Historic Preservation Act of 1988 as amended; Archaeology and Historical Preservation: Secretary of Interior's Standards and Guideline; 36 CFR 80; 36 CFR 81; and 36 CFR 296 as a minimum.

Olin has determined that the sediments would not be classified as a listed hazardous waste under 40 CFR 261. Olin submitted a treatability study work plan/SAP (WCC, 1992) to EPA that includes TCLP tests for further determination of the regulatory classification of the basin sediments. However, based on knowledge of the material and past TCLP analyses conducted for disposal of the samples collected during the RI, it is assumed that the sediments would not be classified as a characteristic hazardous waste. Therefore, LDRs and MTRs and other requirements under 40 CFR 264 would not be

relevant and appropriate. The on-site disposal facility depicted in this FS is based on the relevant and appropriate ADEM solid waste regulations that currently exist (ADEM Administrative Code R.335-1-x-.xx).

Long-Term Effectiveness and Permanence

There should be a long-term permanent decrease in fish tissue concentrations. However, long-term benefits to the ecosystem may not occur. The net result of this alternative would be a significant change in the overall bathymetric profile of the basin. There would no longer be shallower marginal areas. This would eliminate the shallow water habitat that is required by many of the amphibious (e.g., bird species) and aquatic (e.g., mussel species) that use OU-2. Depth was shown to be the predominant limiting factor for the benthic macroinvertebrates, as the most diverse and productive benthic samples were associated with shallow marginal areas of the basin. It is therefore possible that a long-term net loss in benthic macroinvertebrate productivity could occur.

Reduction of Toxicity, Mobility, and Volume

Dredging would result in a reduction of toxicity and volume of contamination in the basin. The sediments would be disposed of in an on-site landfill, which would significantly reduce mobility. After implementation, there may be some mobile constituents present that were suspended/dissolved during dredging.

Short-Term Effectiveness

There would be extensive short-term adverse effects. The entire benthic community would be removed. A large percentage of the aquatic organisms would be destroyed by the dredging, and contaminant concentrations in tissues of the remaining fish would probably increase because of mobilization and dissolution of constituents. Dredging would also increase the potential for contaminant migration out of the basin to the adjacent Tombigbee River. There would be extensive piping and material handling that could result in exposure of remedial workers and the environment. It is estimated that this alternative could be completed within 30 months from the start of construction. Because of the uncertainty associated with dredging (potential obstructions and

uncertain flood conditions), the actual time for completion could vary considerably from this estimate.

Implementability

Dredging is well demonstrated and efficient for sediment removal. The basin sediments are very fine-grained and flocculent. Resuspension of contaminated sediment and settling out over areas that have already been dredged may limit the effectiveness of this alternative at meeting the surface water ARARs. Residual contamination would exist from resuspension of sediment and dissolution as a result of the dredging operations. During the RI, selected sediment samples were analyzed by the elutriate mercury test, a test developed by the USACE to simulate dredging and test disposal processes. The test consisted of mixing the sediments with surface water from the site and agitating the mixture. The water fraction was then analyzed for dissolved mercury. Nineteen samples were collected from the basin: 15 grab samples (0 to 6 inches) and 4 core samples (2 to 4 feet). The elutriate mercury results and the test methods are presented in Appendix I. Mercury was not detected in any of the grab samples at a detection limit of 2 μg/l. Mercury was detected in 2 of the 4 core samples (both at 153 μg/l). These results indicate that there is a potential for dissolution of mercury in the water during the dredging activities. There appears to be a greater potential for dissolution from deeper sediments, possibly because the surficial sediments are already in equilibrium with the water column. The alternative would also destroy an estimated 50 acres of terrestrial habitat adjacent to the basin for construction of the landfill.

A long lead time would be required to construct the on-site landfill if that option is selected. Bench-scale testing would probably be required for the selection of the appropriate dewatering equipment. Further characterization of the basin sediments would also be required for volume estimates and to obtain additional information on the physical properties of the sediment. Underwater obstructions would interfere with dredging operations. It is possible that large, sunken cyprus logs may be present in the basin. Olin was told by a local resident that logs were stored in the basin area as part of timber operations conducted prior to construction of the Olin facility and that some logs sunk and remain in the basin. Investigations would be required to determine the occurrence of these logs prior to any dredging activities.

OU-2 Basin Sediment Alternative E1

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth costs. The referenced cost tables are presented in Appendix G.

Basin Sediment Alternative E1 Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated[1] Present Worth Total Cost ($)
Dredging (Upland)	30	14,869,000	0	14,869,000
Temporary Holding Pond	31	298,000	0	298,000
Mechanical Dewatering	32	22,063,000	0	22,063,000
On-Site Disposal	33	18,370,000	1,891,000	20,261,000
TOTAL		55,600,000	1,891,000	57,491,000

The dredging cost component of this alternative has a contingency factor of 50 percent due to uncertainties associated with flood patterns of the Tombigbee River and possible physical obstructions to the dredging. A 50 percent contingency was adopted for mechanical dewatering because of scope uncertainties such as the type of dewatering equipment and production rates.

4.2.5.6 Basin Sediment Alternative E2: Dredging/Disposal (Confined Disposal Facility)

Basin sediment Alternative E2 would consist of dredging the affected sediments from the basin and allowing them to settle in a confined disposal facility (CDF), stabilizing/solidifying the settled solids, installing a cap, installing monitor wells, and post-closure monitoring.

[1] The cost estimate is based on implementing the remedy for the basin. If the remedy were extended to the two small ponds to the north of the basin, it is estimated that the cost would increase about 10 percent.

Confined disposal facility is a term used by the USACE for a unit designed for settling and dewatering dredged sediments. Numerous CDFs exist in the nation, mostly for dewatering dredged sediments from navigable waterways.

For the purpose of estimating volumes, it was assumed that dredging would be conducted 2 feet deep across the entire basin, with an additional 2 feet in the southern one-third, where contaminated sediments were found to a greater depth. Based on these assumptions, the estimated volume of in-place sediment to be removed is 340,000 cubic yards. If the remedial action were extended to the two small ponds to the north of the basin, it is estimated that an additional 26,000 cubic yards would be dredged, for a total of 366,000 cubic yards. If a dredging alternative is implemented, the limits of dredging would have to be better defined through further sediment characterization.

It was assumed that removal of sediment would be conducted with a barge-mounted hydraulic dredge. Based on a review of the sediment characteristics and the scope of the alternative, a cutterhead or augerhead dredge would probably be appropriate. Discussions with contractors indicated that the best approach may be to customize a dredge to meet the project objectives. The type of dredge would be selected during the design phase based on characteristics of the sediments and possibly through pilot-scale testing.

Based on 340,000 cubic yards of in-place sediment to be dredged, and with an assumed bulking factor of 1.5, the conceptual CDF is sized for 510,000 cubic yards of dredged material. A 2-foot settling zone and a 2-foot ponding depth would increase the capacity of the CDF to 750,000 cubic yards. The CDF would be located on the upland area west of the basin, above the 100-year floodplain. The area is heavily wooded, and extensive clearing and grubbing would be required. For the purpose of estimating costs, the dimensions are assumed to be about 600 x 2,500 feet. The CDF would be constructed about 10 feet below grade with a 4-foot perimeter dike.

The CDF unit would be a continuous flow-through system during dredging operations. Dredged sediment would enter one end of the unit; after particle settling and clarification, water would be discharged to the basin from the other end. Commonly, CDFs are constructed with various dike arrangements to increase retention time and

allow the finer sediments to settle out; polymers may be added to aid the clarification. Bench-scale settling tests would be required to determine the basin settling characteristics. It was assumed for the purpose of this FS that no treatment in the CDF would be required (e.g., no polymer addition) and that the CDF could be constructed such that primary settling alone would meet discharge limits.

The sediments would probably not consolidate and dewater to the extent that they could sustain the weight of a cap. Therefore, this alternative would also include in situ solidification of the sediment prior to cap construction. It has been assumed for cost estimation that solidification/stabilization could be performed one year after completion of the dredging operation. It was also assumed that stabilization/solidification would be performed to a depth of 5 feet in the CDF. The CDF would be sized so that after consolidation and solidification/stabilization, the material would be below grade and the dikes could be used as capping material. Post-closure monitoring would be conducted in conformance with relevant and appropriate ADEM regulations.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The calculated human health risks were below the remedial action objections ($1x10^{-4}$ lifetime cancer risk and 1.0 hazard index). As described in Section 1.6, the overall terrestrial and aquatic ecosystems of OU-2 were considered healthy. This alternative would provide added protectiveness to human health by reducing exposure of fish to the basin sediments. The fish ingestion pathway was identified as the greatest contributor to human health risks. Most of the contaminated sediments would be removed, reducing the potential for ecological risks from site constituents. The basin ecosystem would be severely disrupted. The potential long-term ecological benefits are questionable, as described below under long-term effectiveness and permanence.

Compliance with ARARs

Compliance with ARARs is uncertain. With any dredging operation there would be residual contamination due to resuspension. Water quality criteria, particularly for mercury, may still be exceeded after the alternative is implemented. A waiver may be

justified, as it may not be technically practical to meet the water quality criteria. (See discussion under implementability.)

The alternative could be implemented to comply with the action-specific and location-specific ARARs. Since the OU-2 basin is natural and not manmade for the purpose of Waste Management or Wastewater Treatment, and since it is contiguous with the Tombigbee River, it is outside the probable scope for exemption from Clean Water Act Section 404 permitting under CERCLA (Mobile District, Army Corps of Engineers, personal communication, September 21, 1993). Therefore, a Department of the Army (U.S. Corps of Engineers) permit will be required according to Section 10 of the Rivers and Harbors Act of 1899 and Section 404 of the Clean Water Act (CWA). Water quality certification under Section 401 of the CWA will be required by the state of Alabama. All government interagency and interdepartmental coordination, as well as the 30-day public notice and comment period, would be included in the permitting activity.

OU-2 currently does not fall within coastal zone jurisdiction. However, the elevation of OU-2 is less than 10 feet (MSL) and subject to tidal influence and thus may qualify for coastal zone management jurisdiction by 1995. All activities proposed within the state coastal zone management boundary require a "certificate for consistency" from the state Coastal Zone Management Agency. Section 401 and the certificate for consistency are coordinated with the state by the U.S. Corps of Engineers (concurrent with Section 404 action), as well as with the U.S. Fish and Wildlife Service, EPA, and other federal agencies.

For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

Of the 22 threatened and endangered species noted in the RI, only the American alligator *(Alligator mississippiensis)* is definitely known to live in OU-2. A single juvenile (1.5 meters total length) was observed along the south shoreline of the OU-2 basin on several occasions during the RI field work. Although the alligator has been delisted and is neither endangered or threatened, for law enforcement purposes they are classified

as threatened due to similarity of appearance to the American crocodile, which is an endangered species. Since the site is west of Florida and well outside the habitat for the American crocodile, consultation under the Endangered Species Act (16 U.S.S. 1531 et seq.) may not be required. However, the U.S. Fish and Wildlife Service and the state of Alabama would make that determination.

The RI report (WCC, 1993) stated that there was a lack of suitable habitat in OU-2 for two threatened species, the eastern indigo snake *(Drymarchon corais couperi)* and the gopher tortoise *(Gopherus polyphemus)* and their probability of occurrence was low. Alternative E2 would include piping along the bluff during dredging and construction and maintenance of the CDF on the upland area west of the bluff. These areas do contain suitable habitat for the indigo snake and the gopher tortoise. Based on post RI observations made in 1993 several mussel species were observed in OU-2. Habitat requirements for a threatened species, the inflated headsplitter *(Potamilus inflatus)*, appears to be present as described in the Recovery Plan (U.S. Fish and Wildlife, 1992). Additional studies would be conducted prior to construction to define whether threatened or endangered species would be affected by implementing Alternative E1. If threatened or endangered species were identified, either during these studies or during construction, consultation and permitting as specified by Section 7 of the Endangered Species Act would be required prior to "taking" any such species.

In the environmental impact assessment for construction of the diaphragm cell chlor-alkali plant (Betz and Converse, 1977), archaeological and historic resources were identified along the McIntosh bluff area. In the opinion of the archaeologist, the bluff is an "important historic site" and would undoubtedly qualify for the National Register of Historic Places. Requirements may include compliance with the National Historic Preservation Act of 1988 as amended; Archaeology and Historical Preservation: Secretary of Interior's Standards and Guideline; 36 CFR 80; 36 CFR 81; and 36 CFR 296, as a minimum.

Long-Term Effectiveness and Permanence

There should be a long-term permanent decrease in fish tissue concentrations. However, long-term benefits to the ecosystem may not occur. The net result of this

alternative would be a significant change in the overall bathymetric profile of the basin. There would no longer be shallower, marginal areas. This would eliminate the shallow water habitat that is required by many of the amphibious (e.g., bird species) and aquatic (e.g., mussel species) that use OU-2. Depth was shown to be the predominant limiting factor for the benthic macroinvertebrates, as the most diverse and productive benthic samples were associated with shallow marginal areas of the basin. It is therefore possible that a long-term net loss in benthic macroinvertebrate productivity could occur. The alternative would also destroy an estimated 50 acres of terrestrial habitat adjacent to the basin for construction of the CDF.

Olin has determined that the sediments would not be classified as a listed hazardous waste under 40 CFR 261. Olin submitted a treatability study work plan/SAP (WCC, 1992) to EPA that includes TCLP tests for further determination of the regulatory classification of the basin sediments. However, based on knowledge of the material and past TCLP analyses conducted for disposal of the samples collected during the RI, it is assumed that the sediments would not be classified as a characteristic hazardous waste. Therefore, LDRs and MTRs and other requirements under 40 CFR 264 would not be relevant and appropriate. The CDF depicted in this FS is based on relevant and appropriate ADEM solid waste regulations that currently exist (ADEM Administrative Code R.335-1-x-.xx), as described above.

Reduction of Toxicity, Mobility, and Volume

Dredging would result in a reduction of toxicity and volume of contamination in the basin. The sediments would be disposed of on-site, which would significantly reduce mobility. After implementation, there may be some mobile constituents present that were suspended/dissolved during dredging.

Short-Term Effectiveness

There would be extensive short-term adverse effects. The entire benthic community would be removed. A large percentage of the aquatic organisms would be destroyed by the dredging, and contaminant concentrations in tissues of the remaining fish would probably increase because of mobilization and dissolution of constituents. Dredging

would also increase the potential for contaminant migration out of the basin to the adjacent Tombigbee River. There would be additional effects from control of run-on/runoff from the CDF. The estimated time for completion of this alternative is 60 months from the start of construction. Because of the uncertainty associated with dredging (potential obstructions and uncertain flood conditions) and dewatering the CDF, the actual time for completion could vary considerably from this estimate.

Implementability

Dredging is well demonstrated and efficient for sediment removal. The basin sediments are very fine-grained and flocculent. Resuspension of contaminated sediment and settling out over areas that have already been dredged may limit the effectiveness of this alternative at meeting the surface water ARARs. Residual contamination would exist from resuspension of sediment and dissolution as a result of the dredging operations. During the RI, selected sediments samples were analyzed by the elutriate mercury test, a test developed by the USACE to simulate dredging and test disposal processes. The test consisted of mixing the sediments with surface water from the site and agitating the mixture. The water fraction was then analyzed for dissolved mercury. Nineteen samples were collected from the basin: 15 grab samples (0 to 6 inches) and 4 core samples (2 to 4 feet). The elutriate mercury results and the test methods are presented in Appendix I. Mercury was not detected in any of the grab samples at a detection limit of 2 μg/l. Mercury was detected in 2 of the 4 core samples (both at 153 μg/l). These results indicate that there is a potential for dissolution of mercury in the water during the dredging activities. There appears to be a greater potential for dissolution from deeper sediments, possibly because the surficial sediments are already in equilibrium with the water column.

A long lead time would be required to construct the CDF prior to dredging. Additional sediment physical characterization and settling and consolidation tests would be required to properly design this alternative. Because of the size of the CDF, management of rainwater would be an implementability concern. Underwater obstructions would interfere with dredging operations. It is possible that large, sunken cyprus logs may be present in the basin. Olin was told by a local resident that logs were stored in the basin area as part of timber operations conducted prior to construction of the Olin facility and

that some logs sunk and remain in the basin. Investigations would be required to determine the occurrence of these logs prior to any dredging activities.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth costs. The referenced cost tables are presented in Appendix G.

Basin Sediment Alternative E2 Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated[1] Present Worth Total Cost ($)
Dredging (Upland)	30	14,869,000	0	14,869,000
Confined Disposal Facility	34	12,838,000	0	12,838,000
In Situ S/S and Capping	35	22,063,000	2,198,000	24,261,000
TOTAL		49,770,000	2,198,000	51,968,000

A 50 percent contingency has been adopted for the upland dredging, CDF, and the in situ stabilization/solidification. The contingency for dredging is due to the uncertainties associated with the flood patterns of the Tombigbee River and possible physical obstructions to the dredging. The contingency for the CDF and in situ stabilization/solidification components reflects uncertainties related to the amount of time needed for settling and consolidation of the dredged sediments, the amount of dewatering that could be attained in the CDF, and the amount of reagent needed for stabilization/solidification.

[1] The cost estimate is based on implementing the remedy for the basin. If the remedy were extended to the two small ponds to the north of the basin, it is estimated that the cost would increase by about 10 percent.

4.2.5.7 Wastewater Ditch Sediment Alternative C1: Containment (Backfill)

Alternative C1 would consist of excavating a new ditch adjacent to the existing wastewater ditch and utilizing the excavated soils to backfill the existing ditch. The area would be graded so that stormwater flow would be to the new ditch. The entire length of the wastewater ditch and approximately 300 feet of the discharge ditch would be backfilled.

Plant process water would be temporarily diverted during the construction work through a force main to the Tombigbee River. The main components of the diversion system would be a pump station or lift system and a 10-inch-diameter, polyvinyl chloride (PVC) pipeline. The pump would be run by electricity and would be equipped with instrumentation to allow for continuous operation. The estimated length of the process water diversion pipeline is 6,000 feet. For cost estimating purposes, it has been assumed that the pipeline would be laid in an excavated shallow trench that would be backfilled after the installation.

By working during the dry season, stormwater would be managed by implementing certain operational controls such as diversion of stormwater at working areas. Sedimentation controls would also be required. It is anticipated that the entire length of the ditch would require clearing and grubbing over a width of approximately 150 feet to provide space for the new ditch and the required construction equipment. In order to optimize cut and fill volumes, in addition to minimizing material handling, the new ditch would be excavated into the slope of the existing ditch along the southern bank. (The southern bank has been assumed based on information available for this FS. Additional survey work during final design may indicate that other routes are superior.) The excavated soils would be pushed into the existing ditch, compacted, and graded to maintain the existing site drainage (see Figure 4-25). The newly backfilled ditch would be seeded to promote vegetation. It is estimated that approximately 50,000 cubic yards of soil will be required to backfill the existing ditch with approximately 4 feet of cover. In the floodplain area, the backfill would be mounded to attain an adequate cover. Engineering controls (e.g., sheet piles) may be required to prevent Tombigbee River water intrusion during work in the discharge ditch. Following construction, the process water would be rerouted through the newly constructed ditch.

OU-2 Wastewater Ditch Sediment Alternative C1

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The ditch sediments have not been identified as a human health risk and the wastewater ditch is not considered a significant ecological habitat. This alternative would provide added protectiveness of the environment by reducing the potential for contaminant transport down the ditch.

Compliance with ARARs

Wastewater ditch sediment Alternative C1 would comply with the ARARs. The ditch is used to route Olin's wastewater and stormwater, and the NPDES discharge permit limits that Olin currently complies with are potential ARARs. This alternative would also comply with action-specific and location-specific ARARs. Temporarily redirecting flow would require compliance with Olin's existing NPDES permit. For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

Since some work would be done on the floodplain, Section 404 of the Clean Water Act permitting requirements would be an ARAR. It is anticipated that the work would be in the scope of a permit exemption under CERCLA, but substantive requirements of the permits would have to be met.

RCRA LDRs and MTR, would not apply because the contaminated material would not be excavated, i.e., placement would not occur, to trigger LDRs. MTRs would not apply because disposal would not occur.

Long-Term Effectiveness and Permanence

The backfill would be effective at reducing risks to the environment. An engineering evaluation would be required to ensure that hydraulic conditions would not cause erosion of the buried sediments.

OU-2 Wastewater Ditch Sediment Alternative C1

Reduction of Toxicity, Mobility, and Volume

Mobility of contamination via erosion/surface water transport would be significantly reduced or eliminated. There would be no reduction in inherent toxicity or volume of the contamination. This is considered an appropriate alternative because the remedial action objective is to reduce contaminant transport down the ditch.

Short-Term Effectiveness

There would be moderate short-term adverse effects from increased turbidity and potential for sediment transport during storm events. Contaminated sediments, however, would not be handled directly. The estimated time for the completion of this alternative is 15 months from the start of construction.

Implementability

Based on existing information, this alternative is considered implementable. Additional engineering would be required to evaluate the hydrology for proper construction. The primary construction difficulties would be control of stormwater runoff and working on the floodplain. Materials for construction are readily available and widely used. Access to the ditch and along the ditch may be limited for some equipment.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Wastewater Ditch Sediment Alternative C1 Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Process Water Diversion	36	957,000	0	957,000
Backfilling	37	3,251,000	384,000	3,635,000
TOTAL		4,208,000	384,000	4,592,000

The backfilling component of this alternative has a contingency factor of 50 percent. This contingency is primarily due to the potential construction difficulties caused by stormwater and working on the floodplain.

4.2.5.8 Wastewater Ditch Sediment Alternative E: Excavation/Disposal

Wastewater ditch sediment Alternative E would consist of excavating ditch sediments, transporting the material to an off-site disposal facility, and regrading the ditch after excavation. It was assumed that disposal would be at an off-site RCRA facility. The length of the ditch considered for excavation is 6,300 feet, including the entire length of the wastewater ditch and 300 feet of the discharge ditch.

Plant process water would be temporarily diverted during the construction work through a force main to the Tombigbee River. The main components of the diversion system would be a pump station or lift system and a 10-inch diameter PVC pipeline. The pump would be run by electricity and would be equipped with instrumentation to allow for continuous operation. The estimated length of the process water diversion pipeline is 6,000 feet. For cost estimating purposes, it has been assumed that the pipeline would be laid in an excavated shallow trench that would be backfilled after the installation.

For purposes of this FS, it was assumed that the sediments above the Quaternary upland deposits would be excavated. Based on the sampling conducted at OD15 and OD25, this depth was assumed to be 6 feet. The estimated volume of sediments that would be removed is 43,000 cubic yards, based on an excavation 20 feet wide at the base and having 1:1 slopes. Prior to excavation, samples would be obtained from the ditch to better define the excavation limits. The existing conditions of the ditch are shown in Figure 2-4. A typical cross section of the ditch excavation is shown in Figure 4-26.

Heavy brush, heavy shrubs and trees would be cleared along the length of the wastewater ditch, and access roads would be provided sufficient to handle the transport vehicles. The sediments in the ditch would be excavated with standard excavation equipment. Where accessible, the excavated material would be loaded directly into trucks. However, in some areas, temporary staging areas and rehandling of the material

may be required. After excavation, the ditch would be graded and the side slopes would be revegetated.

By working during the dry season and during low river stage, stormwater would be managed by implementing certain operational controls, such as diversion of stormwater at working areas. Sedimentation controls would have to be implemented downstream of the excavation areas to trap contaminated sediment that becomes entrained during storm events. Engineering controls (e.g., sheet piles) may be required to prevent Tombigbee River water intrusion during work in the discharge ditch.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The ditch sediments have not been identified as a human health risk and the wastewater ditch is not considered a significant ecological habitat. This alternative would provide added protection to the environment by removing the contaminated sediments from the wastewater ditch.

Compliance with ARARs

Wastewater ditch sediment Alternative E would comply with the ARARs. The wastewater ditch is used to route Olin's wastewater and stormwater, and the NPDES discharge permit limits that Olin currently complies with are potential ARARs.

This alternative would also comply with action-specific and location-specific ARARs. Temporarily redirecting flow would require compliance with Olin's existing NPDES permit. For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

Since some work would be done on the floodplain, Section 404 of the Clean Water Act permitting requirements would be an ARAR. It is anticipated that the work would be in the scope of a permit exemption under CERCLA, but substantive requirements of the permits would have to be met.

Olin has determined that the ditch sediment material would not be classified as a listed hazardous waste under 40 CFR 261. Based on knowledge of the material (i.e., dominantly low-solubility constituents in sediment matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. A RCRA hazardous waste disposal facility was assumed, primarily because of potential problems in obtaining acceptance of a CERCLA waste at a solid waste disposal facility, and Olin's stringent internal policies regarding off-site disposal. In the event that some of the excavated soils would not pass the TCLP test, LDRs would apply, and applicable treatment standards would have to be met. If such material is encountered, off-site RCRA incineration would probably be the only available off-site disposal method without prior treatment, although the cost for off-site incineration has not been included in this FS because it is believed that incineration would not be required.

State and federal regulations applicable to transportation of hazardous waste (ADEM Administrative Code R.335-14-4 and 40 CFR 263) would be ARARs for any hazardous waste transported off-site and the U. S. Department of Transportation rules would be ARARs for transporting hazardous materials (49 CFR 107).

Long-Term Effectiveness and Permanence

This alternative would be effective and permanent. Removal and off-site disposal would permanently remove the contamination from the wastewater ditch.

Reduction of Toxicity, Mobility, and Volume

The toxicity and volume of the contamination would be reduced in the wastewater ditch, but there would be no overall reduction in toxicity or volume. Contaminants would be transported to an off-site landfill, where there would be a reduction in mobility.

Short-Term Effectiveness

The short-term adverse effects may be significant. Contaminated runoff from excavation areas may require construction controls to minimize release of contamination during

construction. Also, transportation of the contaminated sediments poses a short-term risk of releases to the public. It is estimated that this alternative could be completed within 15 months from the start of construction.

Implementability

This alternative would be moderately difficult to implement. The primary construction difficulty would be control of stormwater runoff and working on the floodplain. There would also be difficulties related to excavating contaminated, saturated ditch sediments. Readily available construction equipment and contractors could be used to implement this alternative. Access to the ditch and along the ditch may be limited for some equipment.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Wastewater Ditch Sediment Alternative E Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Process Water Diversion	36	957,000	0	957,000
Excavation	38	10,511,000	0	10,511,000
Off-Site Disposal (RCRA)	39	29,325,000	0	29,325,000
TOTAL		40,793,000	0	40,793,000

The excavation component of this alternative has a 70 percent contingency, primarily because of uncertainties such as storm events and the difficulty associated with excavating the saturated ditch sediments, particularly the portion of the ditch that is in the floodplain. Excavation and disposal of debris (an estimated 4,500 tons) was included in the excavation cost table. For cost estimating purposes, it was assumed that the debris would have to be re-handled prior to transportation and disposal.

4.2.5.9 Wastewater Ditch Sediment Alternative G1: Excavation/On-Site Thermal Treatment/Disposal

Alternative G1 would consist of excavating ditch sediments, transporting the excavated sediments to a treatment area, and thermally treating (or incinerating) the sediments on-site, followed by on-site disposal.

Plant process water would be temporarily diverted during the construction work through a force main to the Tombigbee River. The main components of the diversion system would be a pump station or lift system and a 10-inch-diameter PVC pipeline. The pump would be run by electricity and would be equipped with instrumentation to allow for continuous operation. The estimated length of the process water diversion pipeline is 6,000 feet. For cost estimating purposes, it has been assumed that the pipeline would be laid in an excavated shallow trench that would be backfilled after the installation.

For purposes of this FS, it was assumed that the sediments above the Quaternary upland deposits would be excavated. Based on the sampling conducted at OD15 and OD25, this depth was assumed to be 6 feet. The estimated volume of sediments that would be removed is 43,000 cubic yards, based on an excavation 20 feet wide at the base and having 1:1 slopes. Prior to excavation, samples would be obtained from the ditch to better define the excavation limits. The existing conditions of the ditch are shown in Figure 2-4. A typical cross section of the ditch excavation is shown in Figure 4-27.

Heavy brush, heavy shrubs and trees would be cleared along the length of the wastewater ditch, and access roads would be provided sufficient to handle the transport vehicles. The sediments in the ditch would be excavated with standard excavation equipment. Where accessible, the excavated material would be loaded directly into trucks. However, in some areas, temporary staging areas and rehandling of the material may be required. After excavation, the ditch would be graded and the side slopes would be revegetated.

By working during the dry season and during low river stage, stormwater would be managed by implementing certain operational controls, such as diversion of stormwater at working areas. Sedimentation controls would have to be implemented downstream

of the excavation areas to trap contaminated sediment that becomes entrained during storm events. Engineering controls (e.g., sheet piles) may be required to prevent Tombigbee River water intrusion during work in the discharge ditch.

Thermal treatment would be performed using either a mobile incinerator (infrared or rotary kiln) or a thermal desorber. An on-site infrared incinerator was considered for this analysis. The specific type of thermal treatment technology would be determined in the remedial design phase. A transportable incinerator would be mobilized, operated, and closed according to the relevant and appropriate requirements of RCRA. At an estimated moisture content of 30 to 40 percent, a production rate of about 4 tons/day was assumed. Specific operating practices to meet the performance objectives would be determined through a trial burn at the site after installation of the incinerator.

It was assumed that a wet scrubber system would be used for emissions control. It was also assumed that the sludge generated from treatment of scrubber water would be disposed of at an off-site RCRA disposal facility and stabilization/solidification at the disposal facility would be required.

With wastewater ditch sediment Alternative G1, the incinerated material would be disposed of in an on-site landfill. The material would probably not be classified as a hazardous waste, and therefore the landfill would be constructed in conformance with relevant and appropriate ADEM solid waste regulations (ADEM Administrative Code R.335-1-x-.xx). It was assumed that 43,000 cubic yards would require disposal. The landfill would therefore be constructed approximately 500 x 500 x 6 feet deep. The thermally treated material would be placed in lifts and compacted using standard compaction equipment. The cap would consist of 2 feet of recompacted clay with a permeability of less than 1×10^{-7} cm/sec and 1 foot of vegetated topsoil. Existing in situ clays may be used for the clay liner and cap material. Figure 4-27 shows a cross section of the landfill and also potential locations of the landfill and the treatment area.

Overall Protection of Human Health and the Environment

This alternative would be protective of human health and the environment. The ditch sediments have not been identified as a human health risk and the wastewater ditch is

not considered a significant ecological habitat. This alternative would provide added protectiveness of the environment by removing the contaminated sediments from the wastewater ditch.

Compliance with ARARs

Wastewater ditch sediment Alternative G1 would comply with the ARARs. The wastewater ditch is used to route Olin's wastewater and stormwater, and the NPDES discharge permit limits that Olin currently complies with are potential ARARs.

Temporarily redirecting flow would require compliance with Olin's existing NPDES permit. For any surface water discharges related to this alternative, state or federal discharge permits would probably not have to be obtained, but the substantive requirements of these permits would still have to be met.

Since some work would be done on the floodplain, Section 404 of the Clean Water Act permitting requirements would be an ARAR. It is anticipated that the work would be in the scope of a permit exemption under CERCLA, but substantive requirements of the permits would have to be met.

Olin has determined that the ditch sediment material would not be classified as a listed hazardous waste under 40 CFR 261. Based on knowledge of the material (i.e., dominantly low-solubility constituents in sediment matrix) and past TCLP analyses conducted for disposal of the samples collected during the RI, the material probably would not be classified as a characteristic hazardous waste. Therefore, MTRs and LDRs probably would not be ARARs. In the event that some of the excavated material is a characteristic waste, LDRs would apply, and applicable treatment standards would have to be met. The incinerator would be designed and operated to meet these treatment standards for the organic constituents. It is unlikely that the mercury would trigger LDRs. This alternative assumes off-site RCRA land disposal of any debris that is not compatible with the incinerator. Again, it is anticipated that this material would not be classified as RCRA hazardous waste. A RCRA hazardous waste disposal facility was assumed primarily because of potential problems in obtaining acceptance of a CERCLA waste at a solid waste disposal facility, and Olin's stringent internal policies

regarding off-site disposal. In the event that some of the excavated soils would not pass the TCLP test, LDRs would apply, and applicable treatment standards would have to be met. If such material is encountered, off-site RCRA incineration would probably be the only available off-site disposal method without prior treatment, although the cost for off-site incineration has not been included in this FS because it is believed that incineration would not be required.

The Clean Air Act National Ambient Air Quality Standards and the Alabama Air Quality Regulations were considered ARARs for emissions related to the thermal treatment unit and in situ S/S. OSHA permissible exposure limits (PELs) for workers, established by 29 CFR 1910, would also be action-specific ARARs.

It was assumed that the thermal treatment unit emissions would be treated with a scrubber. If the sludge that is generated from treatment of scrubber water is a hazardous waste, off-site disposal (which is assumed) would trigger LDRs and the applicable treatment standards would have to be met. It may be feasible to stabilize the sludge on-site and dispose of it in the on-site landfill.

If the sludge that is generated from treatment of scrubber water is a hazardous waste, off-site disposal (which is assumed) would trigger LDRs and the applicable treatment standards would have to be met. Bench-scale tests would be required to define the appropriate disposal methods for this sludge.

Standards related to incinerators in 40 CFR 264 Subpart O would be relevant and appropriate. As a CERCLA remedial action, a permit would not be obtained, but the substantive requirements of a permit would have to be met.

State and federal regulations applicable to transportation of hazardous waste (ADEM Administrative Code R.335-14-4 and 40 CFR 263) would be ARARs for any hazardous waste transported off-site, and the U. S. Department of Transportation rules would be ARARs for transporting hazardous materials (49 CFR 107).

Long-Term Effectiveness and Permanence

This alternative would be effective and permanent. Excavation would permanently remove the contamination from the wastewater ditch. Thermal treatment would destroy contaminants.

Reduction of Toxicity, Mobility, and Volume

The toxicity, mobility and volume of contamination would be reduced by thermal treatment. Encapsulation of treated material would prevent exposure to the environment. This satisfies the statutory preference of using treatment as a principal component.

Short-Term Effectiveness

The short-term adverse effects may be significant. Contaminated runoff from excavation areas may require construction controls to minimize release of contamination during construction. There would also be potential risks to workers through operating an incinerator (because of high operational temperatures and complexity of the equipment). These short-term effects would be mitigated through the proper use of safety protocols, proper drainage controls, and restrictions on access to contaminated areas. Although emissions from the incinerator would comply with all air quality regulations, potential accidental releases could temporarily affect air quality in the vicinity of the site. Air monitoring and possible dust and volatile emissions controls would be implemented at the site, primarily during excavation and incineration activities. It is estimated that this alternative could be implemented within 48 months from the start of construction.

Implementability

This alternative would be difficult to implement. The primary construction difficulty for excavation would be control of stormwater runoff and working on the floodplain. Operation of an incinerator is mechanically complex and has stringent monitoring requirements to assure proper performance. The incinerator therefore needs highly

trained and skilled staff and substantial attention. A long lead time may be required for equipment installation and for trial test burns after installation at the site. In addition, it might be necessary to postpone implementation until a suitable incinerator is available.

Cost

The following table summarizes the estimated capital, O&M, and total alternative present worth cost. The referenced cost tables are presented in Appendix G.

Wastewater Ditch Sediment Alternative G1 Alternative Component	Cost Table	Estimated Present Worth Capital Cost ($)	Estimated Present Worth O&M Cost ($)	Estimated Present Worth Total Cost ($)
Process Water Diversion	36	957,000	0	957,000
Excavation	38	10,511,000	0	10,511,000
On-Site Thermal Treatment	40	71,067,000	0	71,067,000
On-Site Disposal	41	2,217,000	778,000	2,995,000
TOTAL		84,752,000	778,000	85,530,000

The excavation component of this alternative has a 70 percent contingency, primarily because of uncertainties such as storm events and the difficulty associated with excavating the saturated ditch sediments, particularly the portion of the ditch that is in the floodplain.

4.3 COMPARATIVE ANALYSIS

This section presents a comparative analysis of the alternatives based on the seven evaluation criteria (excluding state and community acceptance). The comparative analysis is presented for OU-1 groundwater in Section 4.3.1. Three separate comparative analyses were conducted for OU-1 soils, one for the old plant (CPC) landfill (Section 4.3.2), one for the area west of the CPC plant (Section 4.3.3) and one for the sanitary landfills, lime ponds, and well sand residue area combined

(Section 4.3.4). The comparative analyses for the OU-2 sediment alternatives are presented in Sections 4.3.5 and 4.3.6, for the basin and wastewater ditch, respectively.

The analysis identifies whether the alternatives satisfy the two threshold criteria, protection of human health and the environment, and compliance with ARARs. A semi-quantitative rating system is used to show the relative performance of each alternative against the other five criteria. The rating system consists of numbers 1 through 5, with 5 showing the greatest relative performance against the criteria and 1 showing the least.

4.3.1 OU-1 Groundwater

The comparative analysis of the OU-1 groundwater alternatives is presented in this section and summarized in Table 4-7.

Overall Protection of Human Health and the Environment

All the groundwater alternatives, including no action, would provide adequate protection of human health and the environment. The baseline risk assessment indicated that all total excess lifetime cancer risks and hazard indexes for groundwater receptors were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risks and 1.0 hazard index). Alternatives C1, C3 and no action would include continued operation of the RCRA corrective action program (CAP) until the established cleanup standards are achieved. The CAP has been demonstrated to be effective at controlling migration from any known past or current sources, and therefore an increase in exposure would not be expected.

Compliance with ARARs

The RCRA groundwater cleanup standards were identified as applicable chemical-specific ARARs. These cleanup standards are based on MCLs, which were identified as potential relevant and appropriate ARARs. As stated in the RCRA post-closure permit, the estimated time to meet the RCRA cleanup standards with the CAP is 25 to 27 years. Since any of the alternatives would be implemented in conjunction with the

RCRA CAP, they would comply with the chemical-specific ARARs. The groundwater alternatives could be implemented to comply with the action-specific ARARs. There are no known location-specific ARARs for OU-1 groundwater.

Long-Term Effectiveness and Permanence

The groundwater alternatives would not address the soils above the water table in the old plant (CPC) landfill area, but the additional extraction well would result in removal of groundwater at a much greater rate than infiltration. Based on the HELP model, existing downward percolation through the landfill is estimated at 165,000 gal/year. The additional extraction well would operate at rate of about 5 X 10^7 gal/year. Alternative C1 would use conventional vertical wells to accelerate contaminant removal in the saturated zone in the old plant (CPC) landfill area and the area of mercury-containing dense brine. A vertical extraction well would not be as effective at dense brine removal as a horizontal well specified for Alternative C3. The horizontal well would be designed to directly remove the secondary source (the mercury-containing dense brine). Alternatives C1 and C3 would provide similar effectiveness at addressing the organics in the old plant (CPC) landfill area.

Based on the above analysis, the rating of these alternatives against the long-term effectiveness and permanence criteria is as follows:

- Alternative C3 was given a rating score of 5.
- Alternative C1 was given a rating score of 3.
- Alternative A (no action with continuation of existing CAP) was given a rating score of 1.

Reduction of Mobility, Toxicity, and Volume

Alternatives C1 and C3 would both result in a reduction in mobility, by capturing and removing the constituents from the groundwater near the interior of the contaminant plumes. With removal, both alternatives would also decrease the volume of

contaminants within the aquifer. Alternative C3 would be more effective because there would be direct removal of the mercury-containing dense brine. The extracted groundwater would be treated and contaminants would be released through the air stripper or adsorbed onto granular, activated carbon. The carbon would then be disposed of off-site, where there would be a reduction in mobility.

Based on the above analysis, the rating of these alternatives against the criteria of mobility, toxicity, and volume reduction is as follows:

- Alternative C3 was given a rating score of 3.
- Alternative C1 was given a rating score of 2.
- Alternative A (no action with continuation of the existing CAP) was given a rating score of 1.

Short-Term Effectiveness

There would be minimal short-term adverse effects from the groundwater alternatives. These effects would primarily be related to the potential for worker exposure during well installation. The groundwater alternatives could generally be constructed within 12 months.

Based on the above analysis, the rating of these alternatives against the short-term effectiveness criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) was given a rating score of 5.
- Alternatives C1 and C3 were given a rating score of 4.

Implementability

Alternative C1 would be readily implementable. Alternative C3 would be more difficult to implement because of the specialized equipment required to install a horizontal well. Additional characterization prior to design of Alternative C3 would be required to obtain a better definition of the brine layer and thus define the appropriate location and length of the horizontal well.

Based on the above analysis, the rating of these alternatives against the implementability criteria is as follows:

- Alternative A (no action with continuation of the existing CAP), was given a rating score of 5.
- Alternative C1 was given a rating score of 4.
- Alternative C3 was given a rating score of 3.

Cost

The estimated costs for the OU-1 groundwater alternatives are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
No Action (Continuation of the existing CAP)	0	0	0
Alternative C1	1,276,000	2,650,000	3,926,000
Alternative C3	1,920,000	2,650,000	4,570,000

Based on the above analysis, the rating of these alternatives against the cost criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) was given a rating score of 5.

- Alternatives C1 and C3 were given a rating score of 4.

4.3.2 OU-1 Soils - Old Plant (CPC) Landfill

A comparative analysis of the OU-1 soil alternatives for the old plant (CPC) landfill is presented in this section and summarized in Table 4-8.

Overall Protection of Human Health and the Environment

The soil alternatives for the old plant (CPC) landfill, including no action, would provide adequate protection of human health and the environment. The baseline risk assessment indicated that all total excess lifetime cancer risks and hazard indexes for all current and likely future OU-1 soil exposure pathways were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risk and 1.0 hazard index). Although the soils in the old plant (CPC) landfill may be a continuing source of groundwater contamination, each alternative would include continued operation of the RCRA CAP until the established cleanup standards are achieved. The CAP has been demonstrated to be effective at controlling migration from any known past or current sources, and therefore an increase in exposure would not be expected.

Compliance with ARARs

There are no chemical-specific ARARs for soils. The soils environmental remedial action objective is protection of groundwater (i.e., preventing migration of contaminants that would result in groundwater contamination in excess of groundwater ARARs). The RCRA groundwater cleanup standards were identified as applicable chemical-specific ARARs. These cleanup standards are based on MCLs, which were identified as potential relevant and appropriate ARARs. As stated in the RCRA post-closure permit, the estimated time to meet the RCRA cleanup standards with the CAP is 25 to 27 years. Since any of the alternatives would be implemented in conjunction with the RCRA CAP, they would comply with the chemical-specific ARARs.

Each of the alternatives could be implemented to comply with the action-specific ARARs. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

Alternatives E, F and G1 would provide the greatest long-term effectiveness and permanence, because they specify removal and direct treatment of the fill/waste in the old plant (CPC) landfill above 15 feet. There would be residual contamination remaining in the soil below 15 feet, which would be stabilized/solidified to reduce mobility. Alternative D would be only slightly less effective and permanent, because it would be implemented in situ and there would be no aboveground treatment of the waste. However, the RI data indicate that most contaminant migration occurs from zones below 15 feet in portions of the landfill, and the 15- to 23-foot zone is addressed with in situ stabilization/solidification for Alternative D, as with the other three (E, F and G1).

Alternative C (capping) would reduce infiltration. The HELP model indicated that either a multimedia or clay cap would provide an estimated 98 percent reduction in infiltration as compared to existing conditions. Alternative C would not involve removal of contaminants and would not permanently immobilize constituents in the soil matrix.

Based on the above analysis, the rating of these alternatives against the long-term effectiveness and permanence criteria is as follows:

- Alternatives E, F and G1 were given a rating score of 5.
- Alternative D was given a rating score of 4.
- Alternative C was given a rating score of 2.
- Alternative A (no action with continuation of existing CAP) was given a rating score of 1.

Reduction of Mobility, Toxicity, and Volume

On-site thermal treatment (Alternative G1) would result in the greatest reduction in mobility, toxicity and volume, because the contaminants above 15 feet would be destroyed. On-site stabilization/solidification of the upper 15 feet (Alternatives D and E) would result in a reduction in mobility. However, there would be some volume increase (an estimated 20 percent). For off-site RCRA disposal (Alternative F), the material would be taken off-site and disposed of in a landfill, where the mobility would be reduced. All of the soil treatment and removal alternatives would show a similar reduction in mobility for the soils below 15 feet. Based on the RI data, it is the soils below 15 feet that exhibited potential for contaminant migration to the groundwater.

The capping alternative (Alternative C) would result in a reduction in mobility from the decreased infiltration, but the contaminants would not be permanently fixed in the soil matrix. However, containment is considered an appropriate alternative because mobility to the groundwater is the only potential long-term threat posed by OU-1 soils.

Based on the above analysis, the rating of these alternatives against the criteria of mobility, toxicity, and volume reduction is as follows:

- Alternative G1 was given a rating score of 5.
- Alternatives D, E and F were given a rating score of 4.
- Alternative C was given a rating score of 2.
- Alternative A (no action with continuation of the existing CAP) was given a rating score of 1.

Short-Term Effectiveness

Alternatives that involve excavation (Alternatives E, F and G1) would have the greatest potential short-term adverse effects during construction due to the intrusive work and direct handling of the material. Alternative F would have the potential for short-term

risks to the public from spills during off-site transportation. The short-term adverse effects for the two on-site treatment alternatives (E and G1) would be greater than off-site disposal because of the additional material handling after excavation and the potential for emissions during treatment. There would also be short-term adverse effects with Alternative D due to the intrusive work, but this alternative would not involve excavation and would require only minimal direct handling of the material.

Alternative C could generally be constructed within 12 months. The other soil alternatives would take about two to four years for construction.

Based on the above analysis, the rating of these alternatives against the short-term effectiveness criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) and Alternative C were given a rating score of 5.
- Alternative D was given a rating score of 3.
- Alternative F was given a rating score of 2.
- Alternatives E and G1 were given a rating score of 1.

Implementability

On-site thermal treatment (Alternative G1) would be the most difficult to implement. This alternative would involve excavation of the fill/waste material; screening and off-site disposal may be required to separate material that cannot be treated because of size. Thermal treatment is a complex operation that would require specialized staff and equipment and stringent monitoring. Alternative D would also be difficult to implement because of the potential for obstructions in the fill/waste material. Similar to Alternative G1, Alternative E would require excavation, and possibly screening. The stabilization/solidification of excavated material would be easier to implement than thermal treatment, however.

Off-site disposal after excavation (Alternative F) would be less difficult to implement than the on-site treatment alternatives. All of the soil alternatives (except no action) involve in situ solidification/stabilization (D, E, F, and G1), which would require specialized equipment.

Based on the above analysis, the rating of these alternatives against the implementability criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) and Alternative C were given a rating score of 5.
- Alternative F was given a rating score of 3.
- Alternatives D and E were given a rating score of 2.
- Alternative G1 was given a rating score of 1.

Cost

The estimated costs for the OU-1 soil alternatives for the old plant (CPC) landfill are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative A: No Action (Continuation of the existing CAP)	0	0	0
Alternative C	17,727,000	437,000	2,164,000
Alternative D	15,718,000	437,000	16,155,000
Alternative E	29,652,000	437,000	30,089,000
Alternative F	72,910,000	437,000	73,347,000
Alternative G1	108,471,000	437,000	108,908

Based on the above analysis, the rating of these alternatives against the cost criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) was given a rating score of 5.
- Alternative C was given a rating score of 4.
- Alternative D was given a rating score of 3
- Alternative E was given a rating score of 2
- Alternatives F and G1 were given a rating score of 1.

4.3.3 OU-1 Soils - Area West of Former CPC Plant

A comparative analysis of the OU-1 soil alternatives for the area west of the former CPC plant is presented in this section and summarized in Table 4-9.

Overall Protection of Human Health and the Environment

The soil alternatives for the area west of the former CPC plant, including no action, would provide adequate protection of human health and the environment. The baseline risk assessment indicated that all total excess lifetime cancer risks and hazard indexes for OU-1 soil exposure pathways were below the risk-based remedial action objectives (i.e., 10^{-4} excess lifetime cancer risk and 1.0 hazard index). The soils in the area west of the former CPC plant were identified as a potential continuing source of groundwater contamination. This potential is considered low because soil concentrations were below the recommended PSALs, which were developed based on the protection of groundwater. As further protection to groundwater, each alternative would include continued operation of the RCRA CAP until the established cleanup standards are achieved. The CAP has been demonstrated to be effective at controlling migration from an known past or current sources, and therefore any increase in exposure would not be expected.

Compliance with ARARs

There are no chemical-specific ARARs for soils. The soils environmental remedial action objective is protection of groundwater (i.e., prevent migration of contaminants that would result in groundwater contamination in excess of groundwater ARARs). The RCRA groundwater cleanup standards were identified as applicable groundwater chemical-specific ARARs. These cleanup standards are based on MCLs, which were identified as potential relevant and appropriate ARARs. As stated in the RCRA post-closure permit, the estimated time to meet the RCRA cleanup standards with the CAP is 25 to 27 years. Since any of the alternatives would be implemented in conjunction with the RCRA CAP, they would comply with the chemical-specific ARARs.

Each of the alternatives could be implemented to comply with the action-specific ARARs. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

OU-1 Alternatives F and G would provide the greatest long-term effectiveness and permanence, because they specify removal and destruction of contaminants or removal and disposal of the contaminated soils.

Stabilization/solidification alternatives (D and E) would have marginal, if any, increased effectiveness over extending the existing cap (Alternative C). Stabilization/ solidification would be effective at permanently immobilizing contaminants, thus reducing contaminant migration to the groundwater, but the detected soil concentrations in the area were below the potential soil action levels[1], which were developed for protection of groundwater. Alternative C (extend existing capping) would reduce infiltration. The HELP model indicated that a clay cap would provide an estimated 62

[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

percent reduction in infiltration as compared to existing conditions and protect against direct contact.

Based on the above analysis, the rating of these alternatives against the long-term effectiveness and permanence criteria is as follows:

- Alternatives F and G were given a rating score of 5.
- Alternatives C, D and E were given a rating score of 4.
- Alternative A (no action with continuation of existing CAP) was given a rating score of 3.

Reduction of Mobility, Toxicity, and Volume

On-site thermal treatment (Alternative G) would result in the greatest reduction in mobility, toxicity and volume, because the contaminated soil would be destroyed. On-site stabilization/solidification (Alternatives D and E) would result in a reduction in mobility. However, there would be some volume increase (an estimated 20 percent). For off-site RCRA disposal (Alternative F), the material would be taken off-site and disposed of in a landfill, where the mobility would be reduced.

The capping alternative (Alternative C) would result in a reduction in mobility from decreased infiltration, but the contaminants would not be permanently fixed in the soil matrix. However, containment is considered an appropriate alternative because mobility to the groundwater is the only potential long-term threat posed by OU-1 soils, and the contaminant migration to the groundwater in this area is considered low for existing conditions.

Based on the above analysis, the rating of these alternatives against the criteria of mobility, toxicity, and volume reduction is as follows:

- Alternative G was given a rating score of 5.

- Alternatives D, E and F were given a rating score of 4.

- Alternative C was given a rating score of 3

- Alternative A (no action with continuation of the existing CAP) was given a rating score of 1.

Short-Term Effectiveness

Alternatives that involve excavation (Alternatives E, F and G) would have the greatest potential short-term adverse effects during construction due to the intrusive work and direct handling of the material. Alternative F would have the potential for short-term risks to the public from spills during off-site transportation. The short-term adverse effects for the two on-site treatment alternatives (E and G) would be greater than off-site disposal because of the additional material handling after excavation and the potential for emissions during treatment. There would also be short-term adverse effects with Alternative D due to the intrusive work, but this alternative would not involve excavation and would require only minimal direct handling of the material.

Alternative C could generally be constructed within 2 months from the start of construction. Alternatives D, E and F would take about 6 to 8 months, and Alternative G would take about 8 to 12 months from the start of construction.

Based on the above analysis, the rating of these alternatives against the short-term effectiveness criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) and Alternative C were given a rating score of 5.

- Alternative D was given a rating score of 3.

- Alternative F was given a rating score of 2.

- Alternatives E and G were given a rating score of 1.

Implementability

Excavation and on-site thermal treatment (Alternative G) would be the most difficult to implement. Excavation would be in a relatively confined area and an adjacent railroad would have to be either protected or removed. Thermal treatment is a complex operation that would require specialized staff and equipment and stringent monitoring. Alternative D would be moderately difficult to implement because it would also involve intrusive work in a relatively confined area, and the adjacent railroad may cause construction difficulties. Specialized equipment may be required for the in situ S/S. Similar to Alternative G, Alternative E would require excavation. The stabilization/solidification of excavated material would be easier to implement than thermal treatment, however.

Off-site disposal after excavation (Alternative F) would be less difficult to implement than the on-site treatment alternatives.

Based on the above analysis, the rating of these alternatives against the implementability criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) and Alternative C were given a rating score of 5.

- Alternative F was given a rating score of 3.

- Alternatives D and E were given a rating score of 2.

- Alternative G was given a rating score of 1.

Cost

The estimated costs for the OU-1 soil alternatives for the area west of the former CPC plant are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative A: No Action (Continuation of the existing CAP)	0	0	0
Alternative C	173,000	206,000	379,000
Alternative D	1,101,000	206,000	1,307,000
Alternative E	2,142,000	206,000	2,348,000
Alternative F	7,354,000	206,000	7,560,000
Alternative G	13,971,000	206,000	14,177,000

Based on the above analysis, the rating of these alternatives against the cost criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) was given a rating score of 5.
- Alternative C was given a rating score of 4.
- Alternative D was given a rating score of 3.
- Alternative E was given a rating score of 2.
- Soil Alternatives F and G were given a rating score of 1.

4.3.4 OU-1 Soils - Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area

A comparative analysis of the OU-1 soil alternatives for the sanitary landfills, lime ponds, mercury cell plant and well sand residue area is presented in this section and summarized in Table 4-10.

Overall Protection of Human Health and the Environment

The soil alternatives, including no action, would provide adequate protection of human health and the environment. The fate and transport analysis described in Section 1.4 indicates that the four SWMUs addressed by these alternatives are not continuing sources of groundwater contamination. This analysis further shows that the existing caps are not required to ensure continued protection of groundwater[1]. The risk calculations summarized in Section 4.2.4.1 and presented in Appendix H demonstrate that soils at the four SWMUs/AOCs would not produce any unacceptable risks to human health (i.e., above the RAO) from ingestion, dermal contact and inhalation under any current or likely future scenarios.

Compliance with ARARs

There are no chemical-specific ARARs for soils. The soils environmental remedial action objective is protection of groundwater (i.e., preventing migration of contaminants that would result in groundwater contamination in excess of groundwater ARARs). The fate and transport analysis described in Section 1.4 indicated that the four SWMUs/AOCs are not continuing sources of groundwater contamination. Regardless, Olin is required to attain chemical-specific groundwater ARARs (the RCRA permit

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[1] Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

limits, MCLs) with the CAP. Each of the soil alternatives could be implemented to comply with the action-specific ARARs. There are no known location-specific ARARs for OU-1 soils.

Long-Term Effectiveness and Permanence

All of the assembled soil alternatives would provide adequate long-term effectiveness and permanence because no unacceptable risks to human health and the environment were identified with the no action alternative. Alternative C2 would be most effective at ensuring continued protectiveness because it provides improved containment at the sanitary landfills, the lime ponds and the well sand residue area. Alternative C1 would be only sightly less effective because it does not include containment of the well sand residue area. Containment of the well sand would provide marginal, if any, added protection because it is a cemented material with mercury bound in the matrix. Alternatives B1 and B2 would also be effective at ensuring conditions would not change with the cap inspection/maintenance programs and expanded groundwater monitoring programs. Alternative B1, which includes groundwater monitoring in the vicinity of the lime ponds and the mercury cell plant, provides minimal, if any, increased effectiveness over Alternative B2. It would be very difficult to distinguish contamination due to past releases from a continuing release resulting from the lime ponds or the mercury cell plant area, and the mercury cell plant and lime ponds are already within the compliance boundaries of the existing RCRA monitoring programs. The additional surface water sampling in the vicinity of the sanitary landfills would also have limited effectiveness, because a sample is already collected downstream, prior to the runoff entering the wastewater ditch.

Based on the above analysis, the rating of these alternatives against the long-term effectiveness and permanence criteria is as follows:

- Soil Alternatives C1 and C2 were given a rating score of 5.
- Soil Alternatives B1 and B2 were given a rating score of 4.
- Alternative A was given a rating score of 3.

Reduction of Mobility, Toxicity, and Volume

Alternatives C1 and C2 would result in the greatest reduction in mobility due to the improved capping. Alternative C2 would provide a slightly greater reduction than C1 due to containment of the well sand material, although any reduction would be marginal, as discussed above. Alternatives B1 and B2 include cap maintenance programs to ensure that no increase in mobility would occur; therefore, they were rated higher than no action against this criteria. None of the alternatives would reduce the toxicity or volume of contaminants.

Based on the above analysis, the rating of these alternatives against the criteria of mobility, toxicity, and volume reduction is as follows:

- Alternative C2 was given a rating score of 4.
- Alternative C1 was given a rating score of 3.
- Soil Alternatives B1 and B2 were given a rating score of 2.
- Alternative A was given a rating score of 1.

Short-Term Effectiveness

None of the alternatives would have a high potential for short-term adverse effects, because there would be minimal direct handling of contaminated material. Alternatives C1 and C2 would have the greatest potential for short-term effects because of potential hazards associated with earthwork for construction of the caps. The short-term effects would be slightly greater for Alternative C2 due to the loading, transporting and disposal of the well sand. There would be some potential for short-term adverse effects from worker exposure during well installation and sampling with all the alternatives, which would be greater for B2, where wells would be situated in the interior of the contaminant plume. Well installation for Alternatives B1 and B2 would take approximately 1 to 2 months from the start of construction. The containment

alternatives (C1 and C2) could be implemented within about 6 to 8 months from the start of construction.

Based on the above analysis, the rating of these alternatives against the short-term effectiveness criteria is as follows:

- Alternatives A and B1 were given a rating score of 5.
- Alternatives B2 and C1 were given a rating score of 4.
- Alternative C2 was given a rating score of 3.

Implementability

None of the alternatives would be difficult to implement. The multimedia cap over the lime ponds associated with C1 and C2 would be the most difficult to implement of the alternatives' components. The maintenance and monitoring programs associated with the institutional alternatives could be easily implemented, with B2 somewhat more difficult than B1.

Based on the above analysis, the rating of these alternatives against the implementability criteria is as follows:

- Alternatives A and B1 were given a rating score of 5.
- Alternative B2 was given a rating score of 4.
- Alternatives C1 and C2 were given a rating score of 3.

Cost

The estimated costs for the soils alternatives for the sanitary landfills, lime ponds, mercury cell plant and well sand residue area are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative A: No Action	0	0	0
Alternative B1	244,000	2,619,000	2,863,000
Alternative B2	527,000	3,219,000	3,746,000
Alternative C1	4,157,000	2,619,000	6,796,000
Alternative C2	4,430,000	2,619,000	7,069,000

Based on the above analysis, the rating of these alternatives against the cost criteria is as follows:

- Alternative A (no action with continuation of the existing CAP) was given a rating score of 5.
- Alternative B1 was given a rating score of 4.
- Alternative B2 was given a rating score of 3
- Alternative C1 was given a rating score of 2
- Alternative C2 was given a rating score of 1.

4.3.5 OU-2 Basin Sediment

A comparative analysis of the OU-2 basin sediment alternatives is presented in this section and summarized in Table 4-11.

Overall Protection of Human Health and the Environment

All total excess lifetime cancer risks and hazard indexes for the receptors with potential exposure to the basin (sediment, surface water and fish) were below the risk-based remedial action objectives, and therefore, based on the risk assessment, remedial action

would not be required to satisfy the criteria of overall protection of human health. The RI did not identify appreciable ecological risks. Since the sources of the site constituents of concern have been effectively eliminated, maximal impacts and risks probably have already occurred and the basin ecosystem is probably in a state of natural recovery.

All alternatives are considered protective. For the no action alternative, it is noted that the baseline risk assessment was developed from a single sampling event, and monitoring may be required (fish and sediment) to confirm protectiveness and establish that no unexpected future increase in risks would occur.

Compliance with ARARs

The state and federal water quality criteria were identified as potential ARARs. For mercury, these criteria range from 0.012 μg/l (freshwater chronic) to 2.4 μg/l (freshwater acute). The potential to meet these criteria is uncertain and it may be technically impracticable from an engineering perspective. Backfilling (Alternative C) would reduce exposure of contaminated basin sediments to surface water and significantly reduce the potential for exceedances of state and federal water quality criteria in the former basin area. There would, however, be a potential for exceedances of the criteria in other areas of OU-2 and exceedances in the basin may occur during construction. With any dredging operation (Alternatives D, E1 and E2) there would be residual contamination due to resuspension, and as indicated by the elutriate mercury analyses, there is a potential for dredging to cause dissolution of mercury in the water column.

Each of the alternatives could be implemented to comply with the identified action-specific and location-specific ARARs. Compliance with Section 404 of the Clean Water Act, and compliance with the Endangered Species Act may be critical in the implementation of Alternatives C, D, E1 and E2. Historic sites may be present on the bluff, which could affect implementation of Alternatives C, E1 and E2.

Long-Term Effectiveness and Permanence

Backfilling (Alternative C) would afford the highest degree of long-term effectiveness and permanence. A majority of the contaminated sediments would be covered by backfill material, eliminating exposure of the biota in the covered areas. The preliminary results of the hydrodynamic survey indicate that the basin is a depositional system, and it would take an unexpected change in the natural hydrodynamic conditions to cause erosion of the backfill. Wetlands would be established in the capped area over the long term, which should result in a long-term healthy ecosystem.

Alternatives E1 and E2 (dredging/disposal) would provide the next greatest degree of long-term effectiveness and permanence. Although these alternatives involve removal of contaminated sediments from the basin ecosystem, they are considered less effective and permanent than Alternative C, because with any dredging alternative there would be residual contamination due to resuspension of suspended sediments. Also, the long-term benefits to the basin ecosystem would be questionable, because there would be a complete alteration of the basin bathymetric profile, eliminating the shallow margin habitats. Although Alternative C would also alter the existing habitat, wetlands would be established, which would have equal or greater value over the long term.

Alternative D would involve dredging contaminated sediments to the deepest portion of the basin and then capping the sediments with additional dredged material. Over the long term, this alternative is considered less effective and permanent than Alternatives C, E1 or E2, because the dredged contaminated material would be covered by the low-density sediments from the basin. Some residual contamination would be expected because of resuspension of sediments. Similar to Alternatives E1 and E2, the long-term benefits to the basin ecosystem would be questionable because of the change in the bathymetric profile.

Alternatives A and B (no action and institutional actions, respectively) would rely on natural recovery of the basin ecosystem for long-term effectiveness. Alternative B would also include monitoring of the sediments and fish to evaluate the rate and magnitude of the recovery. The RI data indicated that the basin is relatively healthy, and since the sources have been removed, there should be a general improvement in the basin

ecosystem. Alternatives A and B would not have the long-term adverse impacts of altering the existing habitats in the basin ecosystem.

Based on the above analysis, the rating of these alternatives against the long-term effectiveness and permanence criteria is as follow:

- Alternative C was given a rating score of 5.
- Alternative B was given a rating score of 4.
- Alternatives E1 and E2 were given a rating score of 3.
- Alternatives A (no-action) and D were given a rating score of 2.

Reduction of Mobility, Toxicity, or Volume

Alternatives C, D, E1 and E2 would all reduce the mobility of the constituents. Alternative C would be most effective at reducing mobility, because with each of the other alternatives (dredging), the residual contamination from resuspension could possibly be mobilized. The dredging and removal alternatives (E1 and E2) would result in a decreased volume of contaminated sediments in the basin. Alternatives that utilize containment to isolate contaminants (Alternatives C and D) are considered appropriate because exposure of biota to contaminants was the only potential long-term threat identified for the basin sediments.

For Alternatives A and B there would be some reduction in mobility and bioavailability because of natural recovery of the system.

Based on the above analysis, the rating of these alternatives against the criteria of mobility, toxicity, and volume reduction is as follows:

- Alternative C was given a rating score of 5.

- Alternatives D, E1 and E2 were given a rating score of 4.

- Alternatives A and B were given a rating score of 2.

Short-Term Effectiveness

Backfilling (Alternative C) would have the greatest short-term adverse impacts, because the deep water habitat of the basin and the adjacent upland habitat would be completely altered. There would also be potential for sediment transport to the river during implementation. The dredging alternatives (Alternatives D, E1 and E2) would cause a virtual removal of the benthic community, and a large percentage of the aquatic organisms would be destroyed. With dredging, there would also be potential for sediment transport to the river. Dredging would probably cause short-term increases in fish tissue concentrations because of resuspension and dissolution of contaminants in the water column. There would be little or no short-term adverse effects associated with Alternatives A and B.

It is estimated that the covering alternative (Alternative D) could be completed about one year from start of construction. The estimated construction period for backfilling (Alternative C) is two years (i.e., two non-flood seasons). The dewatering alternatives (Alternative E1 and E2) would take between 30 months and 5 years because of the time required to construct the disposal units and, in the case of Alternative E2, dewater and close the CDF.

Based on the above analysis, the rating of these alternatives against the short-term effectiveness criteria is as follows:

- Alternative A (no action) and Alternative B were given a rating score of 5.

- Alternatives D, E1 and E2 were given a rating score of 2.

- Alternative C was given a rating score of 1.

Implementability

Alternative D would be difficult to implement and would require specialized contractors and equipment for the subaqueous capping. Pilot-scale testing would be required to better define feasibility and the appropriate equipment and procedures. Alternatives E1 and E2 would use more standard construction practices for the dredging and dewatering. However, these alternatives would also be difficult to implement because of the large volume of sediments (an estimated 340,000 cubic yards) that would be dredged and dewatered. The sediments are saturated and very fine-grained and would not easily dewater for either alternative.

The implementability of Alternative C is uncertain because of the potential problems associated with backfilling over the soft sediments in the basin. Pilot-scale testing would be required. If the pilot testing confirms the feasibility, the alternative would be implemented with standard equipment and construction practices.

Alternative B could be easily implemented.

Based on the above analysis, the rating of these alternatives against the implementability criteria is as follows:

- Alternative A (no action) and Alternative B were given a rating score of 5.
- Alternative C was given a rating score of 3 (assuming the pilot-scale testing confirms the feasibility).
- Alternatives E1 and E2 were given a rating score of 2.
- Alternative D was given a rating score of 1.

Cost

The estimated costs for the OU-2 basin sediment alternatives are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative A (No Action)	0	0	0
Alternative B	211,000	2,383,000	2,594,000
Alternative C	13,871,000	0	13,871,000
Alternative D	13,740,000	1,243,000	14,983,000
Alternative E1	55,600,000	1,891,000	57,491,000
Alternative E2	49,770,000	2,198,000	51,968,000

Based on the above analysis, the rating of these alternatives against the cost criteria is as follows:

- Alternative A was given a rating score of 5.
- Alternative B was given a rating score of 4.
- Alternatives C and D were given a rating score of 3.
- Alternatives E1 and E2 were given a rating score of 1.

4.3.6 OU-2 Wastewater Ditch

A comparative analysis of the OU-2 wastewater ditch sediment alternatives is presented in this section and summarized in Table 4-12. The three retained alternatives were compared against the no action alternative. OU-2 Sediment Alternative B (institutional actions) primarily addresses the basin area and was evaluated in Section 4.3.5.

Overall Protection of Human Health and the Environment

All the alternatives (including no action) are considered protective of the environment. The wastewater ditch sediments were not identified as a human health risk, and the wastewater ditch is not considered a significant ecological habitat. The assembled alternatives would provide additional protectiveness by reducing the potential for contaminant transport down the ditch.

Compliance With ARARs

The wastewater ditch is used to route Olin's wastewater and stormwater, and the NPDES discharge permit limits that Olin currently complies with are potential ARARs. All the wastewater ditch sediment alternatives could be implemented to comply with the identified action- and location-specific ARARs. Compliance with Section 404 of the Clean Water Act may be critical in the implementation of Alternatives C1, E and G1.

Long-Term Effectiveness and Permanence

Alternatives E and G1 would provide equal long-term effectiveness and permanence because the contaminated soils would be removed from the ditch. Alternative C1 would also be effective, but the sediments would be contained rather than removed. Additional engineering would be required for C1 to demonstrate permanence (i.e., ensure that hydraulic conditions would not cause erosion of the buried sediments).

Based on the above analysis, the rating of these alternatives against the long-term effectiveness and permanence criteria is as follows:

- Alternatives E and G1 were given a rating score of 5.
- Alternative C1 was given a rating score of 3.
- The no action alternative (Alternative A) was given a rating score of 1.

Reduction of Mobility, Toxicity and Volume

Alternative G1 would provide the greatest reduction in mobility and toxicity because the contaminants would be destroyed. For Alternative E, contaminants would be removed and placed in a landfill, where the mobility would be reduced, but there would be no reduction in toxicity or volume with off-site landfilling. Alternative C1 would provide sufficient reduction in mobility because backfilling would prevent sediment transport. There would be no reduction in mobility, toxicity or volume for the no action alternative.

Based on the above analysis, the rating of these alternatives against the criteria of mobility, toxicity, and volume reduction is as follows:

- Alternative G1 was given a rating score of 5.
- Alternatives C1 and E were given a rating score of 4.
- The no action alternative (Alternative A) was given a rating score of 1.

Short-Term Effectiveness

Alternatives that include excavation (Alternatives E and G1) would have the greatest short-term adverse impacts because they would disturb the contaminated sediment, with potential transport occurring down the wastewater ditch during construction. The short-term adverse effects for the on-site thermal treatment alternative (Alternative G1) would be greater than for disposal (Alternative E) because of the additional material handling and the potential for emissions during treatment. Alternative E would have the potential for short-term risks to the public from spills during off-site transportation. There would be fewer short-term adverse effects with Alternative C1 because the contaminated sediments would not be handled.

It is estimated that backfilling (Alternative C1) and excavation and disposal (Alternative E) would take approximately 15 months for construction. The estimated time for implementing Alternative G1, which includes on-site thermal treatment, is 48 months.

Based on the above analysis, the rating of these alternatives against the short-term effectiveness criteria is as follows:

- The no-action alternative was given a rating of score of 5.
- Alternative C1 was given a rating score of 4.
- Alternative E was given a rating score of 2.
- Alternative G1 was given a rating score of 1.

Implementability

The excavation and on-site thermal treatment alternative (Alternative G1) would be the most difficult to implement. Excavation would have to be conducted during a relatively dry period, and/or engineering controls would be required to divert the stormwater from the excavation areas. Thermal treatment is a complex operation that would require specialized staff and equipment and stringent monitoring. Disposal after excavation (Alternative E) would be more readily implementable than thermal treatment, but would be subject to the same restrictions and controls as excavation, as well as require transportation to the disposal facility.

Backfilling (Alternative C1) would be easier to implement than excavation. It would not involve direct handling of the contaminated sediments and would not be as affected by stormwater, because the material adjacent to the ditch would be handled rather than the saturated, contaminated wastewater ditch sediments. Proper routing of the newly constructed ditch would be an implementability consideration.

Based on the above analysis, the rating of these alternatives against the implementability criteria is as follows:

- Alternative A (no action) was given a rating score of 5.
- Alternative C1 was given a rating score of 4.

- Alternative E was given a rating score of 2.
- Alternative G1 was given a rating score of 1.

Cost

The estimated costs for the OU-2 wastewater ditch alternatives are summarized below:

Alternative	Capital Cost ($)	Present Worth O&M Cost ($)	Total Present Worth Cost ($)
Alternative A (No Action)	0	0	0
Alternative C1	4,208,000	384,000	4,592,000
Alternative E	40,793,000	0	40,793,000
Alternative G1	84,752,000	778,000	85,530,000

Based on the above analysis, the rating of these alternatives against the cost criteria is as follows:

- The no action alternative was given a rating score of 5.
- Alternative C1 was given a rating score of 4.
- Alternatives E and G1 were given a rating score of 1.

4 9 0310

TABLES

TABLE 4-1

SUMMARY OF DETAILED ANALYSIS
OU-1 GROUNDWATER

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative A: No Action with Continuation of the Existing RCRA CAP	Protective. Olin is committed by the legally enforceable RCRA post-closure permit to operate the CAP until the established clean-up standards are achieved. Controls off-site migration.	Complies: RCRA permit levels, MCLs and MCLGs are chemical-specific ARARS. System as implemented complies with action-specific ARARs. There are no known location-specific ARARs for OU-1 groundwater.	Effective over long term. Permanence dependent on residual contamination remaining after post-closure objectives are achieved.	Reduces toxicity, mobility and volume in the aquifer. Contaminants are transferred to air and carbon. Disposal of carbon reduces mobility.	No short-term adverse effects.	Already Implemented	None
Alternative C1: Extraction/ Treatment/ Discharge (Vertical Extraction Wells)	Protective: Adds to protectiveness of existing CAP with accelerated contaminant removal. Would control off-site migration.	Would Comply: Would reduce time period for compliance with chemical-specific ARARs. System would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 groundwater.	Effective over long term. Permanence dependent on effectiveness at remediating potential source areas.	Reduces toxicity, mobility and volume in the aquifer. Contaminants would be transferred to air and carbon. Disposal of carbon reduces mobility.	Minimal short term adverse effects from potential worker exposure during well installation. Human health risks from exposure during sampling/operation and volatile emissions are considered negligible.	Vertical extraction wells are readily implementable as demonstrated by the existing CAP. Treatability testing may be required to design TDS treatment.	$3,926[1]

4 6 0671

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TABLE 4-1 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 GROUNDWATER

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C3: Extraction/ Treatment/ Discharge (Vertical and Horizontal Extraction Wells)	Protective: Adds to protectiveness of existing CAP with accelerated contaminant removal. Would control off-site migration.	Would Comply: Would reduce time period for compliance with chemical-specific ARARs. Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 groundwater.	Effective over long term. Permanence dependent of effectiveness at remediating potential source areas.	Reduces toxicity, mobility and volume in aquifer. Contaminants would be transferred to air and carbon. Disposal of carbon reduces mobility.	Minimal short term adverse effects from potential worker exposure during well installation. Human health risks from exposure during sampling/operation and volatile emissions are considered negligible.	Vertical extraction well would be readily implementable. Horizontal extraction wells are implementable but require specialized equipment and contractors. Treatability testing may be required to design TDS treatment.	$4,570

NOTES:

1 Treatment for TDS may be required to meet the NPDES permit limits. The cost for reverse osmosis is not included at this time. Preliminary discussions with vendors have indicated it would be very expensive (about 20 to 30 million dollars present worth cost over a 30-year operation period). Olin is continuing to evaluate other options such as recycling the discharge from the carbon adsorber and the air stripper to the brine system of the chlorine plant.

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TABLE 4-2

SUMMARY OF DETAILED ANALYSIS
OU-1 SOIL
OLD PLANT (CPC) LANDFILL

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C: Containment (Improved Capping)	Protective: Most areas beneath the landfill showed concentrations that were below the recommended preliminary soil action levels (PSALs), indicating only localized areas may be a continuing source. Would reduce infiltration to groundwater. - The HELP model indicated that there would be an estimated 98% reduction in infiltration as compared to existing conditions.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Permanence would depend on cap maintenance.	Mobility to groundwater would be reduced with reduced infiltration. No reduction in toxicity or volume.	There would be little to no adverse short-term effects. The existing clay cover would not be removed completely to prevent worker exposure.	Readily implementable: The technology is well demonstrated and could be implemented with standard construction equipment and practices.	$2,164

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TABLE 4-2 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
OLD PLANT (CPC) LANDFILL

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative D: In Situ Stabilization-Solidification/ Containment	Protective: Most areas beneath the landfill showed concentrations that were below the recommended preliminary soil action levels (PSALs), indicating only localized areas may be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants would be permanently immobilized.	Reduction in mobility by reduced infiltration and stabilization/solidification of residual contamination. Volume increase would occur due to addition of reagent. No significant reduction in toxicity Satisfies the statuary preference of using treatment as a principal component.	Potential adverse short-term adverse effects to workers from intrusive activity and dust generation. Short-term adverse effects are not expected for area residents.	Based on existing information, could be implemented with moderate-to-high difficulty. Obstructions may hinder productivity and implementability. Bench-scale testing and additional characterization required.	$16,155

TABLE 4-2 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
OLD PLANT (CPC) LANDFILL

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative E: Excavation/ Stabilization-Solidification/ Containment	Protective: Most areas beneath the landfill showed concentrations that were below the recommended preliminary soil action levels (PSALs), indicating only localized areas may be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants would be permanently immobilized.	Reduction in mobility by reduced infiltration and stabilization/solidification of residual contamination. Volume increase would occur due to addition of reagent. No significant reduction in toxicity Satisfies the statuary preference of using treatment as a principal component.	Potential short-term adverse effects to workers from exposure during excavation and handling of material and dust generation during in situ S/S. Minimal potential off-site adverse effects with proper excavation and engineering controls.	Moderately difficult to implement. Excavation difficulties may occur due to debris in landfill and proximity of surrounding structures. Bench-scale testing and additional characterization required.	$30,089

4 9 0373

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TABLE 4-2 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
OLD PLANT (CPC) LANDFILL

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative F: Excavation/ Off-Site RCRA Disposal	Protective: Most areas beneath the landfill showed concentrations that were below the recommended preliminary soil action levels (PSALs), indicating only localized areas may be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants in upper 15 feet would be removed from the site. Permanent immobilization of contamination in residual material (15 to 30 feet)	Volume of waste on-site would be reduced. Reduction in mobility by reduced infiltration and stabilization/solidification of residual contamination from 15 to 30 feet. No reduction in toxicity of material.	Potential short-term adverse effects to workers from exposure during excavation and handling of material and dust generation during in situ S/S. Minimal potential off-site adverse effects with proper excavation and engineering controls. Potential for short-term risks to public from spills during off-site transportation.	Moderately difficult to implement due to excavation and in situ stabilization/solidification. Excavation difficulties may occur due to debris in landfill and proximity of surrounding structures. Bench-scale testing for in situ stabilization/ solidification and additional characterization required.	$73,347

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TABLE 4-2 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
OLD PLANT (CPC) LANDFILL

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative G1: Excavation/ On-Site Thermal Treatment/ Disposal	Protective: Most areas beneath the landfill showed concentrations that were below the recommended preliminary soil action levels (PSALs), indicating only localized areas may be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants in upper 15 feet would be permanently destroyed. Permanent immobilization of contamination in residual material (15 to 30 feet).	Reduction in toxicity/mobility and volume of contaminated material in upper 15 feet with thermal treatment. Reduction in mobility of residual contamination Satisfies the statuary preference of using treatment as a principal component.	Potential short-term adverse effects to workers from exposure during excavation and handling of material and dust generation during in situ S/S. Minimal potential off-site adverse effects with proper excavation and engineering controls. Potential risk to workers during operation of incinerator due to high operating temperatures and complexity of equipment. Potential air emissions could temporarily affect air quality.	Difficult to implement. Bench-scale testing and additional characterization required. Excavation difficulties may occur due to debris in landfill and proximity of surrounding structures. Incinerator is complex technology, requires highly-skilled personnel. A long lead time may be required due to incinerator availability.	$108,908

TABLE 4-3

SUMMARY OF DETAILED ANALYSIS
OU-1 SOIL
AREA WEST OF FORMER CPC PLANT

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C: Containment (Extend Existing Cap)	Protective: Soil concentrations were below the recommended preliminary soil action levels (PSALs), indicating a low potential for the soils to be a continuing source. Would reduce infiltration to groundwater. - The HELP model indicated that there would be an estimated 62.5% reduction in infiltration as compared to existing conditions.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Permanence would depend on cap maintenance.	Mobility to groundwater would be reduced with reduced infiltration. No reduction in toxicity or volume.	There would be little to no adverse short-term effects.	Readily implementable: The technology is well demonstrated and could be implemented with standard construction equipment and practices.	$379

NOTES:

1 Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. All of the recalculated PSALs from the PESTAN model are significantly above the concentrations detected in the soils indicating that remedial action is not required for protection of groundwater (See Table 2-9).

4 9 0375

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TABLE 4-3 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
AREA WEST OF FORMER CPC PLANT

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative D: In Situ Stabilization-Solidification/ Containment	Protective: Soil concentrations were below the recommended preliminary soil action levels (PSALs), indicating a low potential for the soils to be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants would be permanently immobilized.	Reduction in mobility by reduced infiltration and stabilization/solidification of residual contamination. Volume increase would occur due to addition of reagent. No significant reduction in toxicity Satisfies the statuary preference of using treatment as a principal component.	Potential adverse short-term adverse effects to workers from intrusive activity and dust generation. Short-term adverse effects are not expected for area residents.	Based on existing information, could be implemented with moderate difficulty. Bench-scale testing and additional characterization required.	$1,307

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TABLE 4-3 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
AREA WEST OF FORMER CPC PLANT

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative E: Excavation/ Stabilization-Solidification/ Containment	Protective: Soil concentrations were below the recommended preliminary soil action levels (PSALs), indicating a low potential for the soils to be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants would be permanently immobilized.	Reduction in mobility by reduced infiltration and stabilization/solidification of residual contamination. Volume increase would occur due to addition of reagent. No significant reduction in toxicity Satisfies the statuary preference of using treatment as a principal component.	Potential short-term adverse effects to workers from exposure during excavation and handling of material and dust generation during in situ S/S. Minimal potential off-site adverse effects with proper excavation and engineering controls.	Moderately difficult to implement. Excavation may be difficult because the work would be in a relative confined area and an adjacent railroad track would have to be either removed or protected. Bench-scale testing required.	$2,348

4 9 0376

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TABLE 4-3 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
AREA WEST OF FORMER CPC PLANT

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative F: Excavation/ Off-Site RCRA Disposal	Protective: Soil concentrations were below the recommended preliminary soil action levels (PSALs), indicating a low potential for the soils to be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants in upper 14 feet would be removed from the site.	Volume of contaminated soil on-site would be reduced. Contaminated soil would be disposed of in an off-site landfill where mobility would be reduced. No reduction in toxicity.	Potential short-term adverse effects to workers from exposure during excavation and handling of material. Potential for short-term risks to public from spills during off-site transportation.	Moderately difficult to implement. Excavation may be difficult because the work would be in a relative confined area and an adjacent railroad track would have to be either removed or protected.	$7,560

TABLE 4-3 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
AREA WEST OF FORMER CPC PLANT

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative G1: Excavation/ On-Site Thermal Treatment/ Disposal	Protective: Soil concentrations were below the recommended preliminary soil action levels (PSALs), indicating a low potential for the soils to be a continuing source. Would reduce further degradation of the Alluvial Aquifer.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would result in reduction in rate of infiltration to the groundwater. Contaminants in upper 14 feet would be permanently destroyed.	Reduction in toxicity/mobility and volume of contaminated material. Satisfies the statuary preference of using treatment as a principal component.	Potential short-term adverse effects to workers from exposure during excavation and handling of material. Potential risk to workers during operation of incinerator due to high operating temperatures and complexity of equipment. Potential air emissions could temporarily affect air quality.	Difficult to implement. Bench-scale testing required. Excavation may be difficult because the work would be in a relative confined area and an adjacent railroad track would have to be either removed or protected. Incinerator is complex technology, requires highly-skilled personnel. A long lead time may be required due to incinerator availability.	$14,177

4 6 0377

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TABLE 4-4

SUMMARY OF DETAILED ANALYSIS
OU-1 SOIL
SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative A: No Action	Protective: The fate transport analysis, which was conducted without consideration of the existing caps, shows that the four SWMUs/AOCs are not continuing sources of groundwater contamination. Risk calculations indicate that the soils would provide continued protection of human health from ingestion, direct contact and inhalation hazards for any current or likely future conditions. Any unacceptable surface water runoff would from these SWMUs/AOCs would be detected with the existing NPDES and stormwater monitoring programs.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Olin currently complies with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would provide long-term effectiveness and permanence because no unacceptable risks to human health and the environment were identified, and even without the existing institutional actions (e.g., caps and monitoring) conditions should remain protective.	No reduction in toxicity or mobility.	No short term adverse effects.	Implementation is not required.	None

4 6 0578

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TABLE 4-4 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative B1: Institutional Actions (Cap Inspection/ Maintenance, Groundwater Monitoring near Sanitary Landfills)	Protective: Would provide added protection (over no action) by ensuring continued maintenance of the caps. Groundwater monitoring would be extended to the sanitary landfill area where currently there is not routine monitoring.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would provide some added long-term effectiveness (over no action) by ensuring that conditions do not change (i.e., risk do not increase). The alternative is considered permanent even though it includes long-term maintenance and monitoring programs because no unacceptable risks to human health and the environment were identified with the no action alternative.	No reduction in toxicity, mobility, or volume. The cap maintenance programs would ensure that the mobility of constituents would not increase.	There would be little to no short-term adverse effects	Could be easily implemented.	$2,863

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TABLE 4-4 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative B2: Institutional Actions (Cap Inspection/ Maintenance, Expanded Groundwater and Surface Water Monitoring)	Protective: Would provide added protection (over no action) by ensuring continued maintenance of the caps. Groundwater monitoring would be extended to the sanitary landfill area where currently there is not routine monitoring.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would provide some added long-term effectiveness (over no action) by ensuring that conditions do not change (i.e., risk do not increase). The alternative is considered permanent even though it includes long-term maintenance and monitoring programs because no unacceptable risks to human health and the environment were identified with the no action alternative. Groundwater monitoring in the vicinity of the lime ponds and the mercury cell plant would have limited effectiveness. The additional surface water sampling would also have limited effectiveness	No reduction in toxicity, mobility, or volume. The cap maintenance programs would ensure that the mobility of constituents would not increase.	There would be little to no short-term adverse effects	Could be easily implemented.	$3,746

4 6 0579

Woodward-Clyde

TABLE 4-4 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C1: Containment (Sanitary Landfills and Lime Ponds)/ Institutional Actions	Protective: Would provide added protection (over no action) with more competent physical barriers over the sanitary landfill soils and the lime ponds. Would provide added protection (over no action) by ensuring continued maintenance of the caps. Groundwater monitoring would be extended to the sanitary landfill area where currently there is not routine monitoring.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would provide some added long-term effectiveness (over no action) with construction of the caps and the monitoring/ maintenance programs by ensuring that conditions do not change	Mobility would be reduced due to the improved caps. There would be no reduction in toxicity or volume of contamination.	There would be little to no short-term adverse effects	Readily implementable.	$6,796

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TABLE 4-4 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-1 SOILS
SANITARY LANDFILLS, LIME PONDS, MERCURY CELL PLANT AND WELL SAND RESIDUE AREA

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C2: Consolidation/ Containment (Sanitary Landfills, Lime Ponds and Well Sand Residue Area)/Institutional Actions	Protective: Would provide added protection (over no action) with more competent physical barriers over the sanitary landfill soils and the lime ponds, and containment of the well sand residue. Would provide added protection (over no action) by ensuring continued maintenance of the caps. Groundwater monitoring would be extended to the sanitary landfill area where currently there is not routine monitoring.	Would Comply: Implemented in conjunction with the RCRA CAP would comply with chemical-specific ARARs for Groundwater (See Table 4-1). Would be implemented to comply with action-specific ARARs. There are no known location-specific ARARS for OU-1 soils.	Would provide some added long-term effectiveness (over no action) with construction of the caps and the monitoring/ maintenance programs by ensuring that conditions do not change. Containment of the well sand would provide marginal, if any, added effectiveness because it is a cemented material with mercury bound in the matrix.	Mobility would be reduced due to the improved caps. There would be no reduction in toxicity or volume of contamination.	There would be little to no short-term adverse effects	Readily implementable.	$7,069

4 9 0 3 3 0

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TABLE 4-5

SUMMARY OF DETAILED ANALYSIS
OU-2 BASIN SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative A: No Action	Protective. Calculated human health risks were below RAOs and no appreciable ecological risks were identified. Monitoring may be required to demonstrate protectiveness.	Compliance uncertain. Constituent concentrations in surface water may exceed federal and state water quality criteria. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. Complies with the identified location-specific ARARs.	Dependent on the effectiveness and rate of natural recovery. There should be reduction in risks over long term with natural recovery of system.	Possible reduction in mobility with natural sedimentation. No reduction in inherent toxicity or volume.	No short-term effects.	No implementation required.	None
Alternative B: Institutional Actions	Protective. Calculated human health risks were below RAOs and no appreciable ecological risks were identified.	Compliance uncertain. Constituent concentrations in surface water may exceed federal and state water quality criteria. A waiver may be justified as it may not be technically practical to meet the water quality criteria. Would be implemented to comply with action- and location- specific ARARs.	Long-term effectiveness of institutional actions would be dependent on continued implementation by Olin. There should be reduction in risks over long term with natural recovery of system.	Possible reduction in mobility with natural sedimentation. No reduction in inherent toxicity or volume.	Little to no short-term effects.	Readily Implementable.	$3,594

Woodward-Clyde

TABLE 4-5 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-2 BASIN SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C: Backfilling	Protective. Calculated human health risks were below RAOs and no appreciable ecological risks were identified. Added protectiveness to human health by eliminating exposure to fish. Potential ecological risks would decrease with establishment of new wetlands habitat.	Compliance uncertain. Would eliminate exposure of contaminated basin sediments to surface water. Constituent concentrations in surface water may exceed federal and state water quality criteria in other areas of OU-2. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. Would be implemented to comply with action- and location-specific ARARs. Compliance with Section 404 of the Clean Water Act, and compliance with the Endangered Species Act may be critical in the implementation of this alternative.	Fish ingestion pathway from the basin would be eliminated. There should be a long-term healthy ecosystem with minimal potential effects from site constituents. Based on preliminary results of hydrodynamic survey, the basin is interpreted to be a depositional area. Would take an unexpected change in natural hydrodynamic conditions to cause erosion.	The basin sediments would be contained, decreasing mobility. No reduction in toxicity or volume.	Extensive short-term effects. The deep water habitat of the basin and the upland habitat of the bluff would be completely altered. Filling activities would mobilize constituents.	Implementability would be dependent on ability to cover basin sediments. Pilot-scale testing would be required to evaluate feasibility. Timing of construction would be dependent on uncertain flood patterns of the Tombigbee River.	$13,871

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TABLE 4-5 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-2 BASIN SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative D: Dredging/ Covering (Contained Aquatic Disposal)	Protective. Calculated human health risks were below RAOs and no appreciable ecological risks were identified. A majority of contaminated sediments would be isolated from aquatic environment resulting in a long-term reduction in fish tissue concentration, thus reducing human health risk. The potential benefits to the ecosystem are questionable.	Compliance uncertain. Constituent concentrations in surface water may exceed federal and state water quality criteria. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. Would be implemented to comply with action- and location-specific ARARs. Compliance with Section 404 of the Clean Water Act, and compliance with the Endangered Species Act may be critical in the implementation of this alternative.	Long-term reduction in fish tissue concentrations. Long-term benefit to ecosystem is questionable. Resuspension/dissolution would occur during dredging, leaving residual contamination. Based on preliminary results of the hydrodynamic survey, the basin is interpreted to be a depositional area. The cover only would be subject to disruption with change in hydrodynamic conditions.	The basin sediments would be contained, decreasing mobility. No reduction in toxicity or volume.	Extensive short-term effects. The entire benthic community and a large percentage of other aquatic organisms would be destroyed by the dredging. Probable short-term increase in fish tissue concentrations. With resuspension, potential for contaminant migration out of the basin.	Subaqueous capping would require specialized contractors. Implementation with minimal resuspension would be critical. Pilot-scale testing and detailed bathymetric profiling would be required. Additional sediment characterization would be required. Buried obstructions may be present that could hinder dredging operation and would require investigation. Timing of construction would be dependent on uncertain flood patterns of the Tombigbee River.	$14,983

4 6 0 3 8 2

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TABLE 4-5 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-2 BASIN SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative E1: Dredging/ Disposal (Mechanical Dewatering)	Protective. Calculated human health risks were below RAOs and no appreciable ecological risks were identified. A majority of contaminated sediments would be removed from the basin resulting in a long-term reduction in fish tissue concentration, thus reducing human health risk. The potential benefits to the ecosystem are questionable.	Compliance uncertain. Constituent concentrations in surface water may exceed federal and state water quality criteria. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. Would be implemented to comply with action- and location-specific ARARs. Compliance with Section 404 of the Clean Water Act, and compliance with the Endangered Species Act may be critical in the implementation of this alternative.	Long-term decrease in fish tissue concentrations. Long-term benefits to ecosystem are questionable. Resuspension/dissolution would occur during dredging, leaving residual contamination. The alternative would destroy an estimated 50 acres of terrestrial habitat adjacent to the basin for construction of the landfill.	Decrease in volume and toxicity in the basin. On-site disposal would decrease mobility. There may be some mobile constituents from resuspension/ dissolution	Extensive short-term effects. The entire benthic community and a large percentage of other aquatic organisms would be destroyed by the dredging. Probable short-term increase in fish tissue concentrations. With resuspension, potential for contaminant migration out of the basin. Piping and material handling related to mechanical dewatering could result in exposure to remedial workers and the environment.	Implementation with minimal resuspension would be critical. Buried obstructions may be present that could hinder dredging operation and would require investigation. Timing of construction would be dependent on uncertain flood patterns of the Tombigbee River. A long lead time would be required to construct landfill. Bench-scale testing would be required to select the appropriate dewatering equipment. Further characterization of the basin sediments would be required for volume estimates and to obtain additional information on the physical properties.	$57,491

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TABLE 4-5 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-2 BASIN SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative E2: Dredging/ Disposal (Confined Disposal Facility)	Protective. Calculated human health risks were below RAOs and no appreciable ecological risks were identified. A majority of contaminated sediments would be removed from the basin resulting in a long-term reduction in fish tissue concentration, thus reducing human health risk. The potential benefits to the ecosystem are questionable.	Compliance uncertain. Constituent concentrations in surface water may exceed federal and state water quality criteria. A waiver may be justified, as it may not be technically practical to meet the water quality criteria. Would be implemented to comply with action- and location- specific ARARs. Compliance with Section 404 of the Clean Water Act, and compliance with the Endangered Species Act may be critical in the implementation of this alternative.	Long-term decrease in fish tissue concentrations. Long-term benefits to ecosystem are questionable. Resuspension/dissolution would occur during dredging, leaving residual contamination. The alternative would destroy an estimated 50 acres of terrestrial habitat adjacent to the basin for construction of the landfill.	Decrease in volume and toxicity in the basin. On-site disposal would decrease mobility. There may be some mobile constituents from resuspension/ dissolution	Extensive short-term effects. The entire benthic community and a large percentage of other aquatic organisms would be destroyed by the dredging. Probable short-term increase in fish tissue concentrations. With resuspension, potential for contaminant migration out of the basin. There would be additional effects from control of run-on/run-off from the CDF. Potential worker exposure during stabilization/ solidification of CDF.	Implementation with minimal resuspension would be critical. Buried obstructions may be present that could hinder dredging operation and would require investigation. Timing of construction would be dependent on uncertain flood patterns of the Tombigbee River. A long lead time would be required to construct CDF. Additional sediment physical characterization, settling and consolidation tests would be required. CDF may be difficult to dewater.	$51,968

4 9 0 3 3

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TABLE 4-6

SUMMARY OF DETAILED ANALYSIS
OU-2 WASTEWATER DITCH SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative C1: Containment (Backfill)	Protective. The ditch sediments have not been identified as a human health risk and the wastewater ditch is not considered a significant ecological habitat. Would provide added protectiveness by covering contaminated sediments and reducing potential for exposure of biota.	Would Comply. Olin currently complies with NPDES permit limits for flow in ditch. Would be implemented to comply with action- and location- specific ARARs. Temporarily redirecting flow would require compliance with Olin's NPDES permit. Compliance with Section 404 of the Clean Water Act may be critical in the implementation of this alternative.	Would be effective at reducing risks to the environment by covering. An engineering evaluation would be required to ensure that hydraulic conditions would not cause erosion of the buried sediments.	Reduction in mobility of contaminants. No reduction in toxicity or volume.	Short-term adverse effects would be moderate. Potential short-term adverse effects from increased turbidity and the potential for sediment transport during storm events. Contaminated sediments would not be handled directly.	Implementable based on existing information. Additional engineering would be required to evaluate the hydrology for proper construction. The primary construction difficulties would be related to control of storm water and working on the floodplain.	$4,592

4 9 0 5 0 4

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TABLE 4-6 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-2 WASTEWATER DITCH SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative E: Excavation/ Disposal	Protective. The ditch sediments have not been identified as a human health risk and the wastewater ditch is not considered a significant ecological habitat. Would provide added protectiveness by removing contaminated sediments from the wastewater ditch.	Would Comply. Olin currently complies with NPDES permit limits for flow in ditch. Would be implemented to comply with action- and location- specific ARARs. Temporarily redirecting flow would require compliance with Olin's NPDES permit. Compliance with Section 404 of the Clean Water Act may be critical in the implementation of this alternative.	Permanent removal of contamination in wastewater ditch.	There would be a reduction in the toxicity and volume of contamination in the wastewater ditch. Contaminants would be transported to an off-site landfill where there would be a reduction in mobility.	Short-term adverse effects may be significant. Potential releases to environment from contaminated runoff. Transportation of contaminated sediments pose a short-term risk to the public from spills.	Moderately difficult to implement. Would require excavation of contaminated, saturated sediments. There would be construction difficulties related to control of stormwater runoff and working on the floodplain.	$40,793

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TABLE 4-6 (Continued)

SUMMARY OF DETAILED ANALYSIS
OU-2 WASTEWATER DITCH SEDIMENTS

Alternative	Overall Protection of Human Health and Environment	Compliance With ARARs	Long-Term Effectiveness and Permanence	Reduction of Mobility, Toxicity and Volume	Short-Term Effectiveness	Implementability	Present Worth Cost Estimate ($1,000)
Alternative G1: Excavation/ On-Site Thermal Treatment/ Disposal	Protective. The ditch sediments have not been identified as a human health risk and the wastewater ditch is not considered a significant ecological habitat. Would provide added protectiveness by removing contaminated sediments from the wastewater ditch.	Would Comply. Olin currently complies with NPDES permit limits for flow in ditch. Would be implemented to comply with action- and location- specific ARARs. Temporarily redirecting flow would require compliance with Olin's NPDES permit. Compliance with Section 404 of the Clean Water Act may be critical in the implementation of this alternative.	Permanent removal and destruction of contamination in wastewater ditch.	There would be a reduction in toxicity, mobility and volume of contamination with thermal treatment. Satisfies the statutory preference of using treatment as a principal component.	Short-term effects may be significant. Potential releases to environment from contaminated runoff. Potential risk to workers during operation of incinerator due to high operating temperatures and complexity of equipment. Potential air emissions could temporarily affect air quality.	Difficult to implement. Would require excavation of contaminated, saturated sediments. Incinerator is complex, requires highly-skilled personnel. A long lead time may be required due to availability of incinerator.	$85,530

4 9 0 3 3 5

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TABLE 4-7

OU-1 GROUNDWATER
SUMMARY OF COMPARATIVE ANALYSIS

4 9 0386

Criteria	No Action with Continuation of Existing CAP	OU-1 Groundwater Alternative	
	A	C1	C3
Overall Protection of Human Health and The Environment	Y	Y	Y
Compliance With ARARs	Y	Y	Y
Long-Term Effectiveness and Permanence	1	3	5
Reduction in Mobility, Toxicity or Volume	1	2	3
Short-Term Effectiveness	5	4	4
Implementability	5	4	3
Cost	5	4	4

NOTES:

Y = Would comply.

A rating of 5 shows the greatest relative performance against the criteria and a rating of 1 shows the least.

Alternative A - No Action With Continuation of Existing RCRA CAP
Alternative C1 - Extraction/Treatment/Discharge (Vertical Extraction Wells)
Alternative C3 - Extraction/Treatment/Discharge (Vertical and Horizontal Extraction Wells)

TABLE 4-8

OU-1 SOILS
OLD PLANT (CPC) LANDFILL
SUMMARY OF COMPARATIVE ANALYSIS

Criteria	No Action with Continuation of Existing CAP	OU-1 Soil Alternative				
	A	C	D	E	F	G1
Overall Protection of Human Health and The Environment	Y	Y	Y	Y	Y	Y
Compliance With ARARs	Y	Y	Y	Y	Y	Y
Long-Term Effectiveness and Permanence	1	2	4	5	5	5
Reduction in Mobility, Toxicity or Volume	1	2	4	4	4	5
Short-Term Effectiveness	5	5	3	1	2	1
Implementability	5	5	2	2	3	1
Cost	5	4	3	2	1	1

NOTES:

Y = Would comply.

A rating of 5 shows the greatest relative performance against the criteria and a rating of 1 shows the least.

Alternative C - Containment (Improve Capping)
Alternative D - In Situ Stabilization-Solidification/Containment
Alternative E - Excavation/Stabilization-Solidification/Containment
Alternative F - Excavation/Off-Site RCRA Disposal
Alternative G1 - Excavation/On-Site Thermal Treatment/Disposal

TABLE 4-12

OU-2 WASTEWATER DITCH SEDIMENTS SUMMARY OF COMPARATIVE ANALYSIS

Criteria	OU-2 Wastewater Ditch Sediment Alternative			
	A (No Action)	C1	E	G1
Overall Protection of Human Health and The Environment	Y	Y	Y	Y
Compliance With ARARs	Y	Y	Y	Y
Long-Term Effectiveness and Permanence	1	3	5	5
Reduction in Mobility, Toxicity or Volume	1	4	4	5
Short-Term Effectiveness	5	4	2	1
Implementability	5	4	2	1
Cost	5	4	1	1

NOTES:

Y = Would comply.

A rating of 5 shows the greatest relative performance against the criteria and a rating of 1 shows the least.

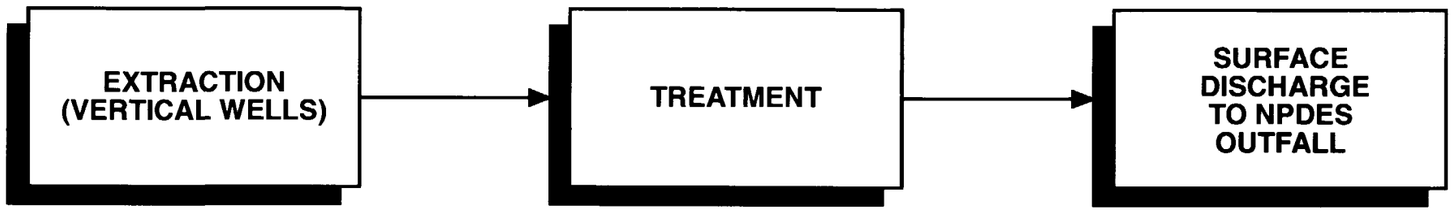
Alternative A - No Action
Alternative C1 - Containment (Backfill)
Alternative E - Excavation/Disposal
Alternative G1 - Excavation/On-Site Thermal Treatment/Disposal

4 9 0392

FIGURES

- **ALTERNATIVE A: NO ACTION WITH CONTINUATION OF EXISTING RCRA CORRECTIVE ACTION PROGRAM**
  - **THE EXISTING RCRA CORRECTIVE ACTION PROGRAM WOULD BE CONTINUED UNTIL THE CLEANUP CRITERIA UNDER THE RCRA POST-CLOSURE PERMIT ARE MET**

- **ALTERNATIVE C1: EXTRACTION/TREATMENT/DISCHARGE (VERTICAL EXTRACTION WELLS)**



- **ALTERNATIVE C3: EXTRACTION/TREATMENT/DISCHARGE (VERTICAL AND HORIZONTAL EXTRACTION WELLS)**

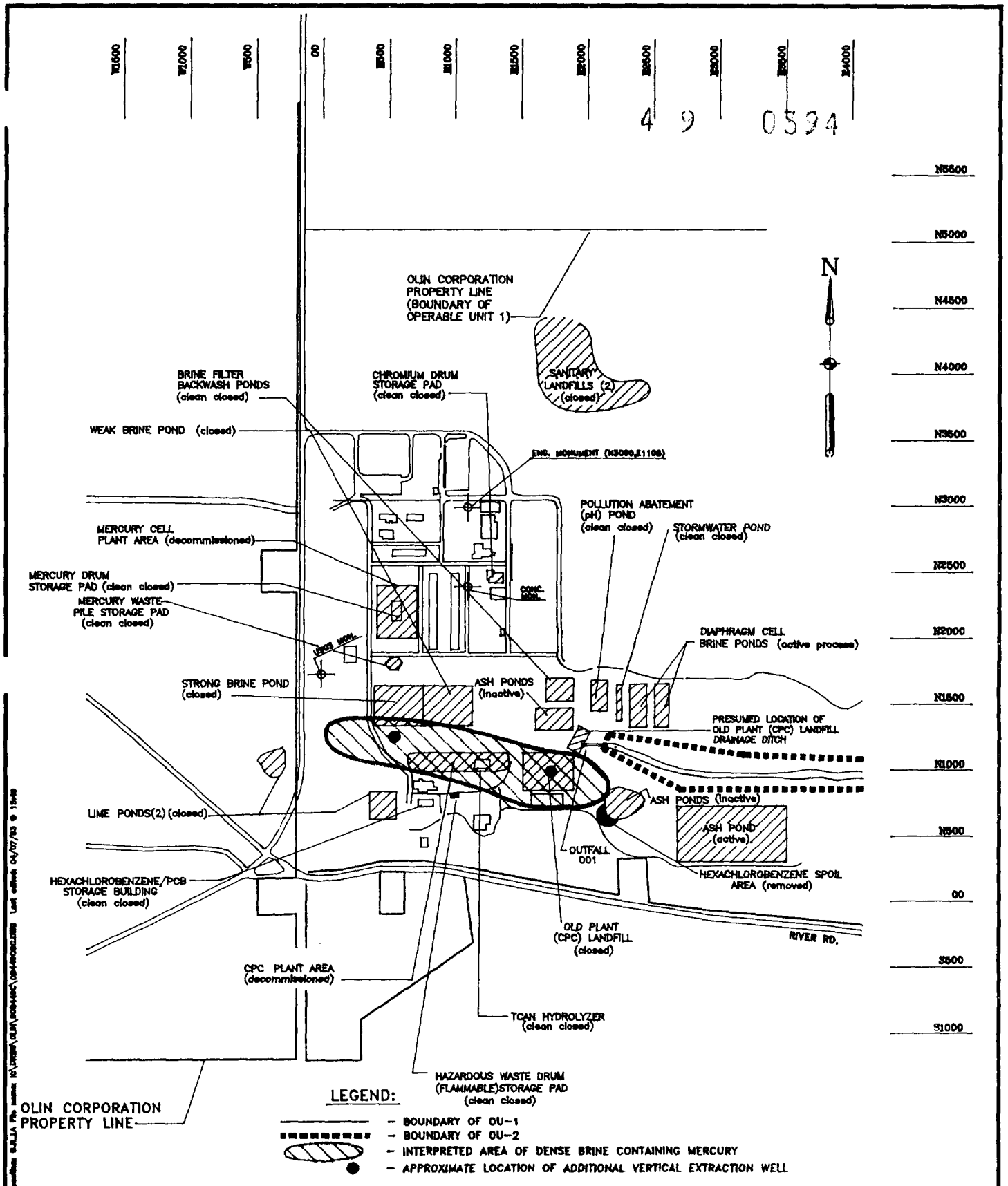
RI/FS
McINTOSH PLANT SITE

Woodward-Clyde Consultants
Engineering & sciences applied to the earth & its environment
Baton Rouge, Louisiana

Olin CHEMICALS
CHARLESTON, TENNESSEE

SCALE:	DRAWN BY: D.P. OLSON	DATE: 04/07/93	FILE NO.	FIGUR
N/A	CHECKED BY: W. BEAL	DATE: 04/07/93	90B449C-6	4-1

SUMMARY OF RETAINED OU-1 GROUNDWATER ALTERNATIVES



OLIN CHEMICALS	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	RI/FS McINTOSH PLANT SITE GROUNDWATER ALTERNATIVE C1	FILE NO. 90B449C FIG. NO. 4-2
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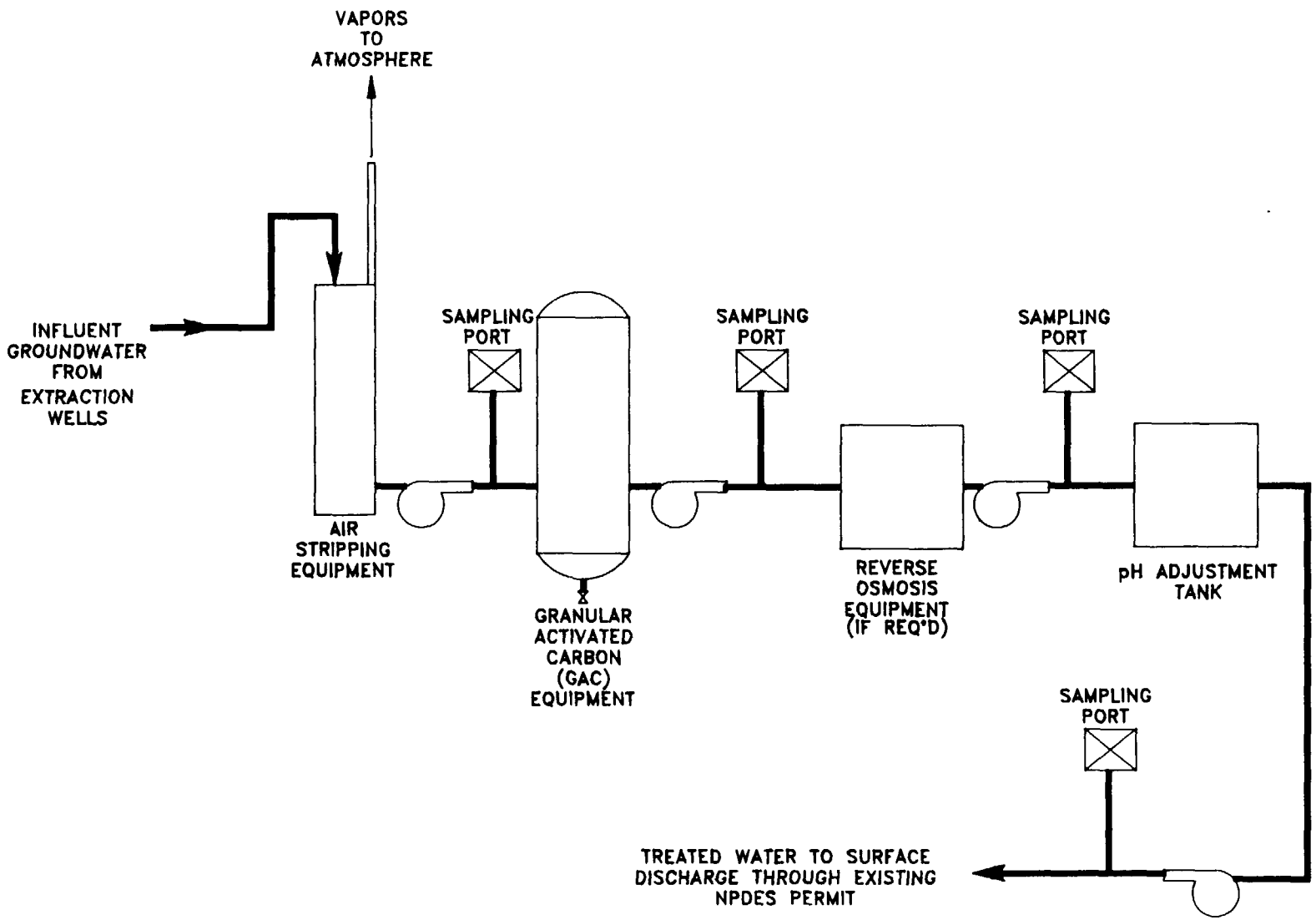

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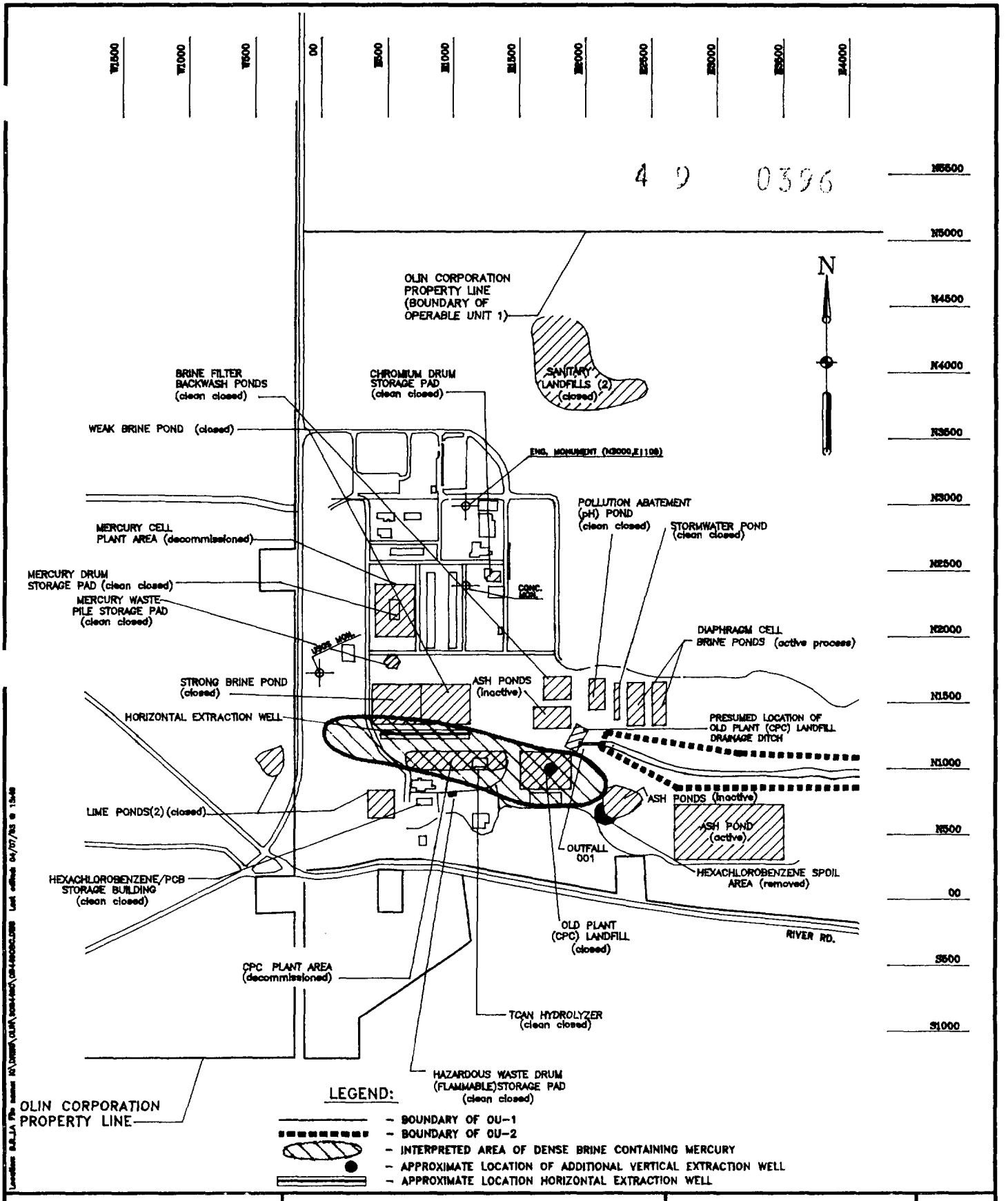
OLIN CHEMICAL CORPORATION
CHARLESTON, TENNESSEE

Woodward-Clyde Consultants
Consulting Engineers, Geologists
and Environmental Scientists
Baton Rouge, Louisiana

SCALE:
DRAWN BY: G.T.
DATE: 10/19/92
CHKD. BY: [illegible]
DATE: 10/19/92

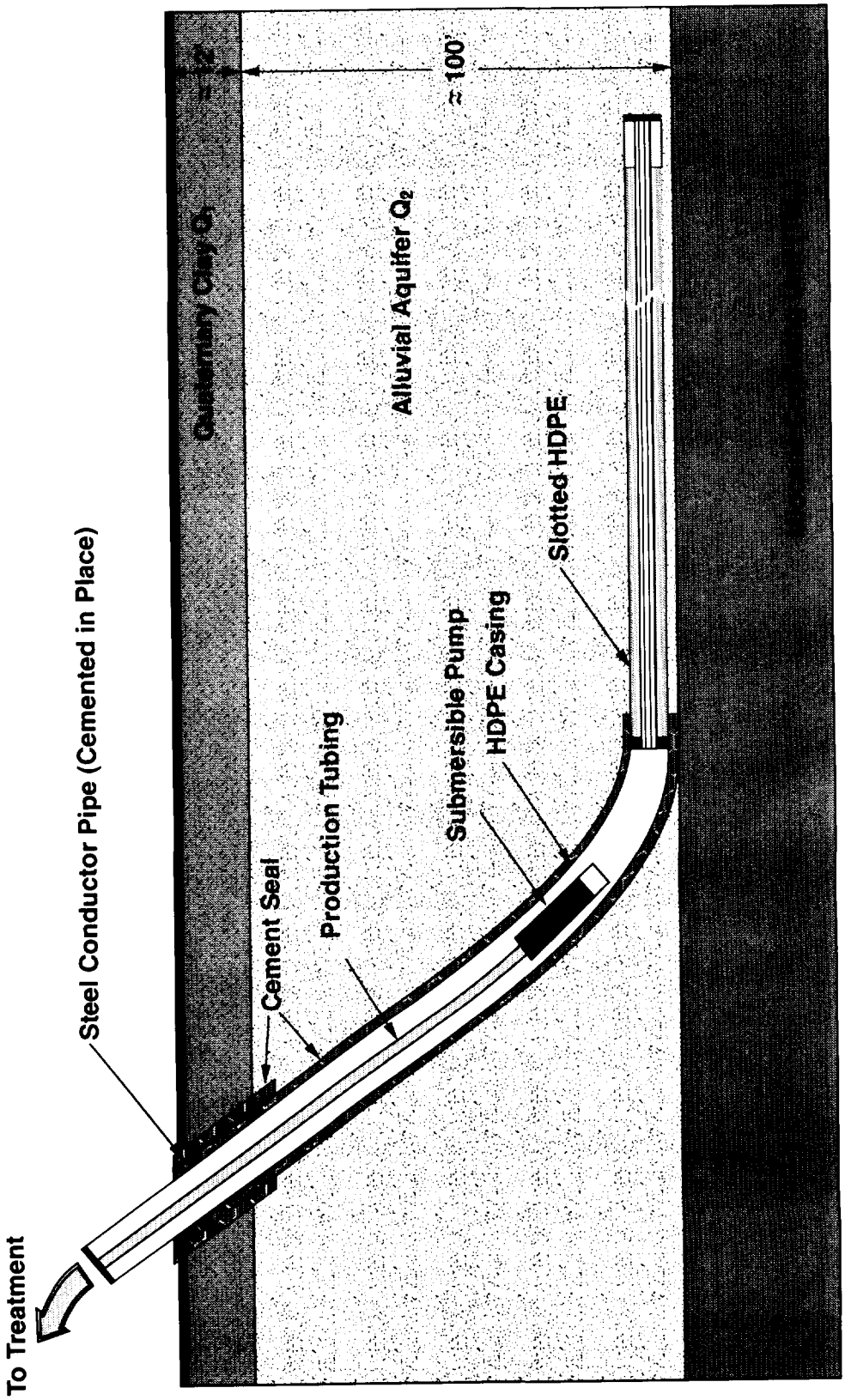
CONCEPTUAL PROCESS
FLOW DIAGRAM
GROUNDWATER
TREATMENT

FILE NO. 90B448C
FIG. NO. 4-3



4 9 0396

OLIN CHEMICALS	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	RI/FS McINTOSH PLANT SITE GROUNDWATER ALTERNATIVE C3	FILE NO. 90B449C
	SCALE: 1"=1000' / DRAWN BY: G THORNTON / DATE: 3/24/93 / CHKD. BY: W Beal / DATE: 5/4/93		FIG. NO. 4-4



Not to Scale

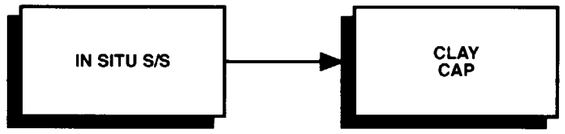
RI/FS McINTOSH PLANT SITE Olin CHEMICALS CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Engineering & sciences applied to the earth & its environment		TYPICAL CROSS SECTION OF HORIZONTAL WELL	FILE NO. 90B449C FIG. NO. 4-5
	SCALE: AS NOTED	DRAWN BY: D.OLSON DATE: 05/04/93 CHKD. BY: W.BEAL DATE: 05/04/93		

OU-1 SOIL ALTERNATIVES - OLD PLANT (CPC) LANDFILL

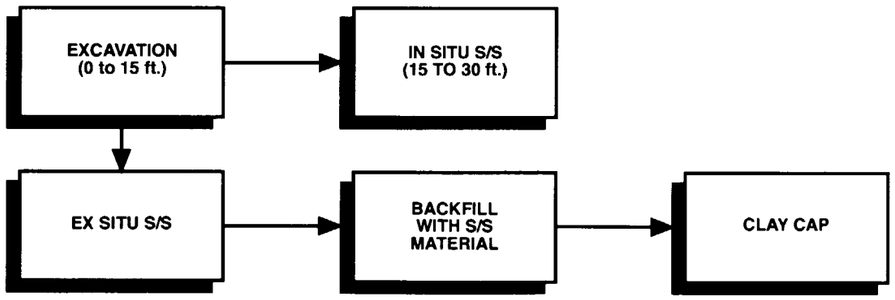
- **ALTERNATIVE A: NO ACTION**

- **ALTERNATIVE C: CONTAINMENT (IMPROVE CAPPING)**

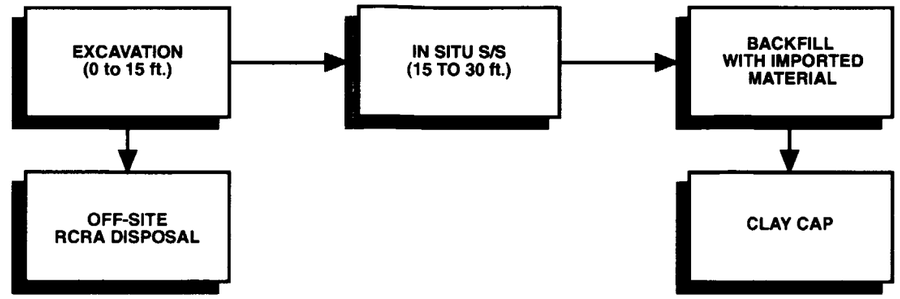
- **ALTERNATIVE D: IN SITU STABILIZATION-SOLIDIFICATION (S/S)/CONTAINMENT**



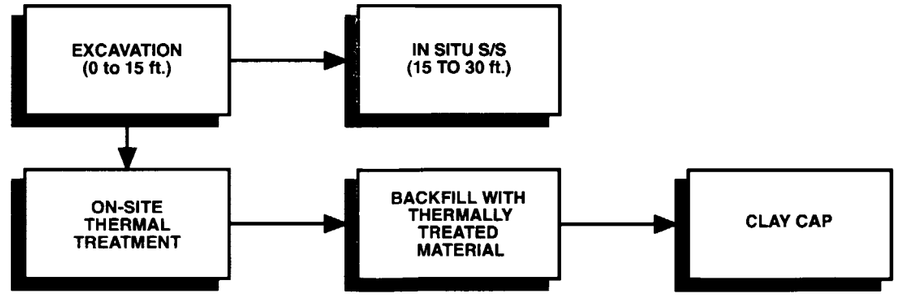
- **ALTERNATIVE E: EXCAVATION/STABILIZATION-SOLIDIFICATION/CONTAINMENT**



- **ALTERNATIVE F: EXCAVATION/OFF-SITE RCRA DISPOSAL**



- **ALTERNATIVE G1: EXCAVATION/ON-SITE THERMAL TREATMENT/DISPOSAL**



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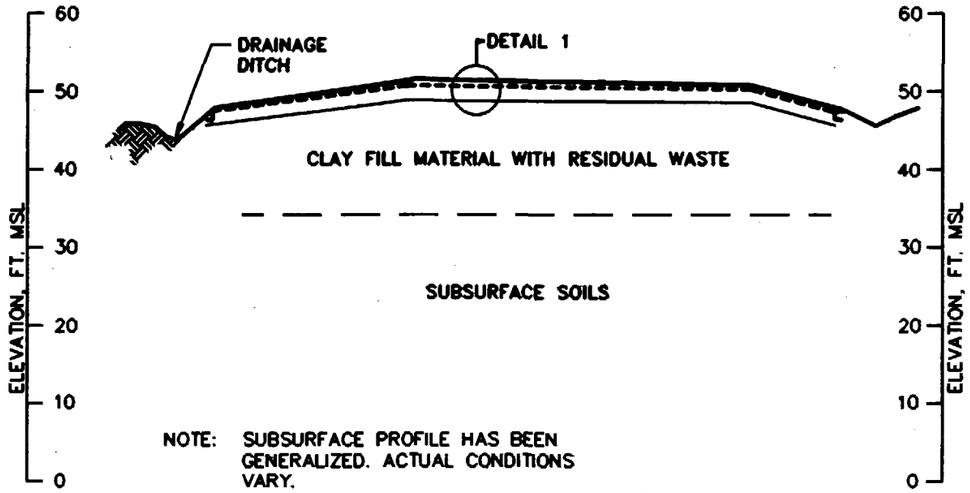
N/A	CHECKED BY: W. BEAL	DATE: 09/27/93	90B449C-6	4-6

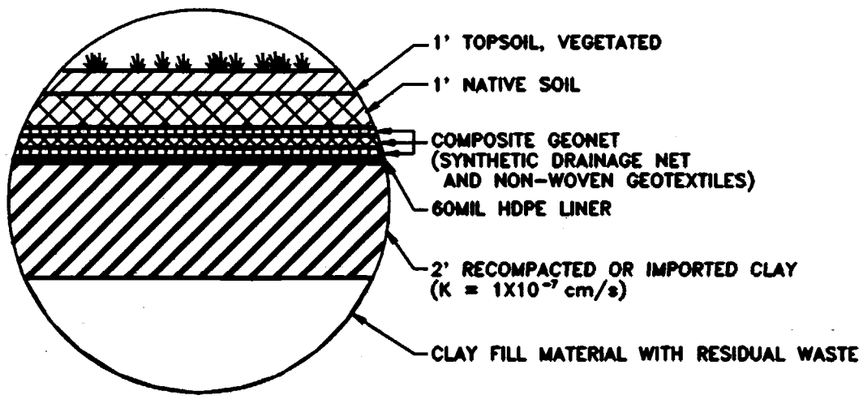
SUMMARY OF RETAINED OU-1 SOIL ALTERNATIVES
OLD PLANT (CPC) LANDFILL



SECTION A – A'

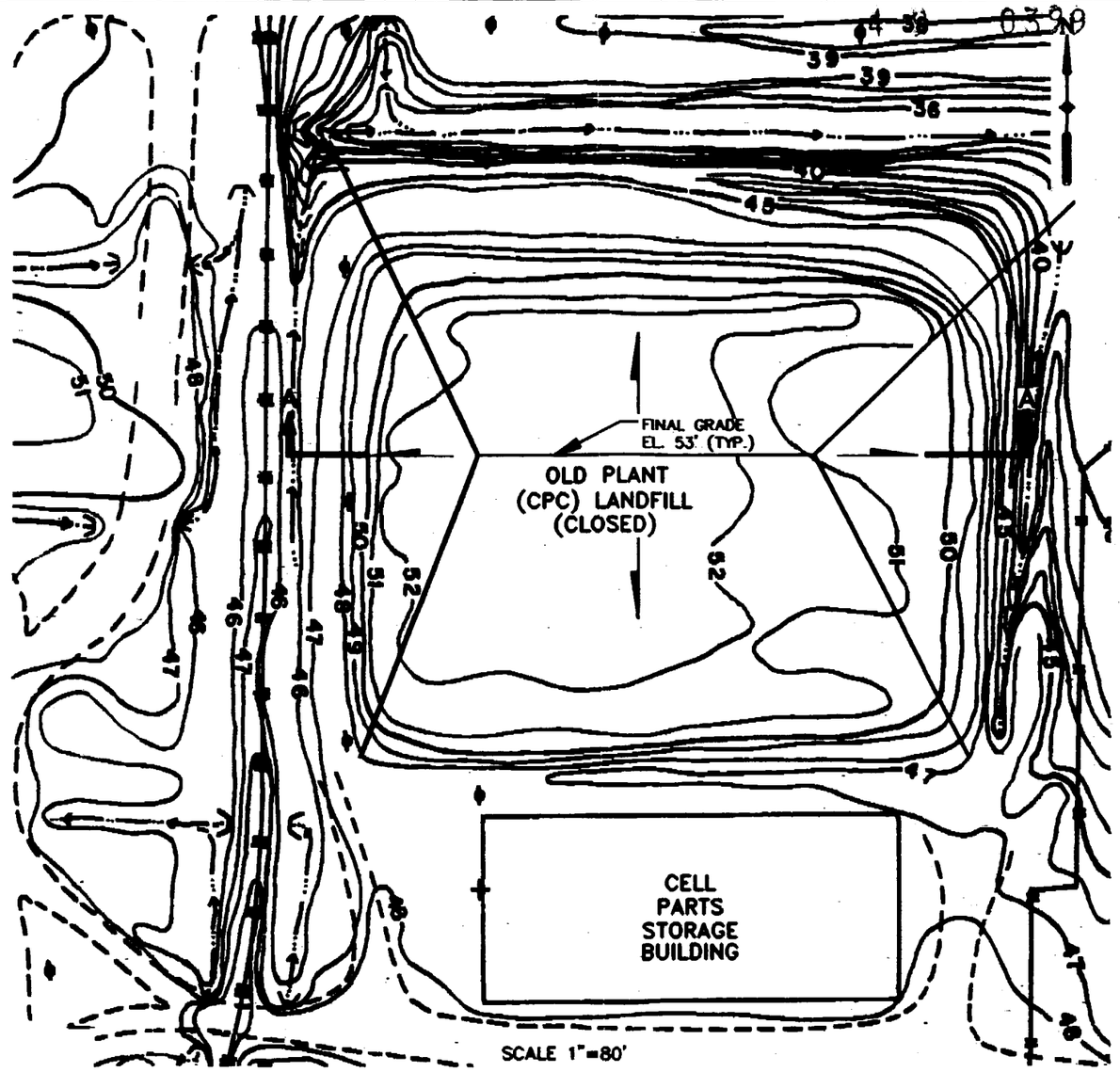
20 FT.

SCALE 80 FT.



DETAIL 1
NOT TO SCALE

MULTIMEDIA CAP



DATE	REVISION	DRWN/CHKD

OU-1 SOILS

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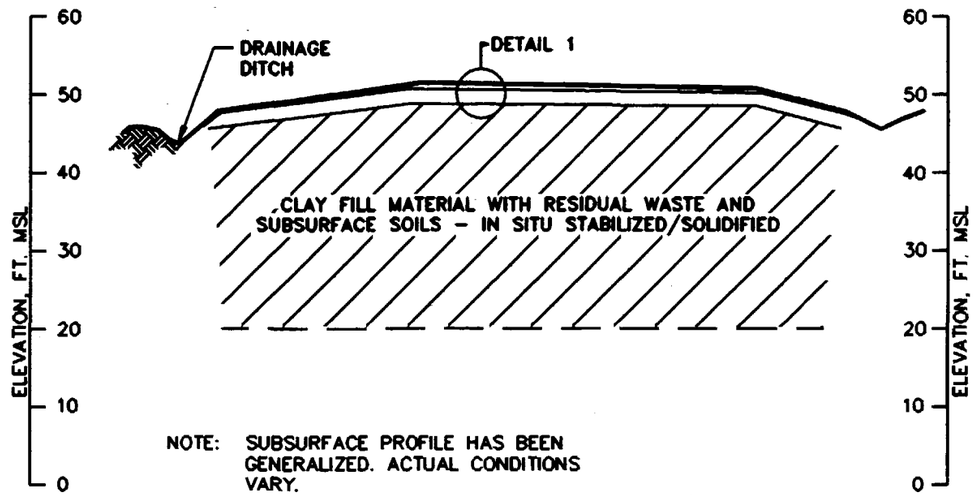
AS SHOWN	CHECKED BY:	DATE:	90B449C

SOIL ALTERNATIVE C
CONTAINMENT (IMPROVED CAPPING)
OLD PLANT (CPC) LANDFILL

FIGURE 4-7

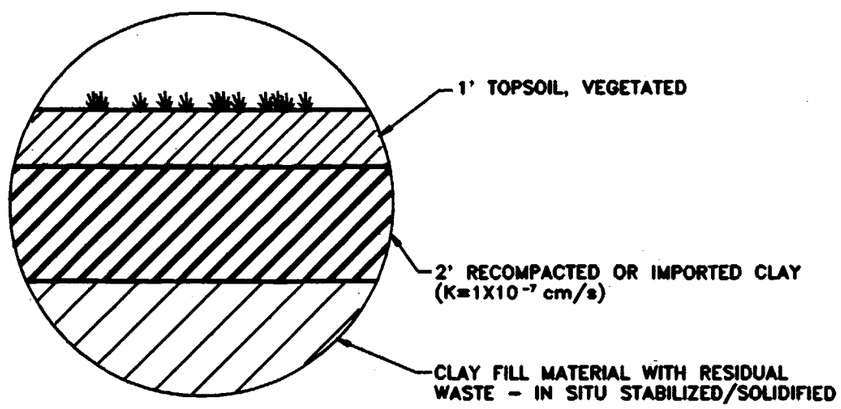
Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\DB449CBA.DWG Last edited: 10/14/93 @ 10:28



NOTE: SUBSURFACE PROFILE HAS BEEN GENERALIZED. ACTUAL CONDITIONS VARY.

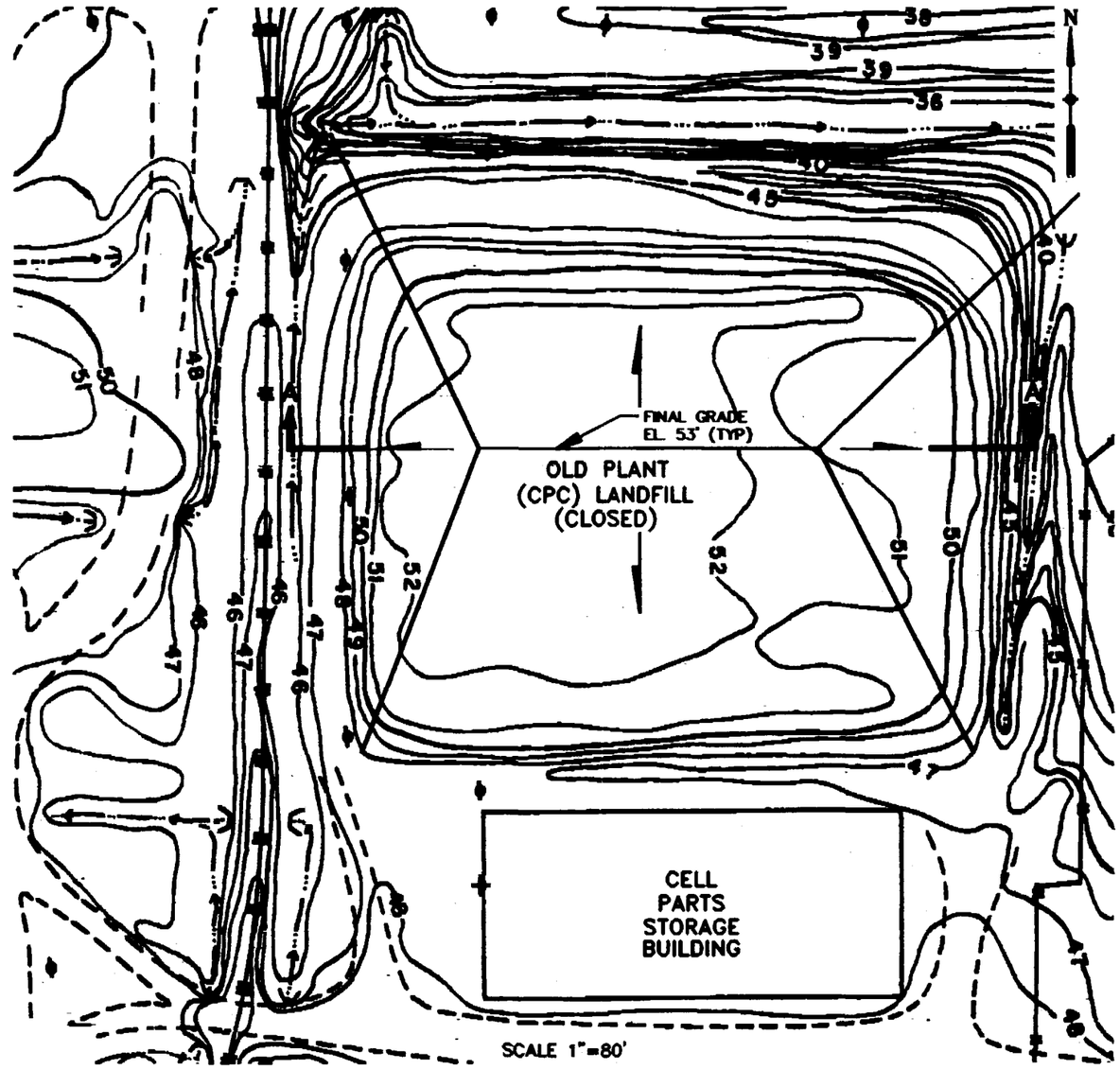
SECTION A - A'

20 FT.
80 FT.
SCALE



DETAIL 1
NOT TO SCALE

CLAY CAP



DATE	REVISION	DRWN/CHKD

OU-1 SOILS

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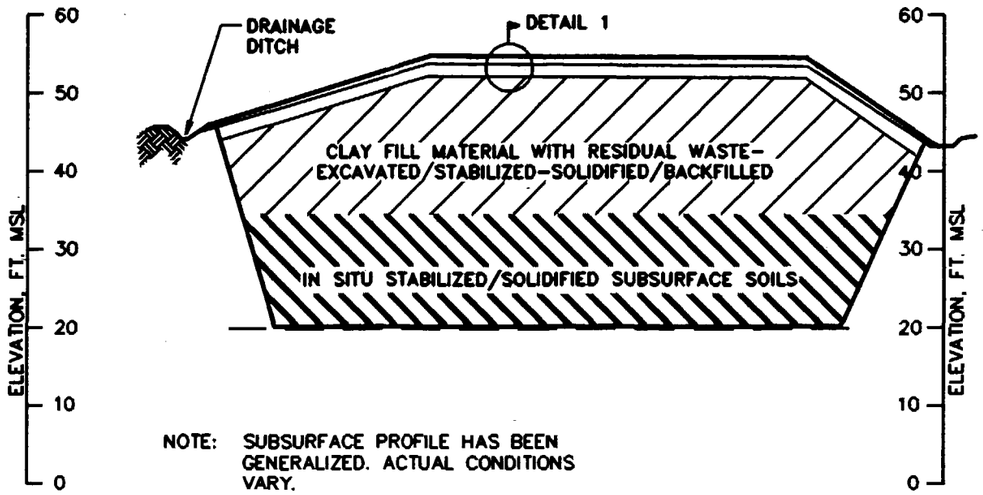
AS SHOWN	CHECKED BY: [illegible]	DATE: 10/19/93	90B449C

SOIL ALTERNATIVE D
IN SITU STABILIZATION-SOLIDIFICATION/
CONTAINMENT, OLD PLANT (CPC) LANDFILL

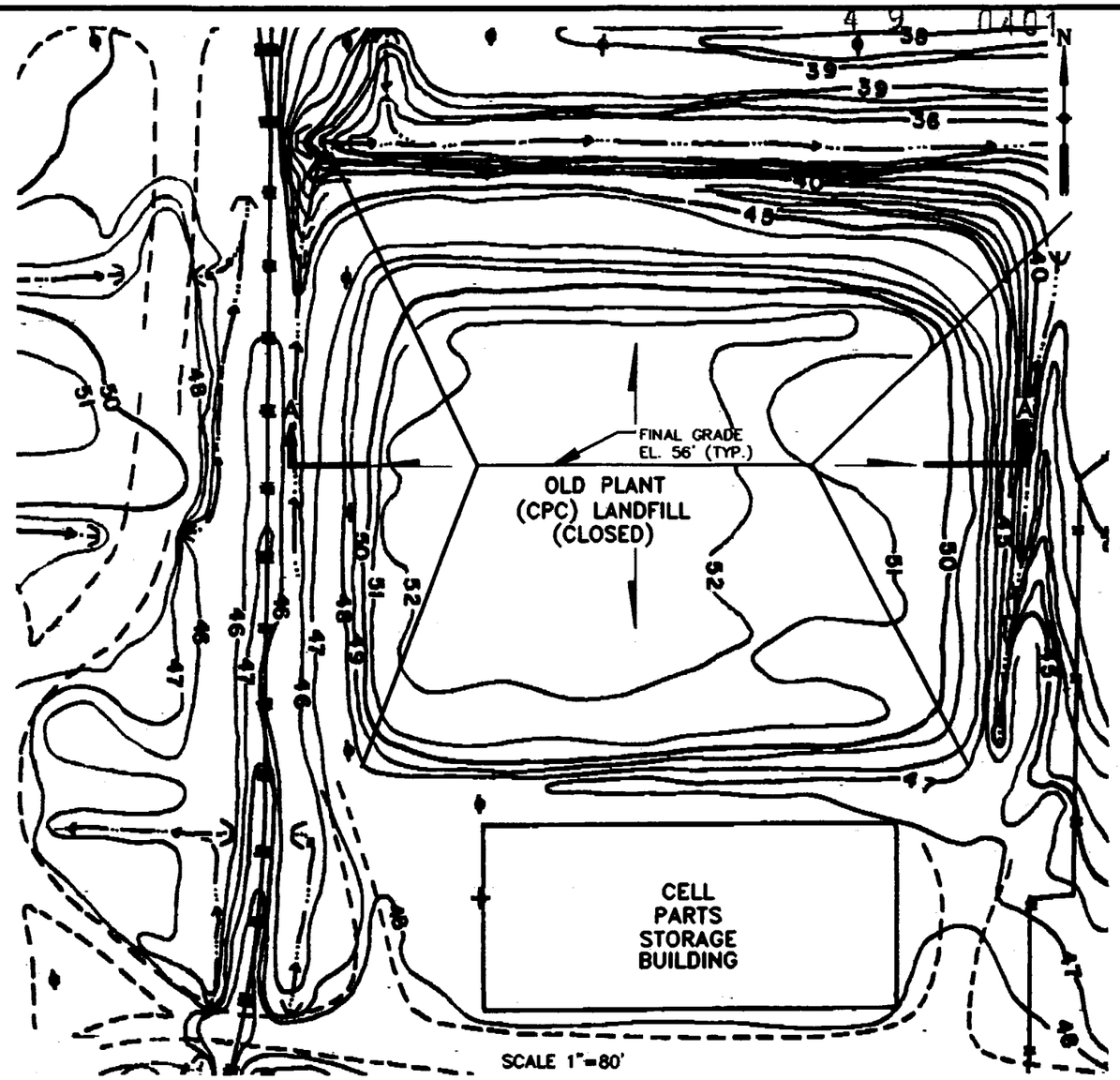
FIGURE 4-8

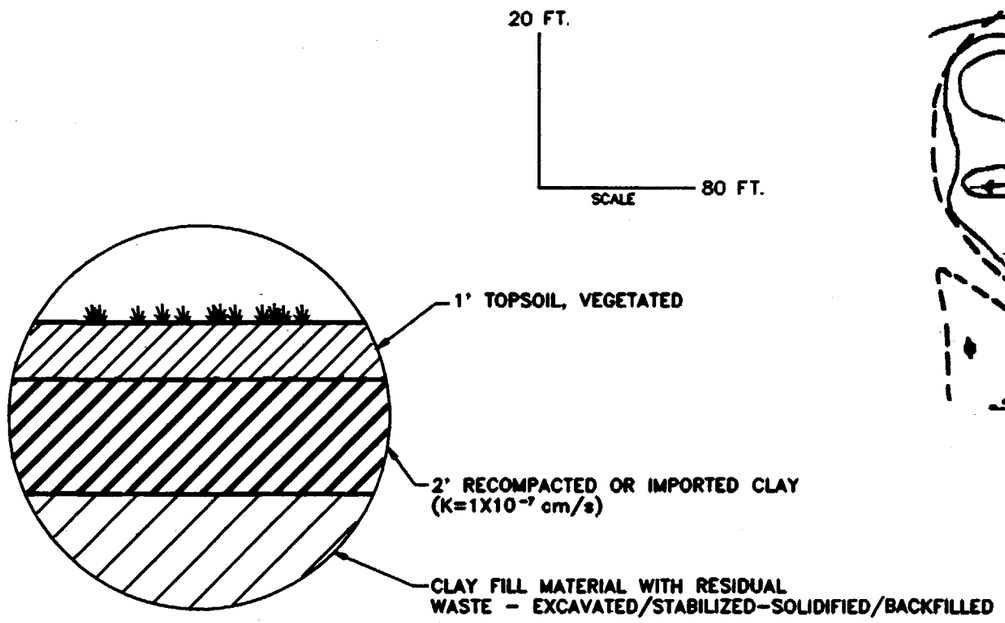
Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CBA.DWG Last edited: 10/14/93 ● 09:51



NOTE: SUBSURFACE PROFILE HAS BEEN GENERALIZED. ACTUAL CONDITIONS VARY.

SECTION A – A'





DETAIL 1
NOT TO SCALE

CLAY CAP

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OU-1 SOILS

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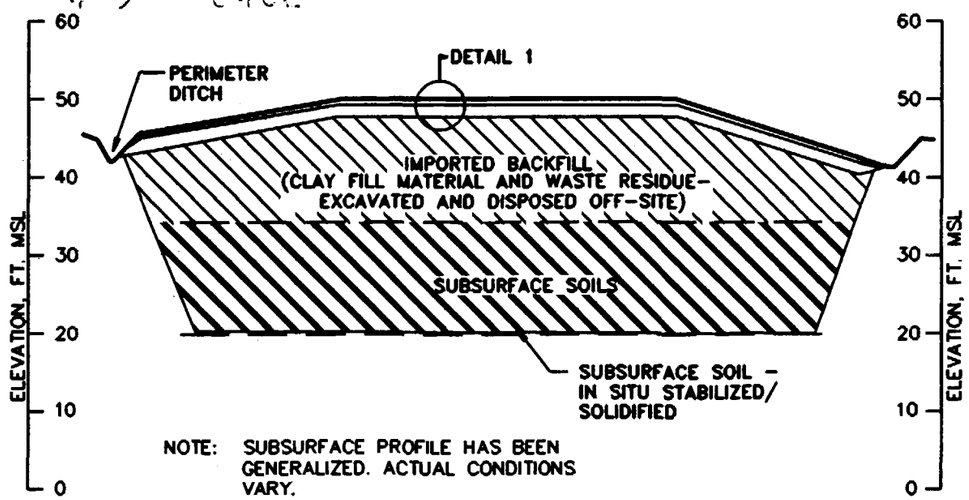
SOIL ALTERNATIVE E
EXCAVATION/STABILIZATION-SOLIDIFICATION/CONTAINMENT, OLD PLANT (CPC) LANDFILL

FIGURE 4-9

Location: B.R.,LA File name: K:\DRWG\OLIN\908449C\08449CBA.DWG Last edited: 10/14/93 ● 08:51



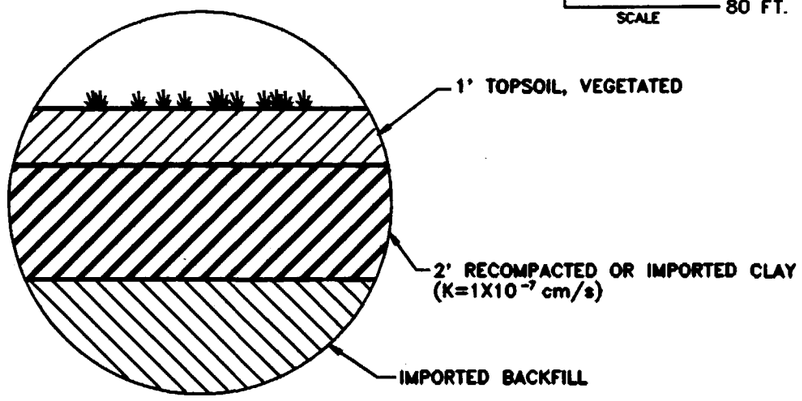
NOTE: SUBSURFACE PROFILE HAS BEEN GENERALIZED. ACTUAL CONDITIONS VARY.

SECTION A – A'

20 FT.

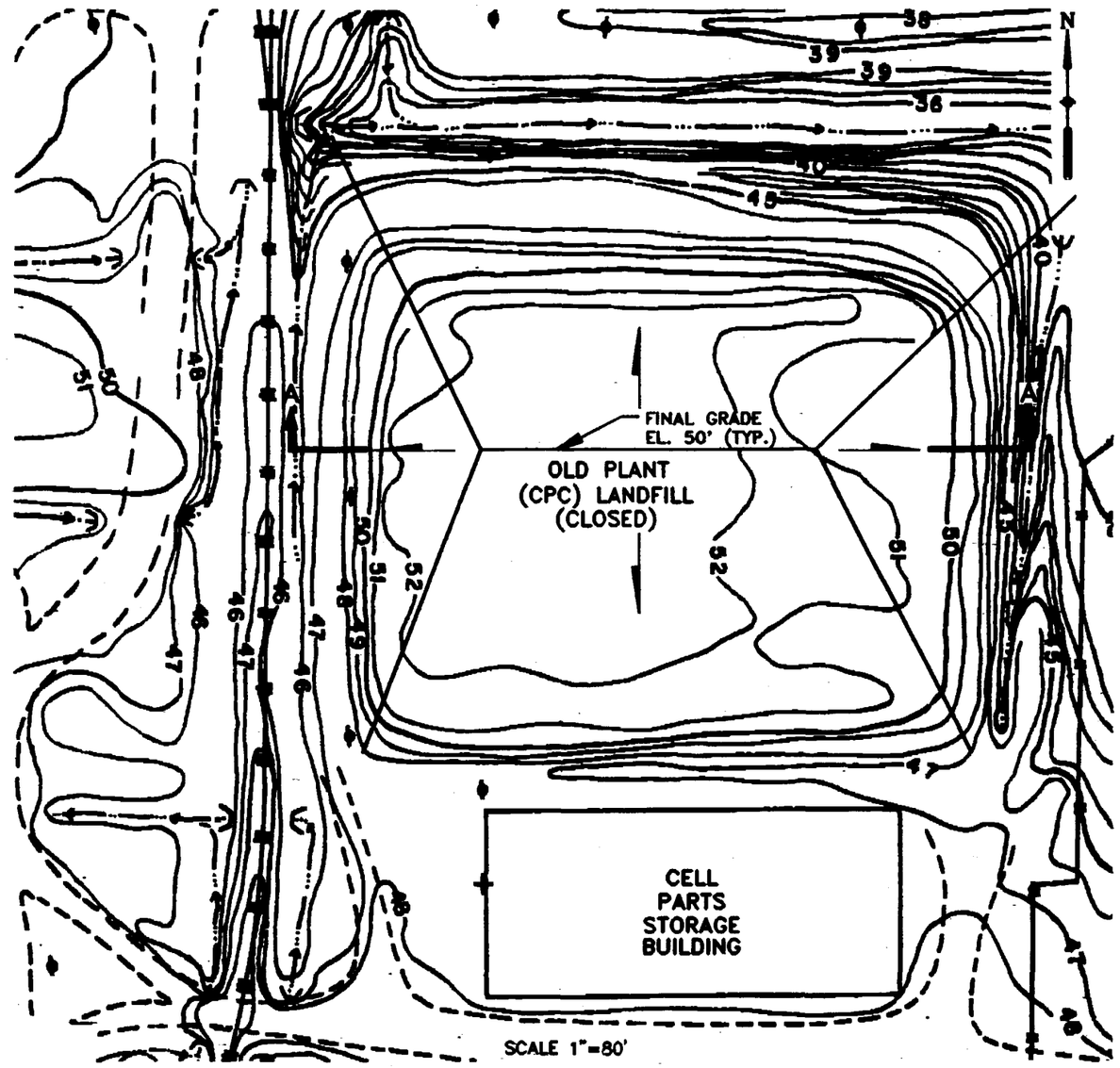
SCALE

80 FT.



DETAIL 1
NOT TO SCALE

CLAY CAP



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OU-1 SOILS

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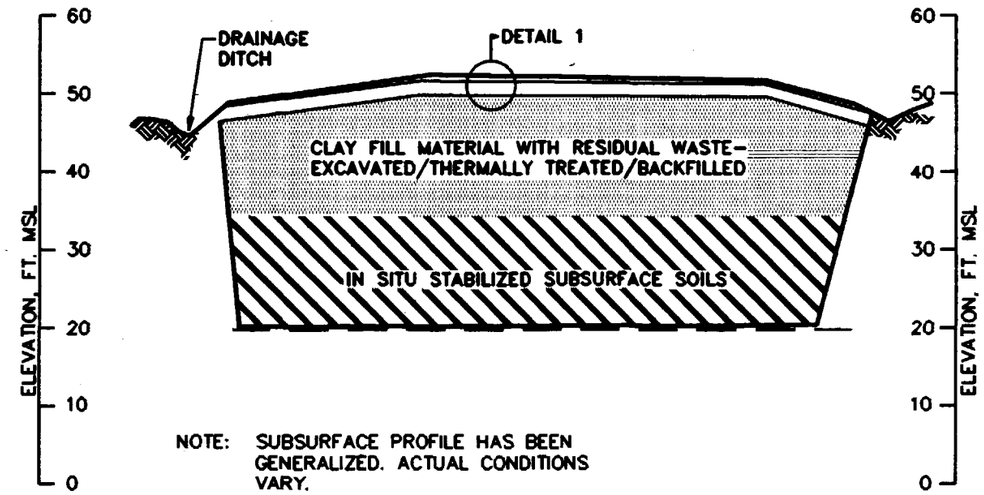
SOIL ALTERNATIVE F
EXCAVATION/OFF-SITE RCRA DISPOSAL
OLD PLANT (CPC) LANDFILL

FIGURE 4-10

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CBA.DWG Last edited: 10/14/93 ● 10:28

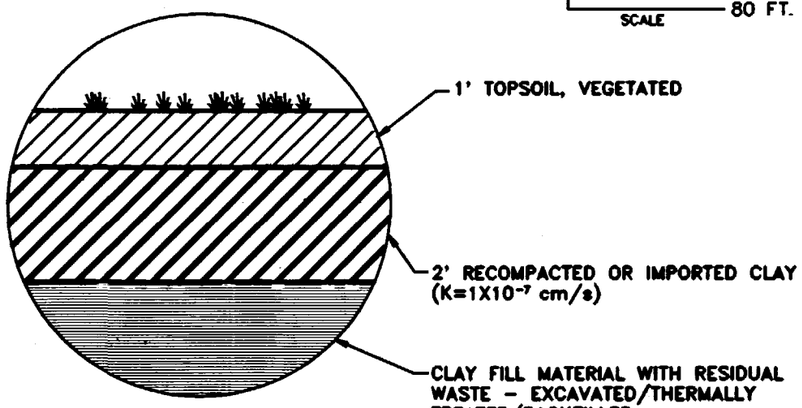


NOTE: SUBSURFACE PROFILE HAS BEEN GENERALIZED. ACTUAL CONDITIONS VARY.

SECTION A – A'

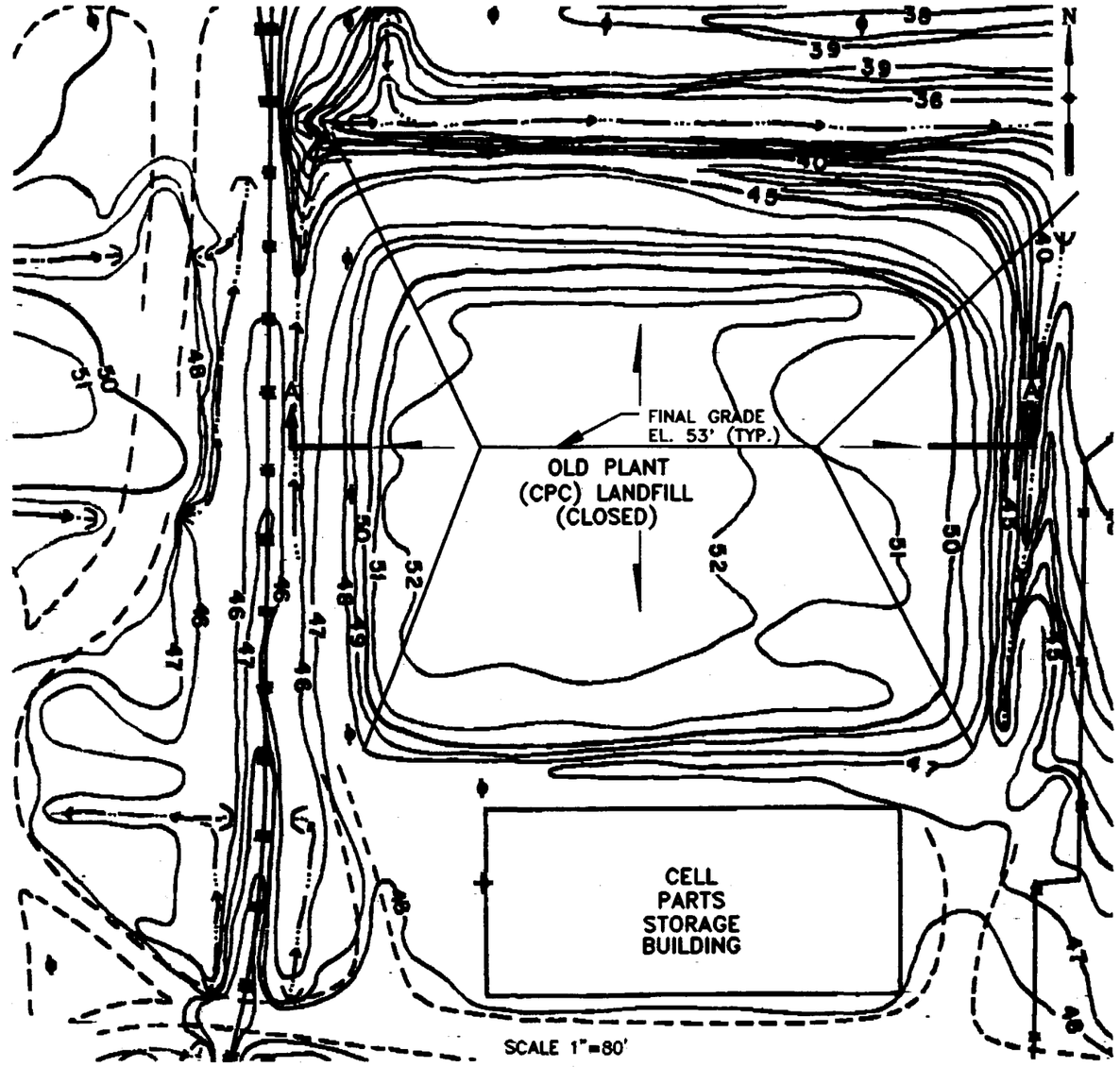
20 FT.

SCALE 80 FT.



DETAIL 1
NOT TO SCALE

CLAY CAP



DATE	REVISION	DRWN/CHKD

OU-1 SOILS

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SOIL ALTERNATIVE G1
EXCAVATION/ON-SITE THERMAL TREATMENT/ DISPOSAL, OLD PLANT (CPC) LANDFILL

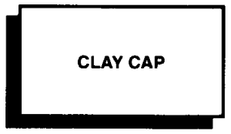
FIGURE 4-11

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CBA.DWG Last edited: 10/14/93 @ 10:28

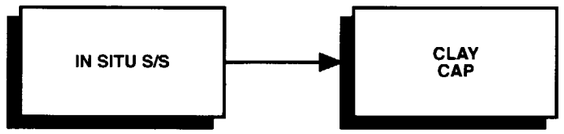
OU-1 SOIL ALTERNATIVES - WEST OF FORMER CPC PLANT

- **ALTERNATIVE A: NO ACTION**

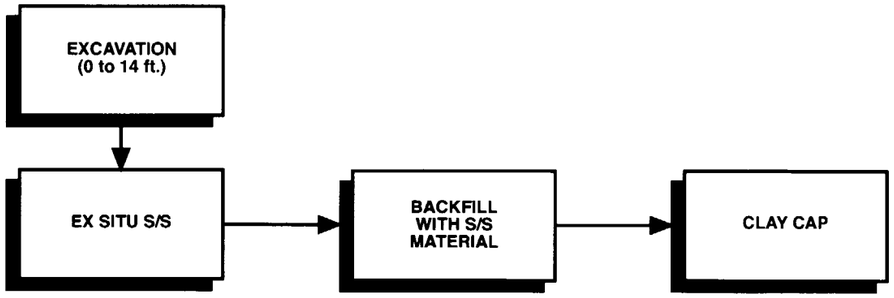
- **ALTERNATIVE C: CONTAINMENT (EXTEND EXISTING CAP)**



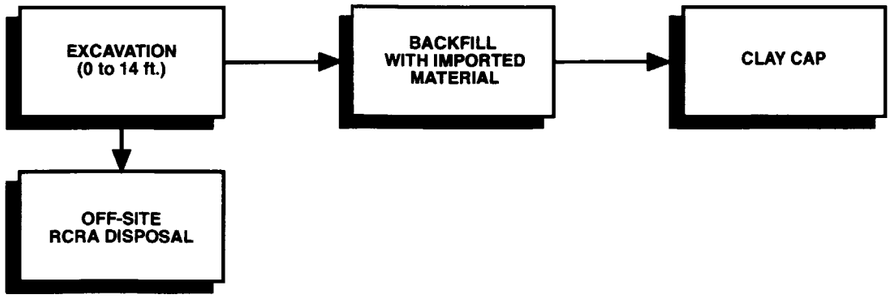
- **ALTERNATIVE D: IN SITU STABILIZATION-SOLIDIFICATION (S/S)/CONTAINMENT**



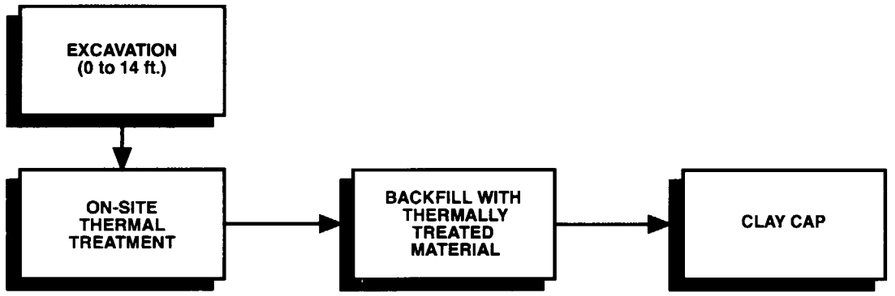
- **ALTERNATIVE E: EXCAVATION/STABILIZATION-SOLIDIFICATION/CONTAINMENT**



- **ALTERNATIVE F: EXCAVATION/OFF-SITE RCRA DISPOSAL**



- **ALTERNATIVE G: EXCAVATION/ON-SITE THERMAL TREATMENT/DISPOSAL**



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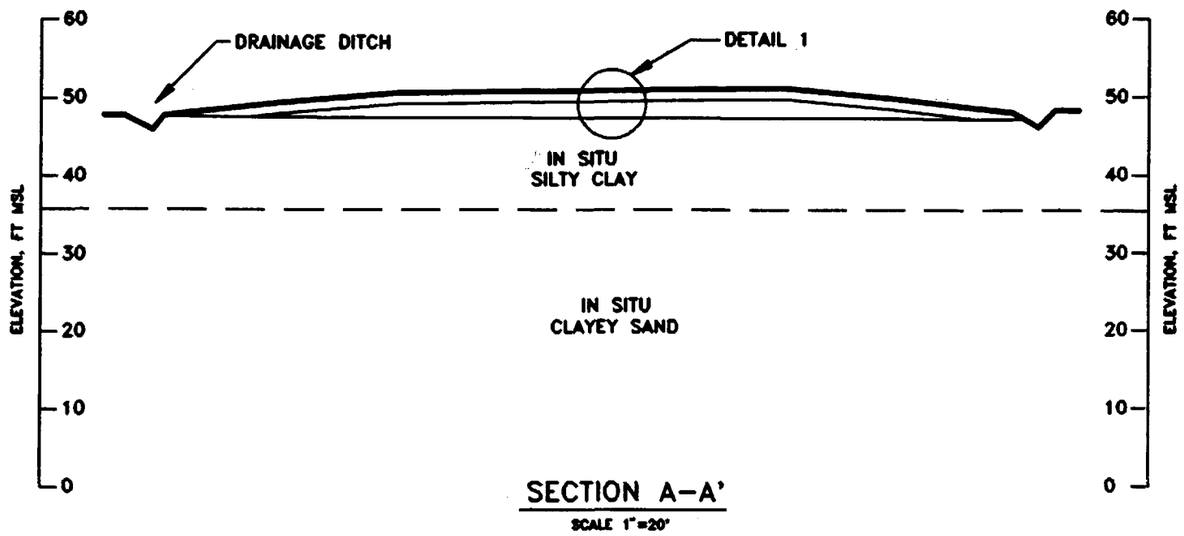
N/A	CHECKED BY: W. BEAL	DATE: 10/18/93	90B449C-6	4-12

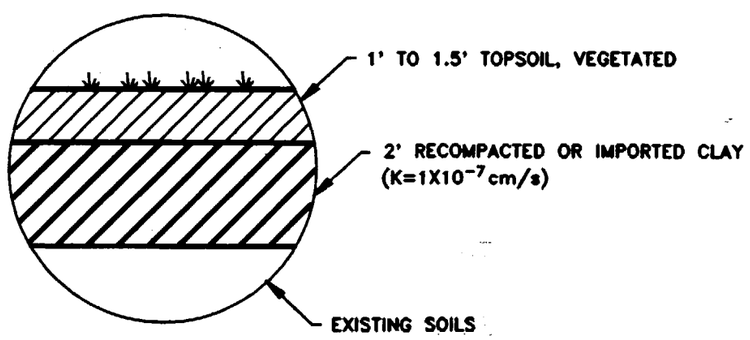
SUMMARY OF RETAINED OU-1 SOIL ALTERNATIVES
AREA WEST OF FORMER CPC PLANT



SECTION A–A'

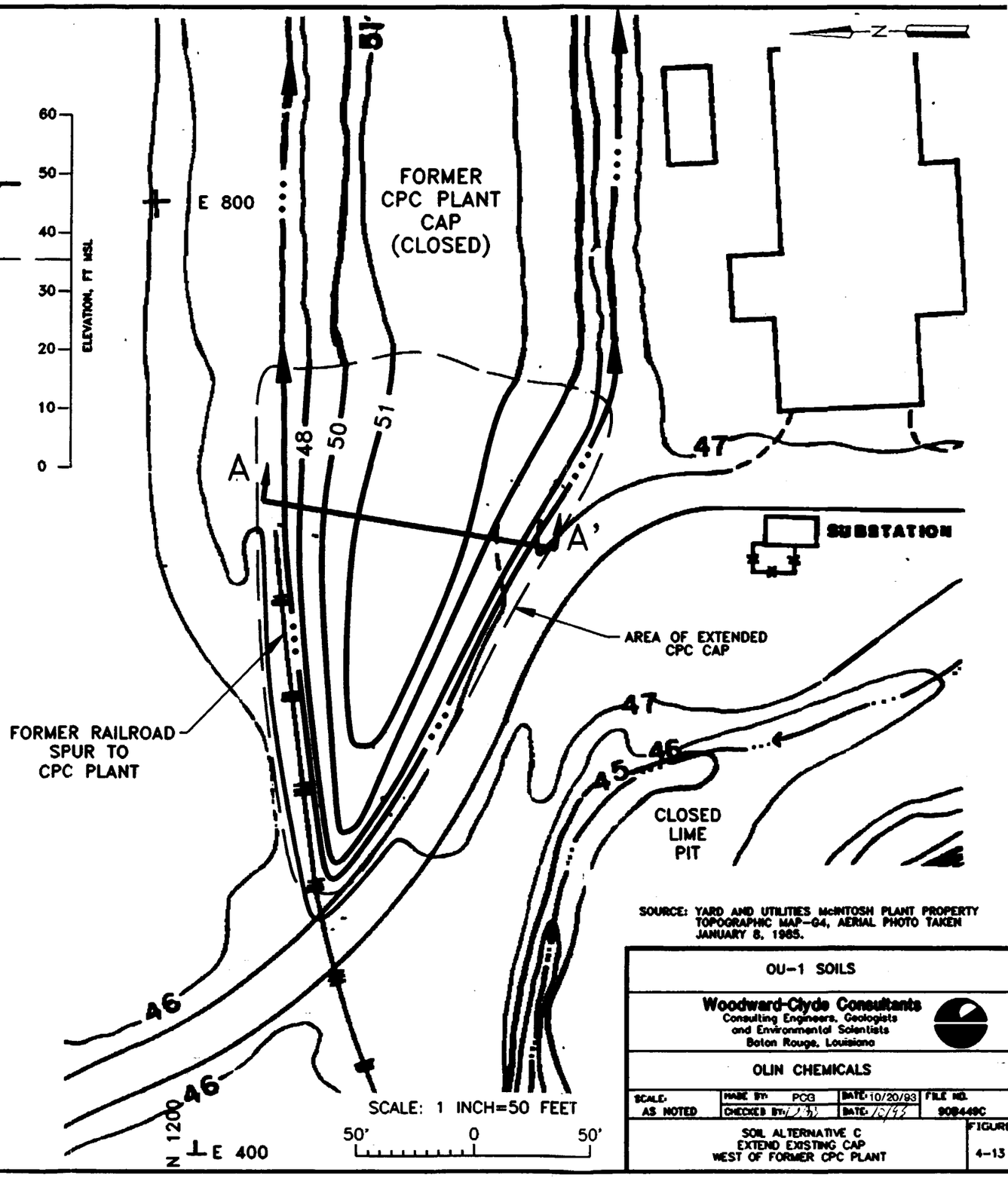
SCALE 1"=20'

NOTE: SUBSURFACE SOILS HAVE BEEN GENERALIZED
ACTUAL CONDITIONS MAY VARY



CLAY CAP
DETAIL 1

NOT TO SCALE



SOURCE: YARD AND UTILITIES McINTOSH PLANT PROPERTY TOPOGRAPHIC MAP–G4, AERIAL PHOTO TAKEN JANUARY 8, 1985.

OU–1 SOILS

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OLIN CHEMICALS

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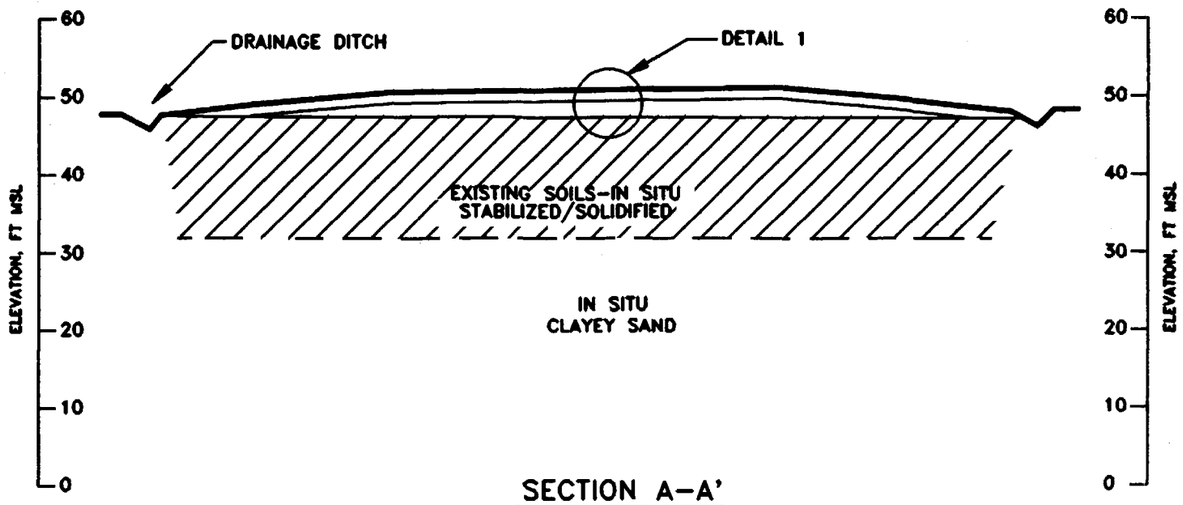
	CHECKED BY:	DATE:	

SOIL ALTERNATIVE C
EXTEND EXISTING CAP
WEST OF FORMER CPC PLANT

FIGURE 4–13

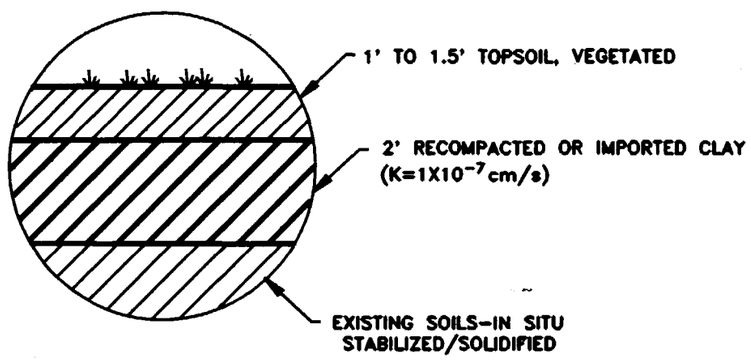
Location: B.R.,LA File name: K:\DRWG\OLIN\908449C\08449C03.DWG Last edited: 10/04/93 ● 15:09



SECTION A-A'

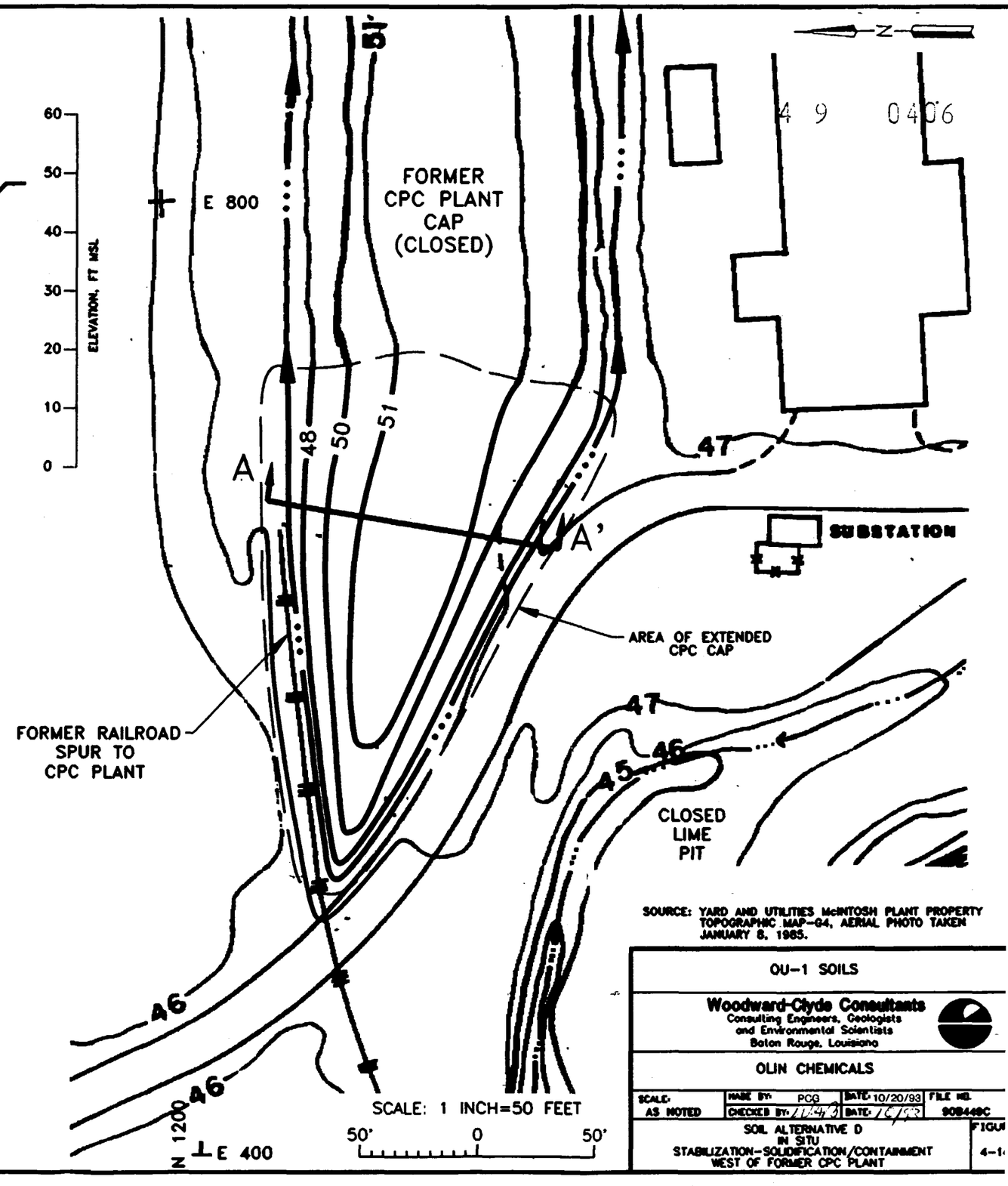
SCALE 1"=20'

NOTE: SUBSURFACE SOILS HAVE BEEN GENERALIZED ACTUAL CONDITIONS MAY VARY



CLAY CAP DETAIL 1

NOT TO SCALE



SOURCE: YARD AND UTILITIES McINTOSH PLANT PROPERTY TOPOGRAPHIC MAP-G4, AERIAL PHOTO TAKEN JANUARY 8, 1985.

OU-1 SOILS

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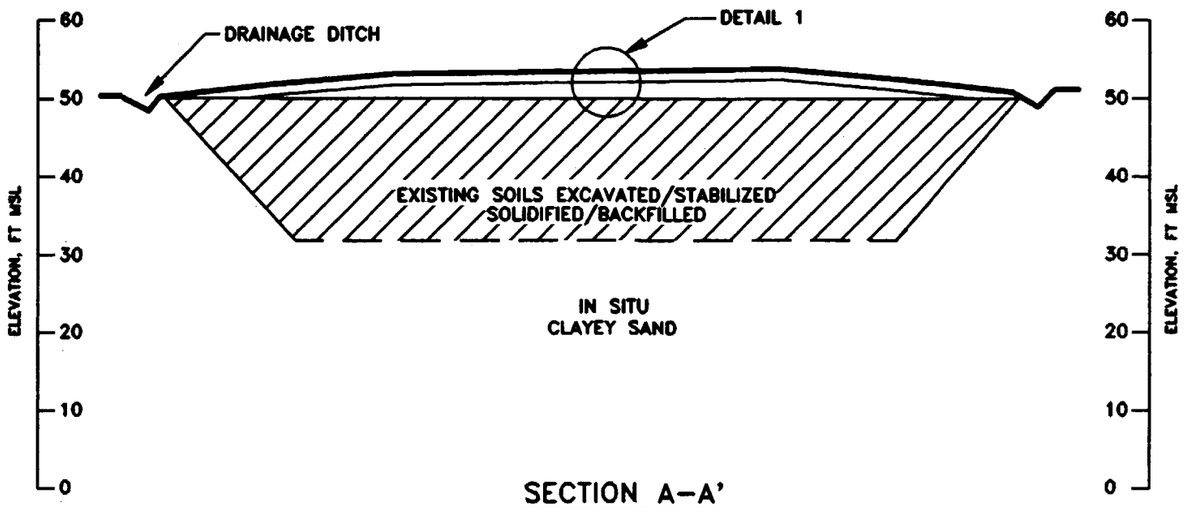
	CHECKED BY:	DATE:	

SOIL ALTERNATIVE D
IN SITU
STABILIZATION-SOLIDIFICATION/CONTAINMENT
WEST OF FORMER CPC PLANT

FIGU 4-1

Location: B.R.LA File name: K:\DRWG\OLIN\90B449C\0B449C03.DWG Last edited: 10/04/93 @ 15:09

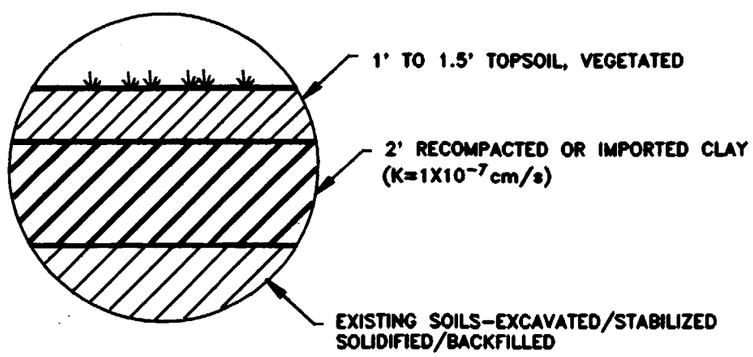


SECTION A–A'

SCALE 1"=20'

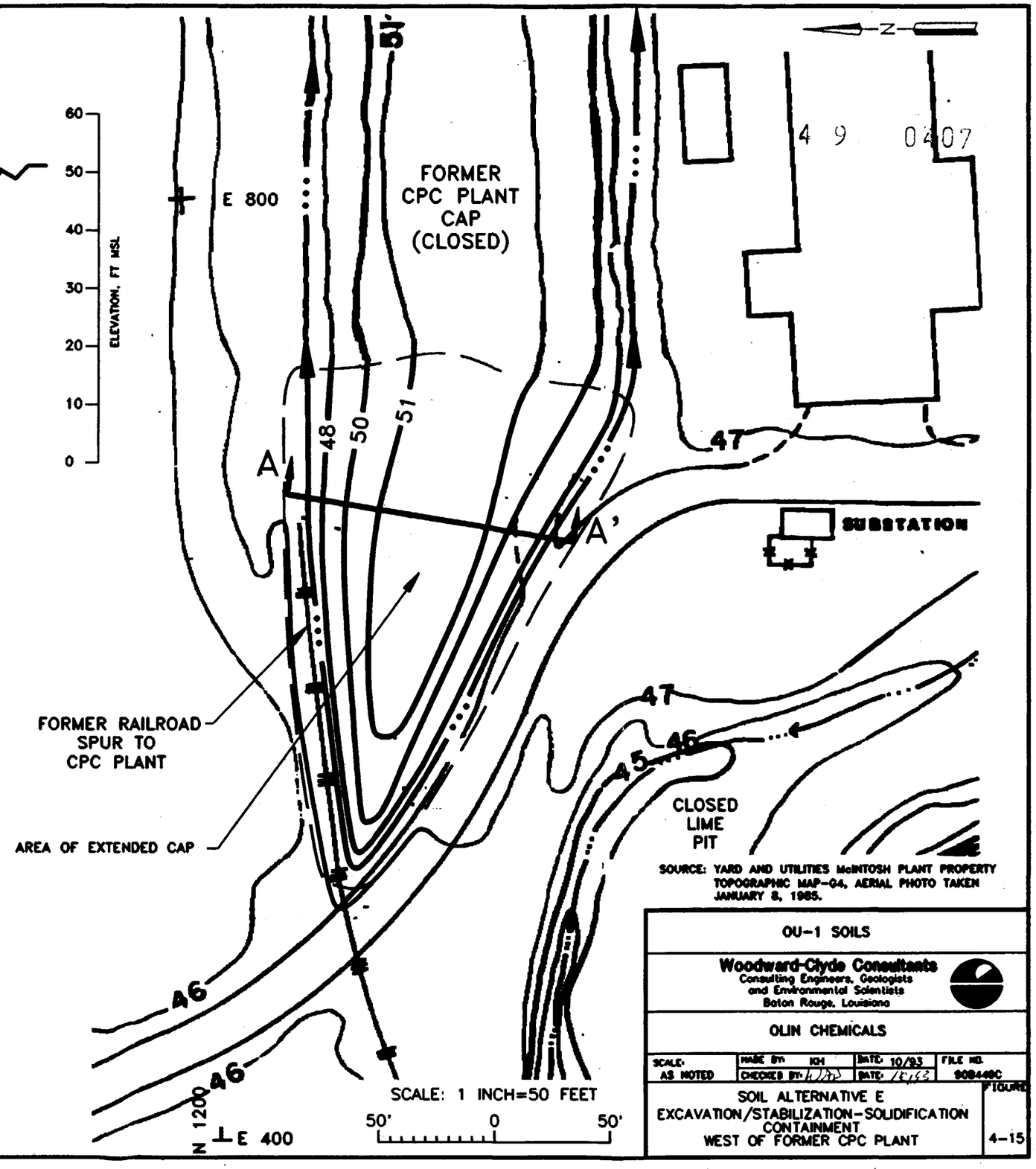
NOTES: (1) SUBSURFACE SOILS HAVE BEEN GENERALIZED ACTUAL CONDITIONS MAY VARY

(2) THE STABILIZED/SOLIDIFIED SOIL WILL BULK APPROXIMATELY 20 PERCENT



CLAY CAP
DETAIL 1

NOT TO SCALE



SOURCE: YARD AND UTILITIES McINTOSH PLANT PROPERTY TOPOGRAPHIC MAP–G4, AERIAL PHOTO TAKEN JANUARY 8, 1985.

OU–1 SOILS

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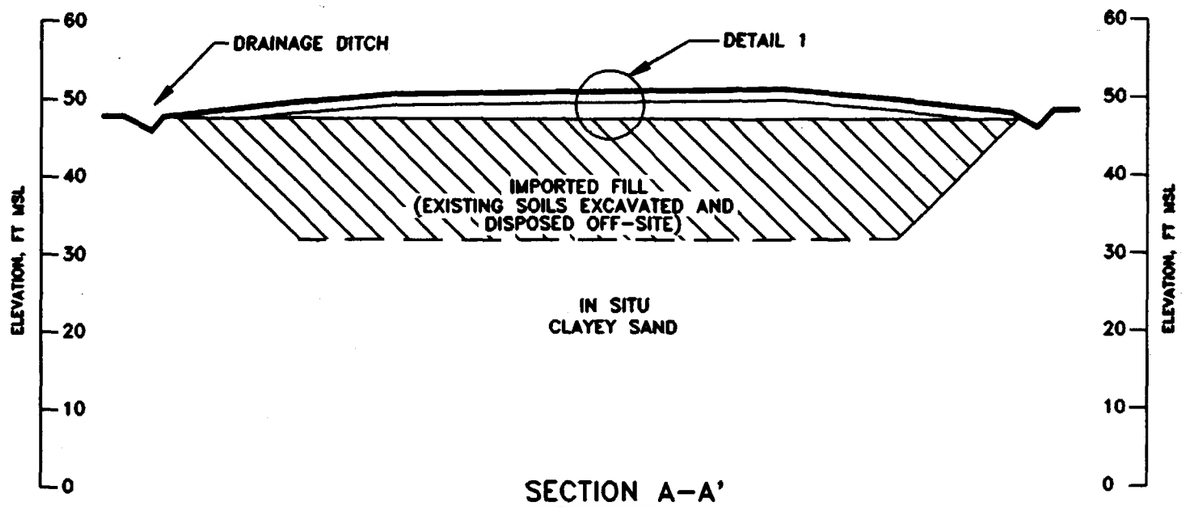
	CHECKED BY:	DATE:	

SOIL ALTERNATIVE E
EXCAVATION/STABILIZATION–SOLIDIFICATION CONTAINMENT
WEST OF FORMER CPC PLANT

FIGURE 4–15

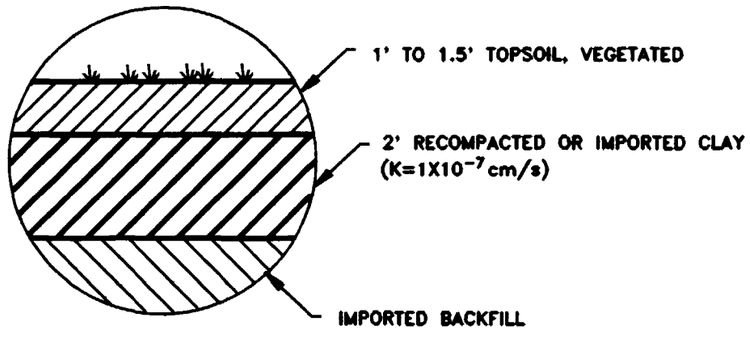
Location: B.R>, La File name: K:\DRWG\OLIN\908449C\08449C04.DWG Last edited: 10/8/93 ● 10:30



SECTION A–A'

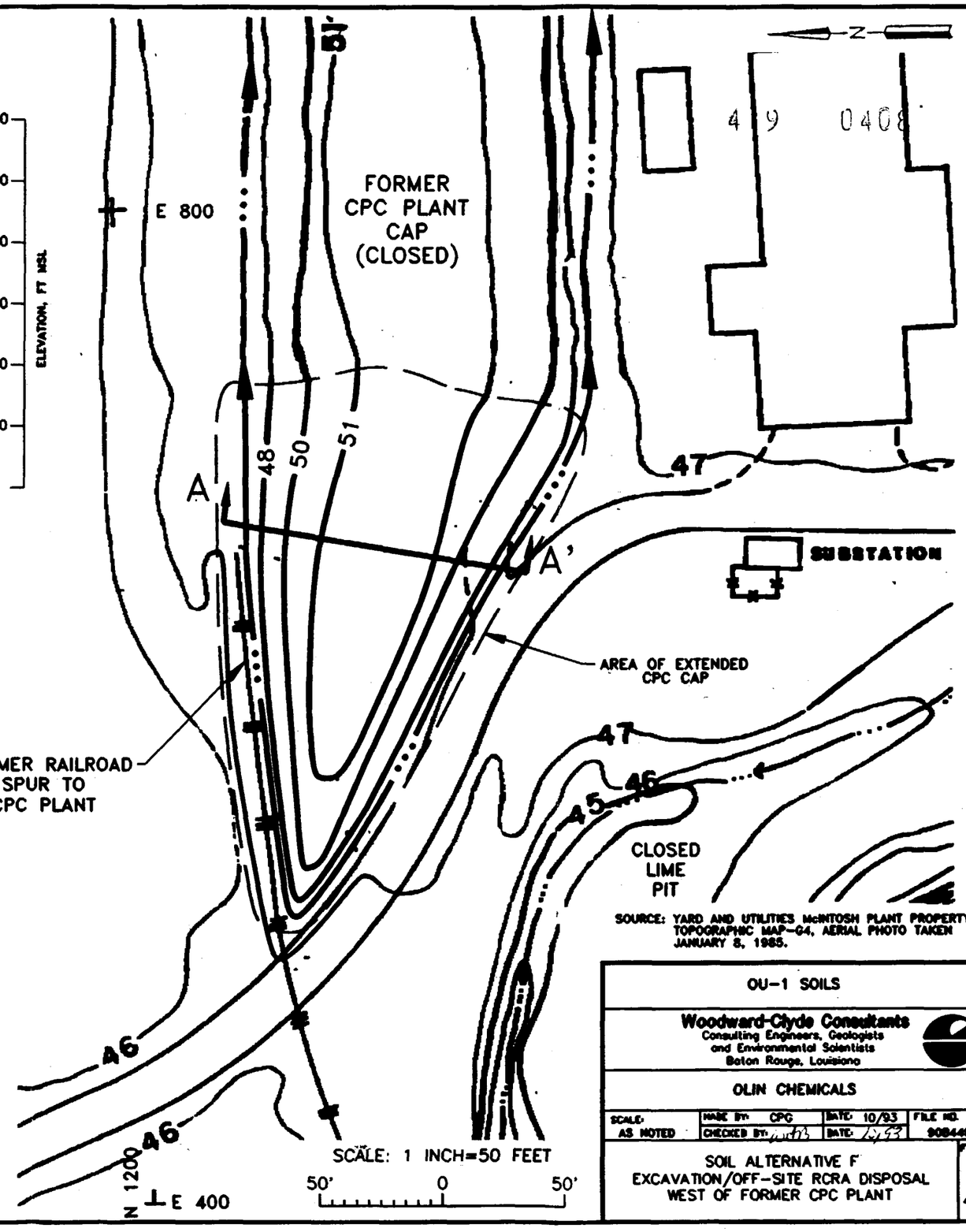
SCALE 1"=20'

NOTE: SUBSURFACE SOILS HAVE BEEN GENERALIZED
ACTUAL CONDITIONS MAY VARY



CLAY CAP
DETAIL 1

NOT TO SCALE



SOURCE: YARD AND UTILITIES McINTOSH PLANT PROPERTY TOPOGRAPHIC MAP–G4, AERIAL PHOTO TAKEN JANUARY 8, 1985.

OU–1 SOILS

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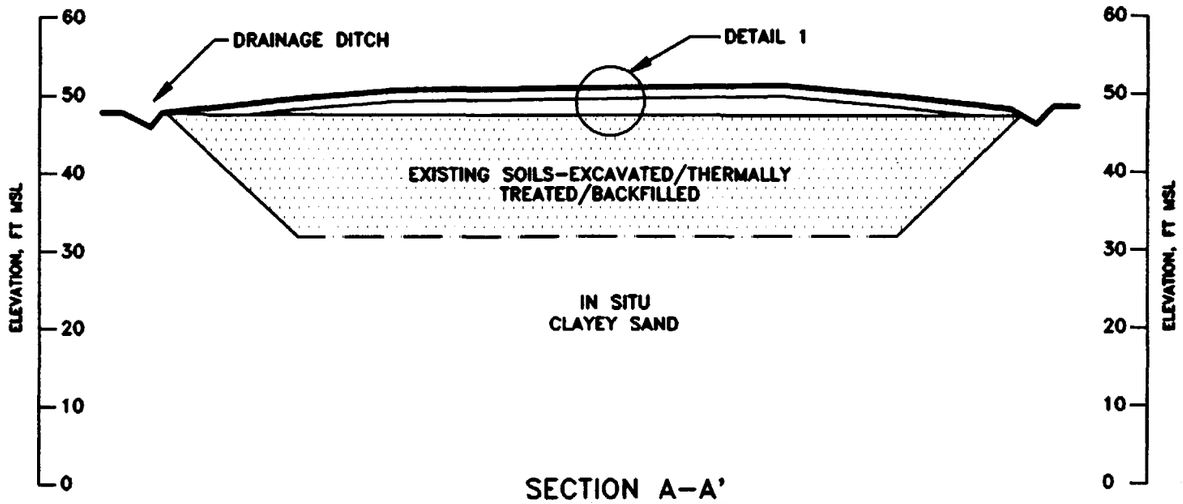
	CHECKED BY:	DATE:	

SOIL ALTERNATIVE F
EXCAVATION/OFF–SITE RCRA DISPOSAL
WEST OF FORMER CPC PLANT

FIGURE 4–16

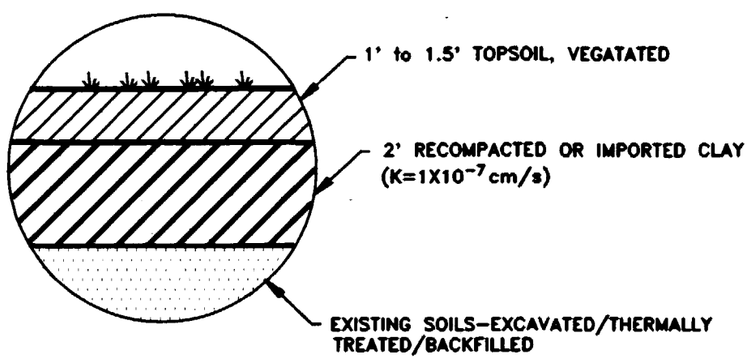
Location: B.R.LA File name: K:\DRWG\OLIN\90B449C\08449C03.DWG Last edited: 10/04/93 ● 15:09



SECTION A-A'

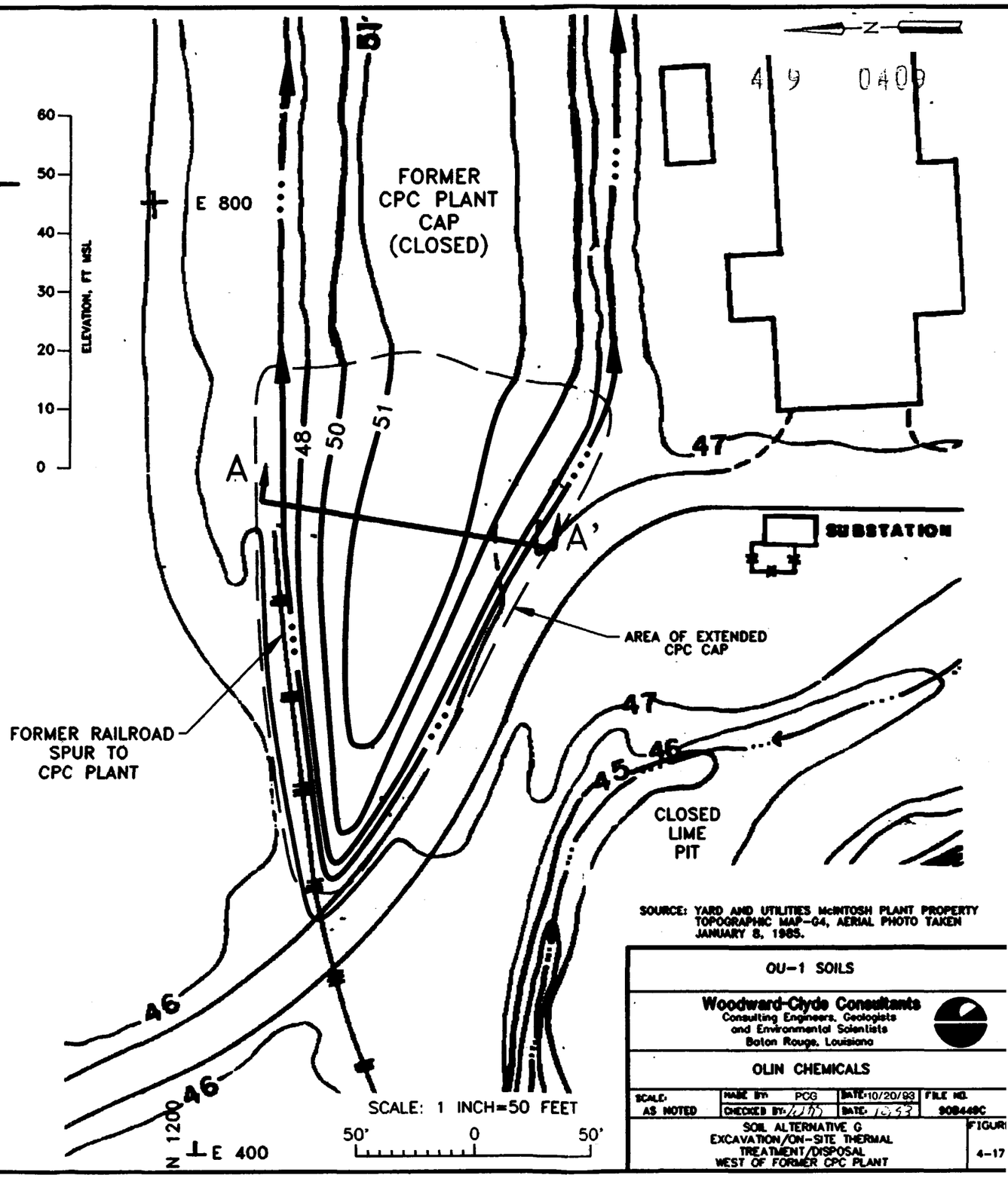
SCALE 1"=20'

NOTE: SUBSURFACE SOILS HAVE BEEN GENERALIZED
ACTUAL CONDITIONS MAY VARY



CLAY CAP
DETAIL 1

NOT TO SCALE



SOURCE: YARD AND UTILITIES McINTOSH PLANT PROPERTY TOPOGRAPHIC MAP-G4, AERIAL PHOTO TAKEN JANUARY 8, 1985.

OU-1 SOILS

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OLIN CHEMICALS

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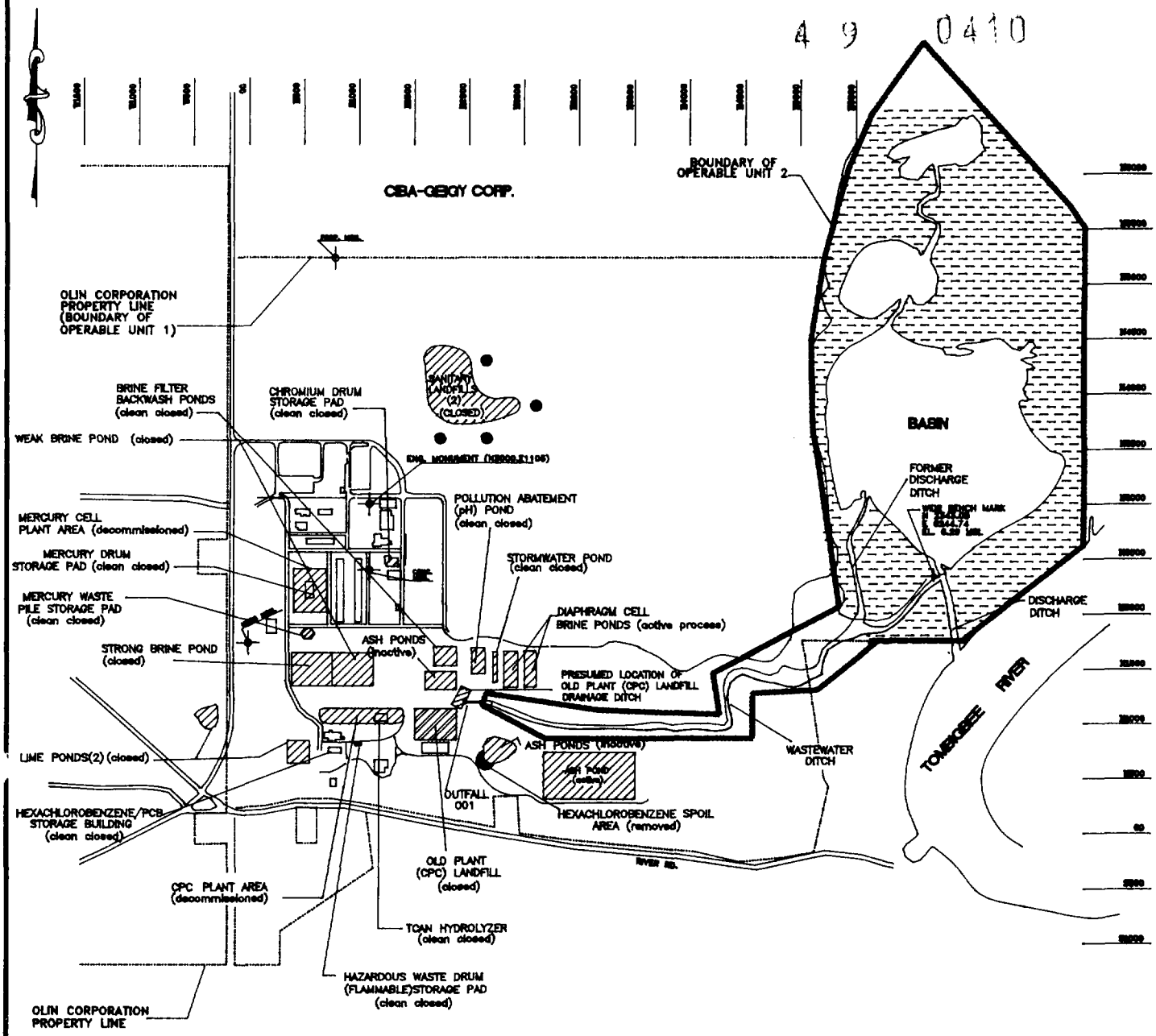
	CHECKED BY:	DATE:	

SOIL ALTERNATIVE G
EXCAVATION/ON-SITE THERMAL TREATMENT/DISPOSAL
WEST OF FORMER CPC PLANT

FIGURE 4-17

Location: B.R.,LA File name: K:\DRWG\OLIN\908449C\08449C03.DWG Last edited: 10/04/93 ● 15:09

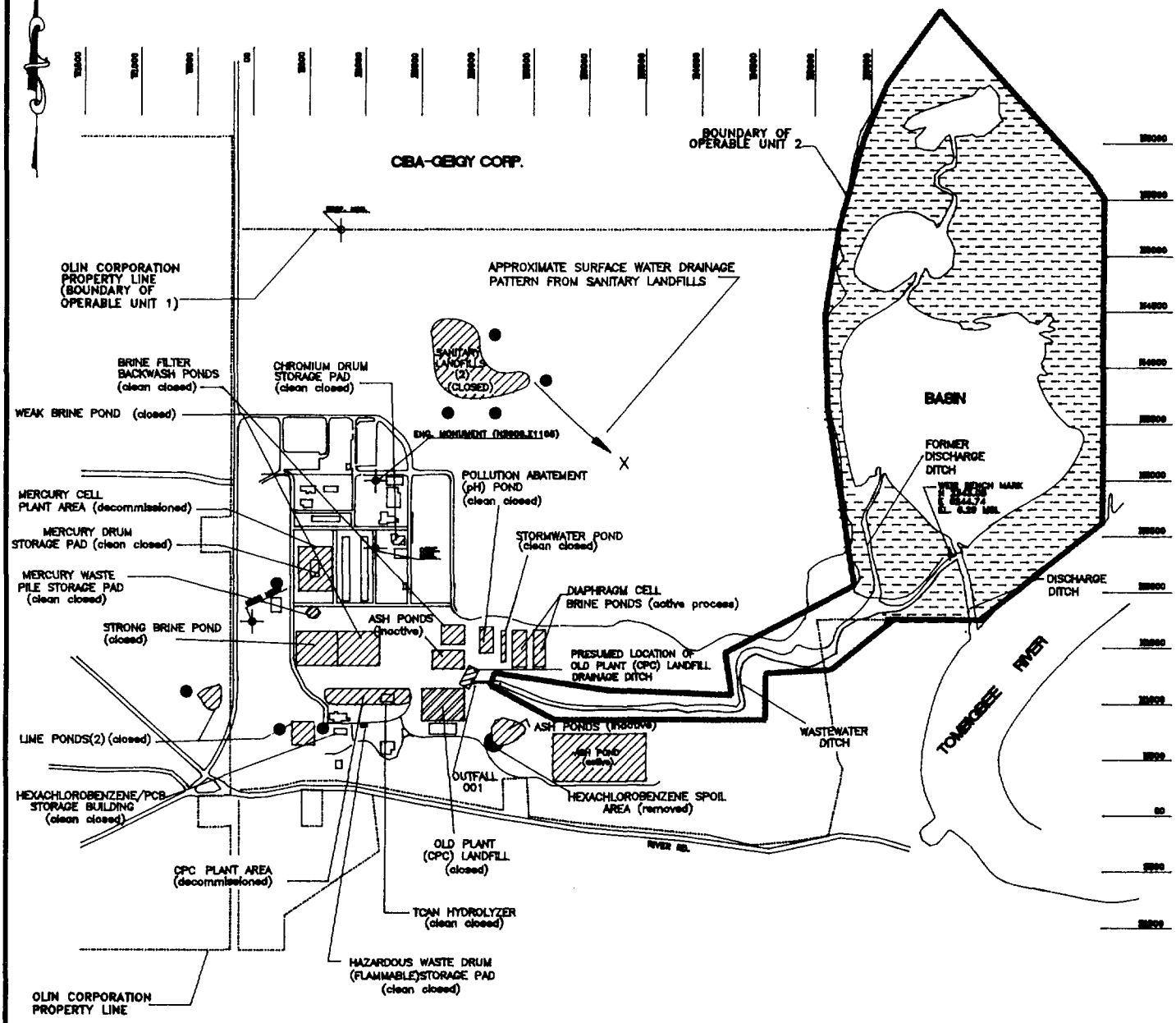
4 9 0410



Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CXI.DWG Last edited: 10/19/93 ● 14:28

OLIN CHEMICALS	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	SOIL ALTERNATIVE B1 INSTITUTIONAL ACTIONS	FILE NO. 90B449C
	SCALE: SHOWN / DRAWN BY: PCG / DATE: 10/19/93 / CHKD. BY: JAB / DATE: 10/93		FIG. NO. 4-18

4 9 0411



LEGEND:

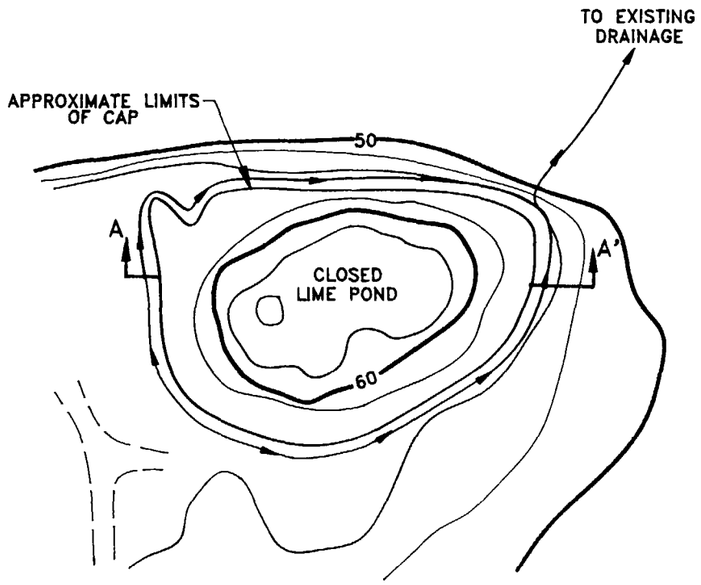
- BOUNDARY OF OU-1
- BOUNDARY OF OU-2
- WETLAND AREA
- ● POTENTIAL LOCATIONS FOR UPPER ZONE AND LOWER ZONE ALLUVIAL AQUIFER MONITOR WELLS
- X POTENTIAL LOCATION FOR SURFACE WATER SAMPLING POINT

0 500 1000 1500
SCALE IN FEET

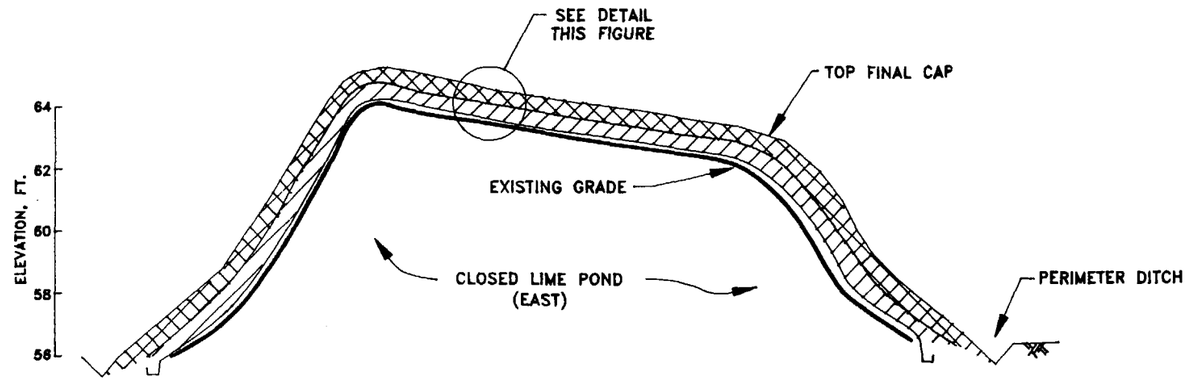
Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CXH.DWG Last edited: 10/19/93 ● 15:42

OLIN CHEMICALS	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	SOIL ALTERNATIVE B2 EXPANDED INSTITUTIONAL ACTIONS	FILE NO. 90B449C
	SCALE: SHOWN / DRAWN BY: PCG / DATE: 10/19/93 / CHKD. BY: DAB / DATE: 10/93		FIG. NO. 4-19

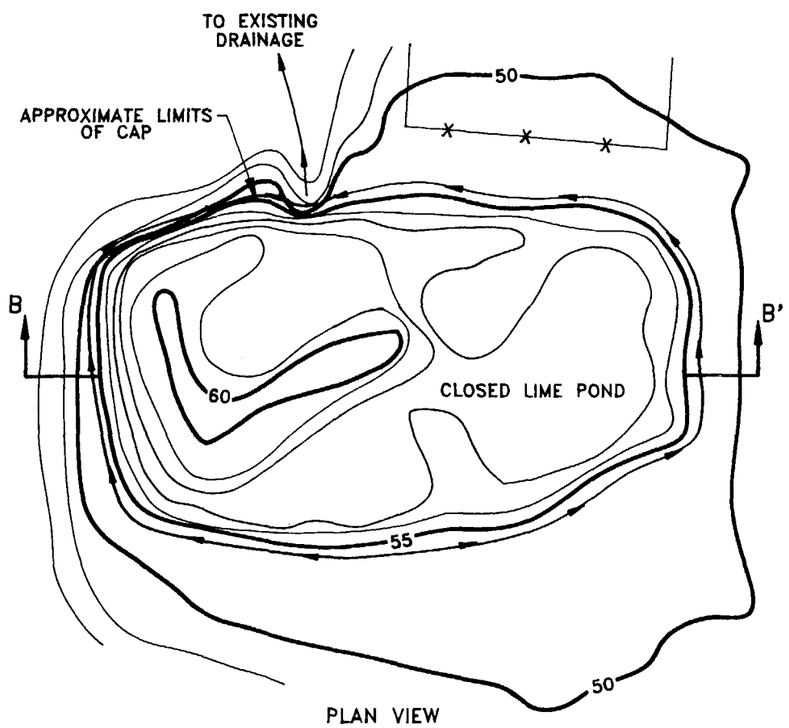
4 9 0412



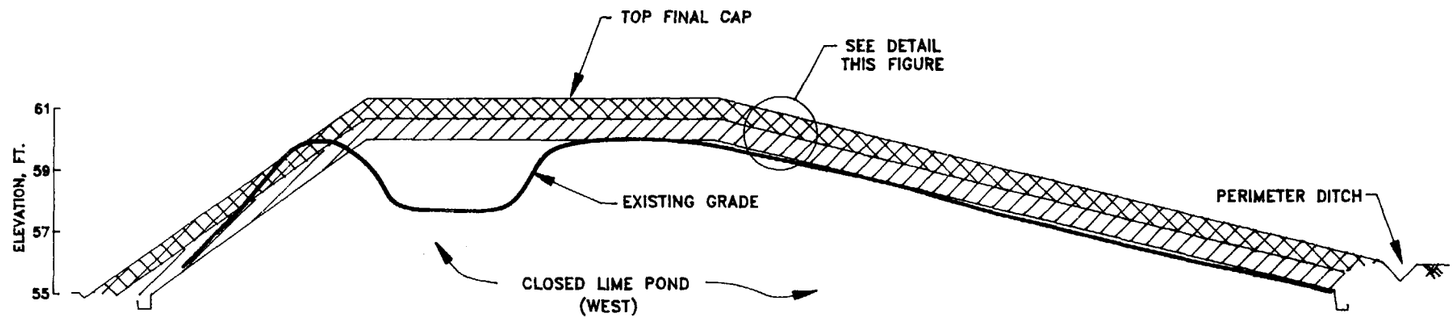
PLAN VIEW
EAST LIME POND
1"=80'



SECTION A–A'
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'

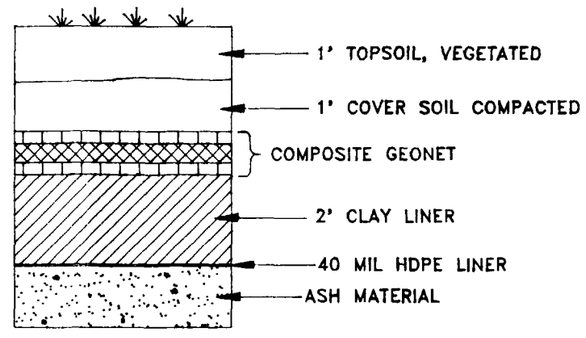


PLAN VIEW
WEST LIME POND
1"=80'



SECTION B–B'
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'

NOTES: (1) THE FINAL GRADES SHOWN ARE CONCEPTUAL ONLY NOTE VERTICAL EXAGGERATION.
(2) COVER ON SECTIONS ARE NOT DRAWN TO SCALE.



CAP DETAIL
N.T.S.

DATE	REVISION	DRWN/CHKD

OU-1 SOILS

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OLIN CHEMICALS

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	CHECKED BY: WAB	DATE: 10/13/93	

SOIL ALTERNATIVES C1 AND C2 CONTAINMENT (LIME PONDS)

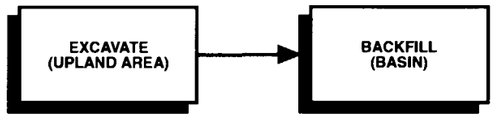
FIGURE 4-20

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449C05.DWG Last edited: 10/13/93 ● 09:47

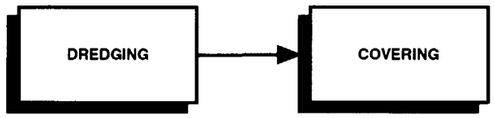
- **ALTERNATIVE A: NO ACTION**
- **ALTERNATIVE B: INSTITUTIONAL ACTIONS**

BASIN

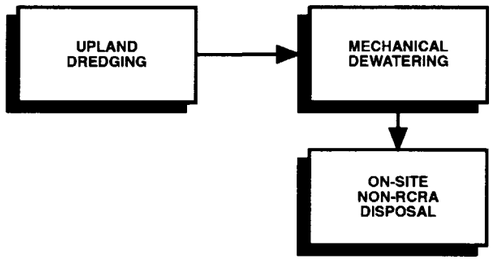
- **ALTERNATIVE C: BACKFILLING**



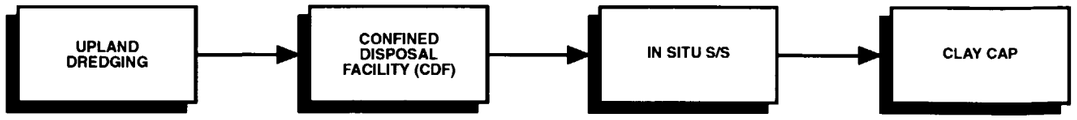
- **ALTERNATIVE D: DREDGING/COVERING (CONTAINED AQUATIC DISPOSAL)**



- **ALTERNATIVE E1: DREDGING/DISPOSAL (MECHANICAL DEWATERING)**



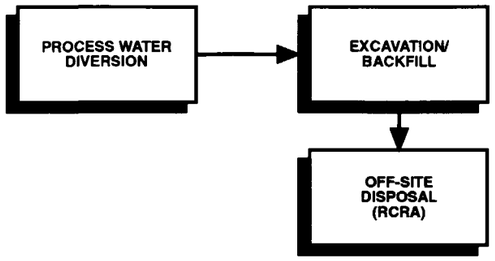
- **ALTERNATIVE E2: DREDGING/DISPOSAL (CONFINED DISPOSAL FACILITY)**



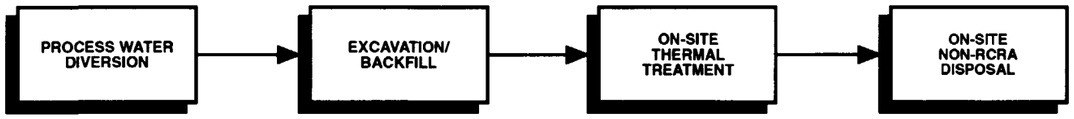
WASTEWATER DITCH

- **ALTERNATIVE C1: CONTAINMENT (BACKFILL)**

- **ALTERNATIVE E: EXCAVATION/DISPOSAL**



- **ALTERNATIVE G1: EXCAVATION/ON-SITE THERMAL TREATMENT/DISPOSAL**



RI/FS
McINTOSH PLANT SITE

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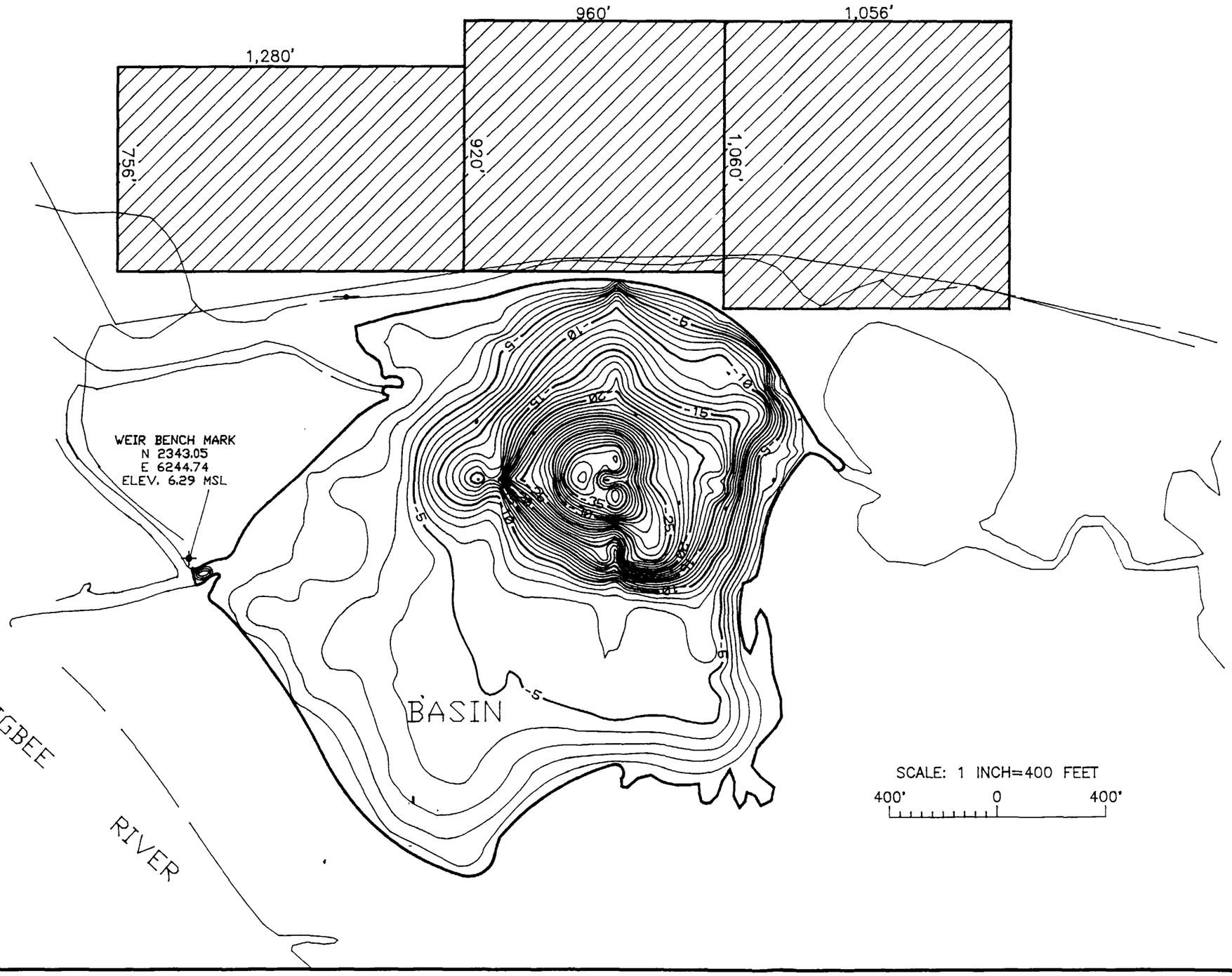
Baton Rouge, Louisiana

Olin CHEMICALS
CHARLESTON, TENNESSEE

SCALE:	DRAWN BY: D.P. OLSON	DATE: 05/04/93	FILE NO.	FIGUR
N/A	CHECKED BY: W. BEAL	DATE: 05/04/93	90B449C-6	4-21

SUMMARY OF RETAINED OU-2
SEDIMENT ALTERNATIVES



N

LEGEND:

– AVAILABLE BORROW (DEPTH OF CUT 13' TO 18')

SCALE: 1 INCH=400 FEET

400' 0 400'

DATE	REVISION	DRWN/CHKD

OU-2 BASIN

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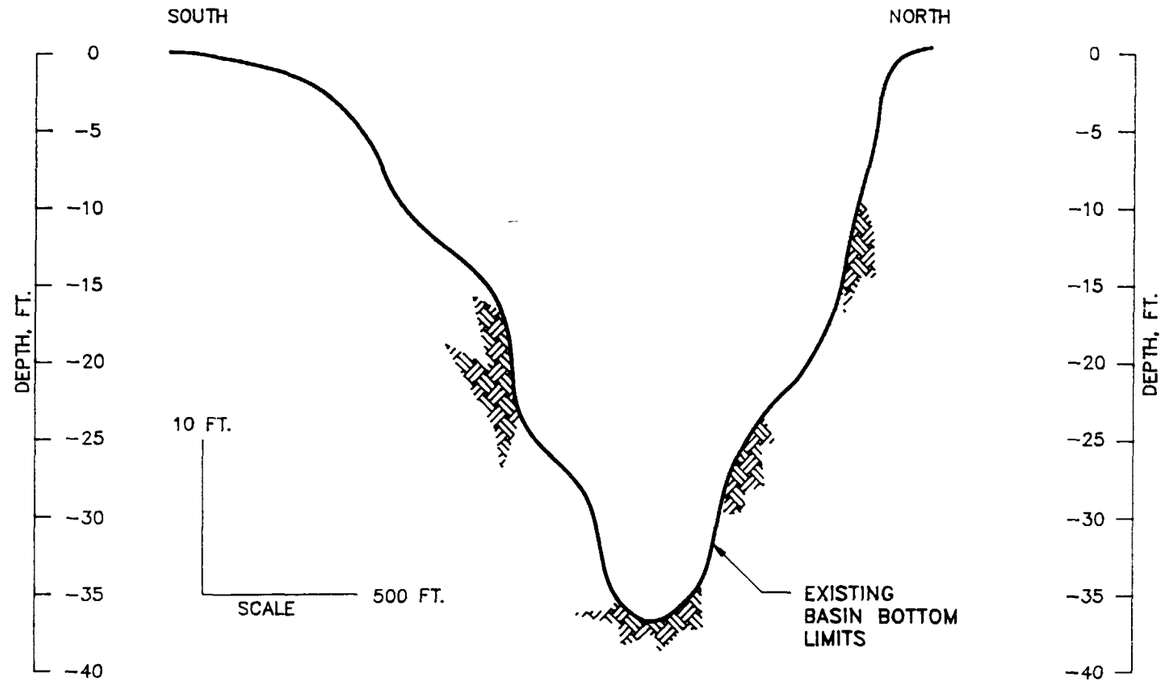
AS SHOWN	CHECKED BY:	DATE: 5/2/93	90B449C

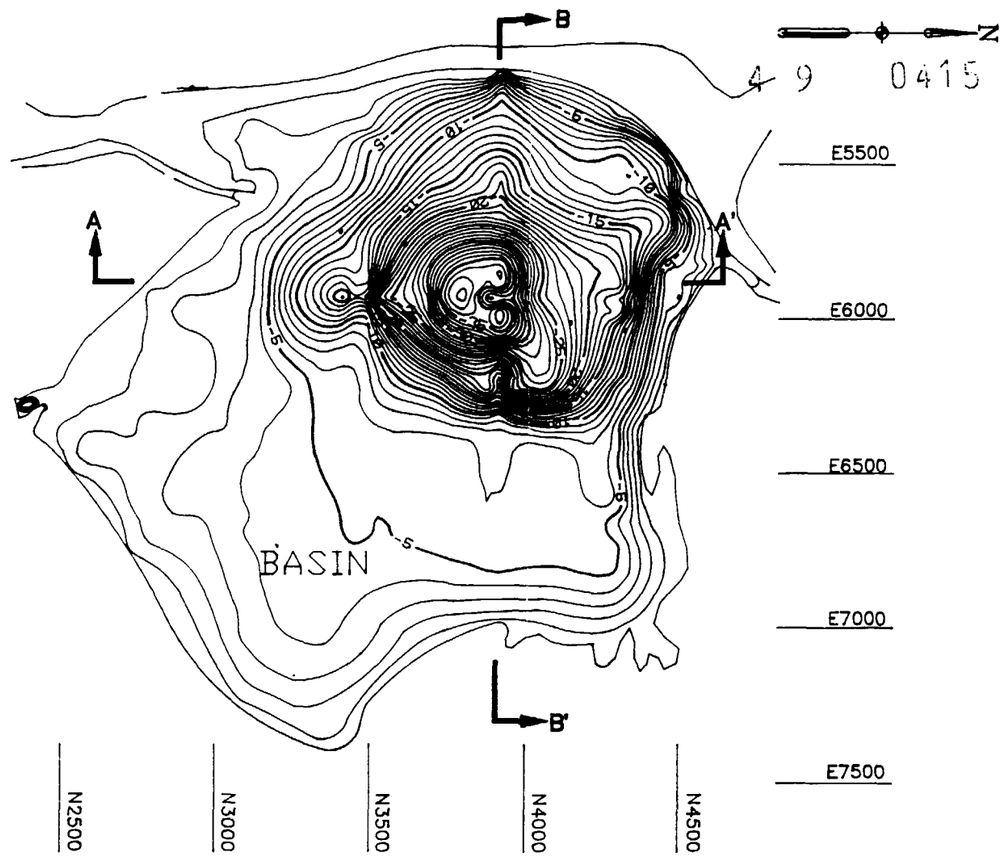
BASIN SEDIMENT ALTERNATIVE C
BACKFILLING

FIGURE 4-22

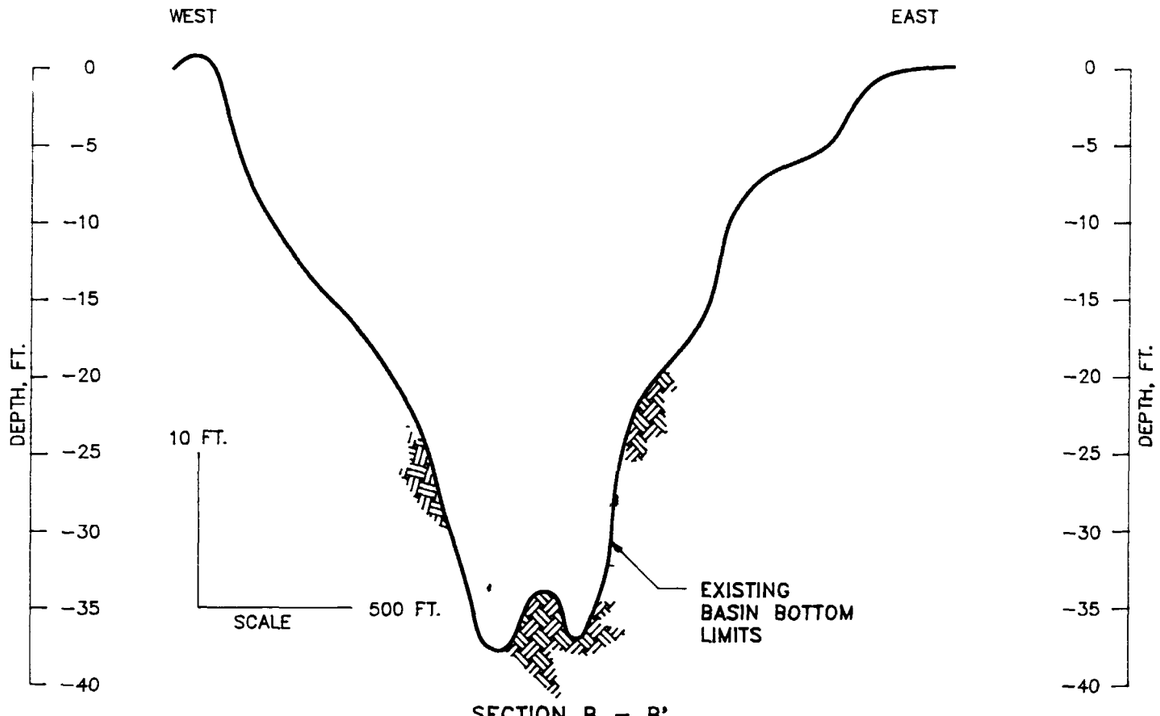
Location: B.R.LA File name: K:\DRWG\OLIN\90B449C\0B449CBE.DWG Last edited: 05/04/93 @ 09:57



SECTION A – A'



PLAN VIEW
SCALE: 1"=500'



SECTION B – B'

DATE	REVISION	DRVN/CHKD

OU-2 BASIN

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Baton Rouge, Louisiana

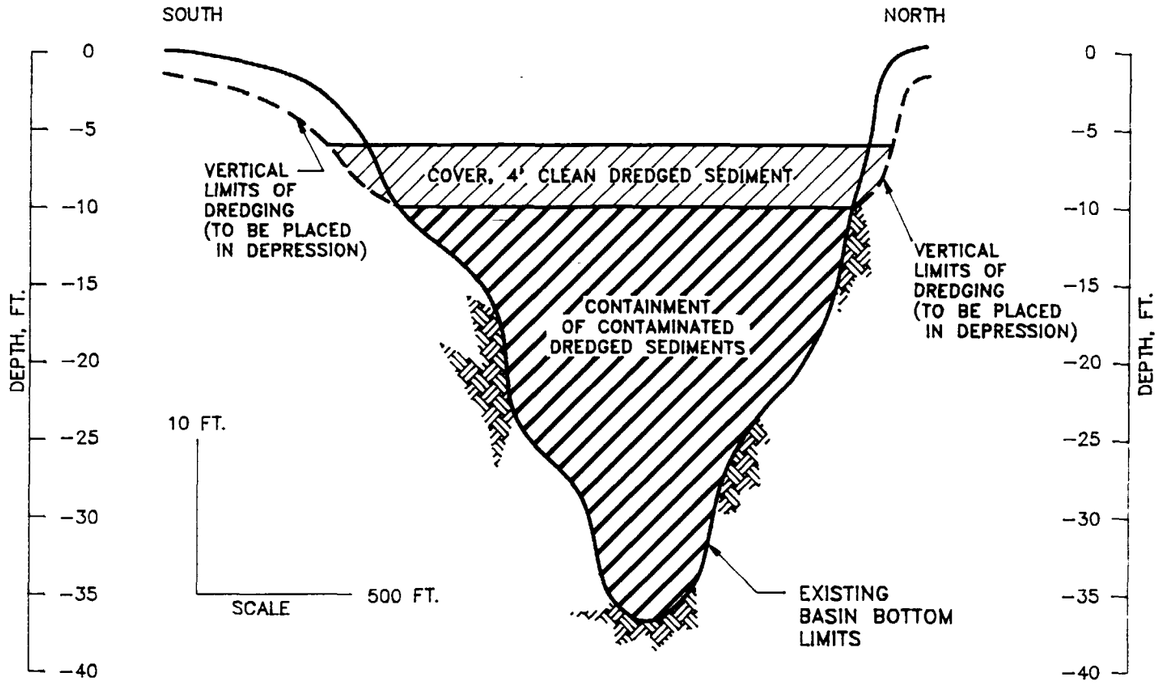
OLIN CHEMICALS

SCALE: AS SHOWN	MADE BY: G THORNTON	DATE: 3/29/93	FILE NO. 90B449C
	CHECKED BY: F. Sicilia	DATE: 5/4/93	

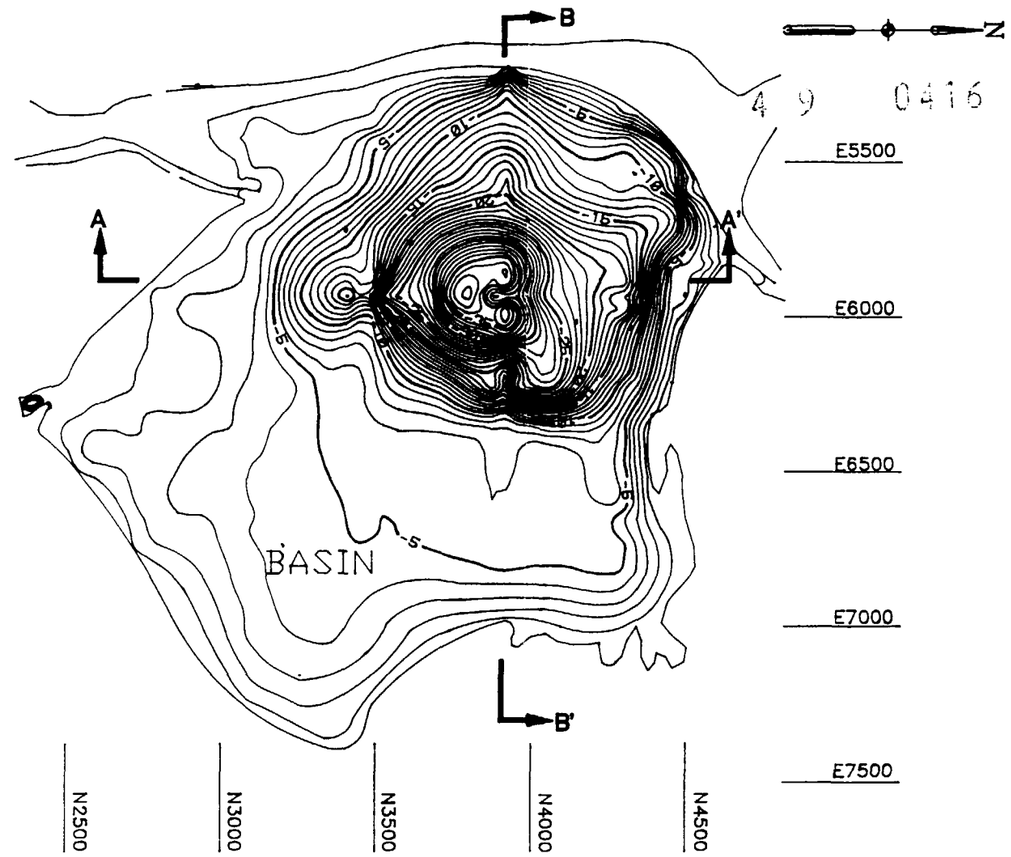
EXISTING BASIN BOTTOM LIMITS AND CROSS SECTIONS

FIGURE 4-23

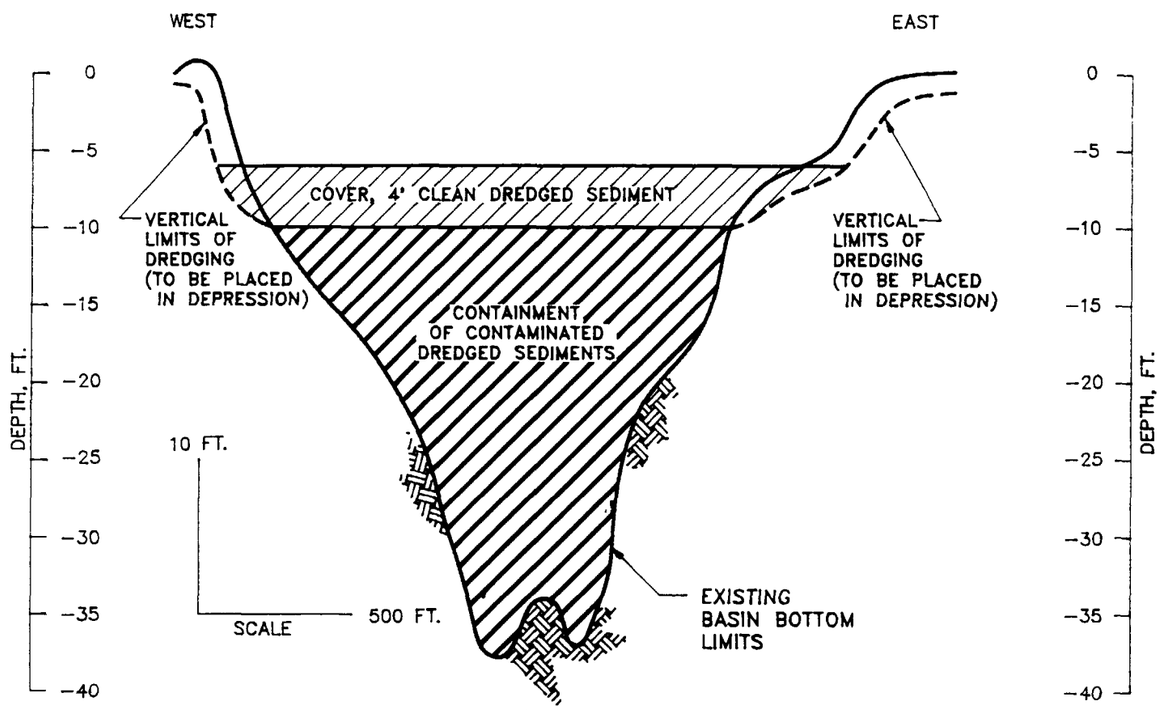
Location: B.R.LA File name: K:\DRWG\OLIN\90B449C\OB449C2D.DWG Last edited: 05/04/93 @ 10:27



SECTION A – A'



PLAN VIEW
SCALE: 1"=500'



SECTION B – B'

DATE	REVISION	DRVN/CHKD

OU–2 BASIN

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OLIN CHEMICALS

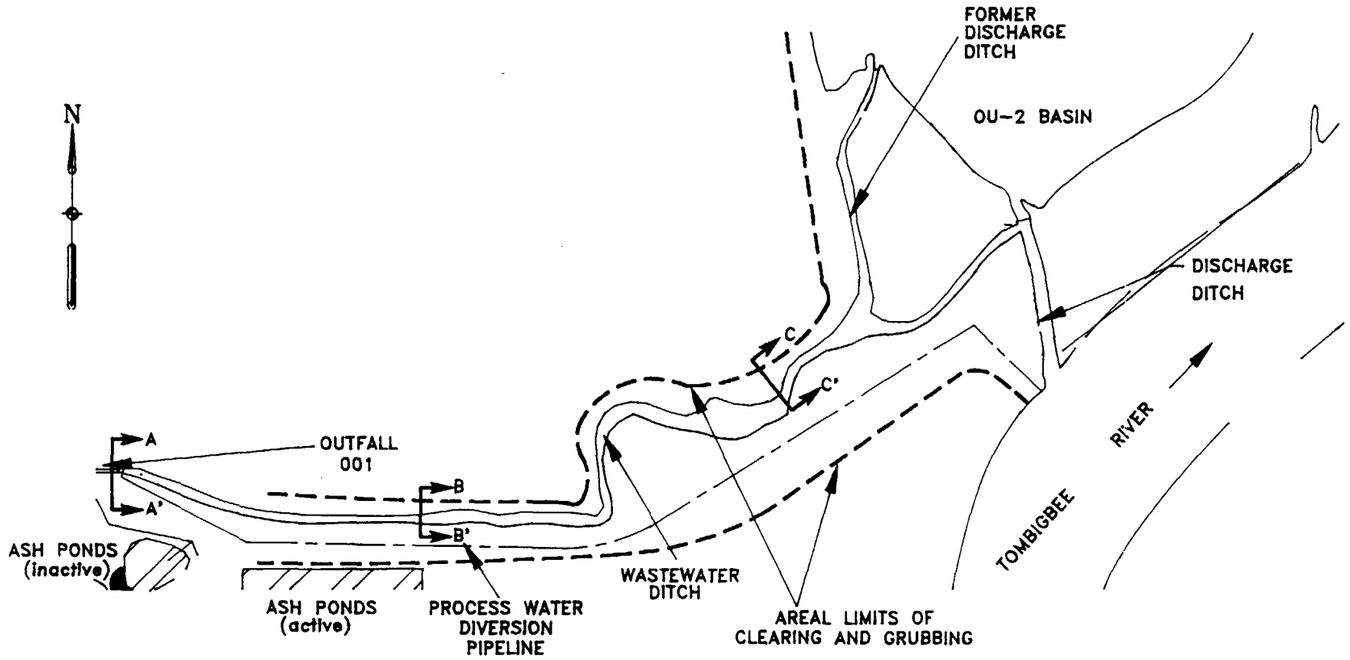
SCALE:	MADE BY: G THORNTON	DATE: 3/25/93	FILE NO.
AS SHOWN	CHECKED BY: F. Sera	DATE: 5/4/93	90B449C

BASIN SEDIMENT ALTERNATIVE D
DREDGING/COVERING
(CONTAINED AQUATIC DISPOSAL)

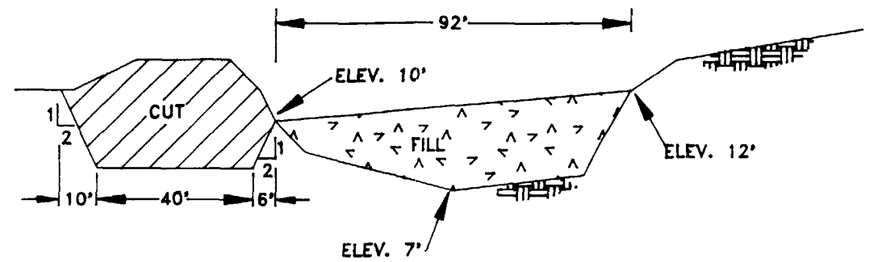
FIGURE 4-24

Location: BR_LA File name: K:\DRWG\OLIN\90B449C\0B449CBD.DWG Last edited: 05/04/93 @ 10:38

4 9 0417

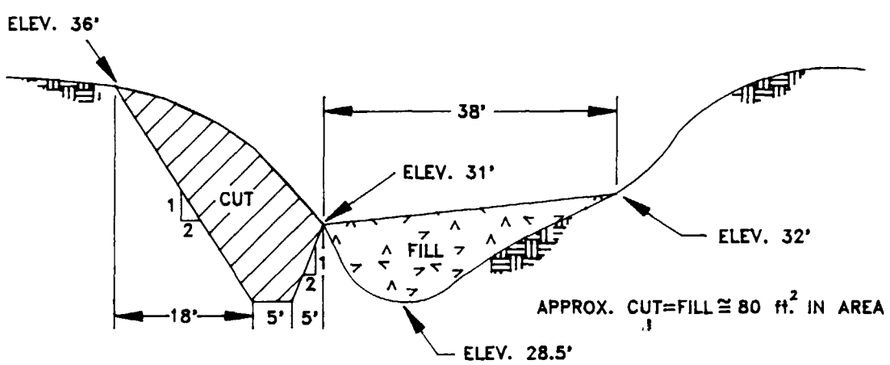


PLAN VIEW
N.T.S.



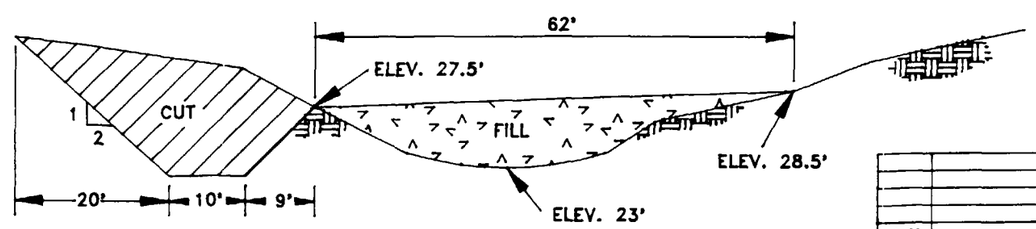
CUT=FILL ≅ 300 ft.^{2} IN AREA

SECTION C–C'
SCALE:
VERTICAL – 1"=10'
HORIZONTAL – 1"=40'



APPROX. CUT=FILL ≅ 80 ft.^{2} IN AREA

SECTION A–A'
SCALE:
VERTICAL – 1"=5'
HORIZONTAL – 1"=20'



CUT=FILL ≅ 130 ft.^{2} IN AREA

SECTION B–B'
SCALE:
VERTICAL – 1"=10'
HORIZONTAL – 1"=20'

DATE	REVISION	DRWN/CHKD

OU–2 WASTEWATER DITCH

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OLIN CHEMICALS

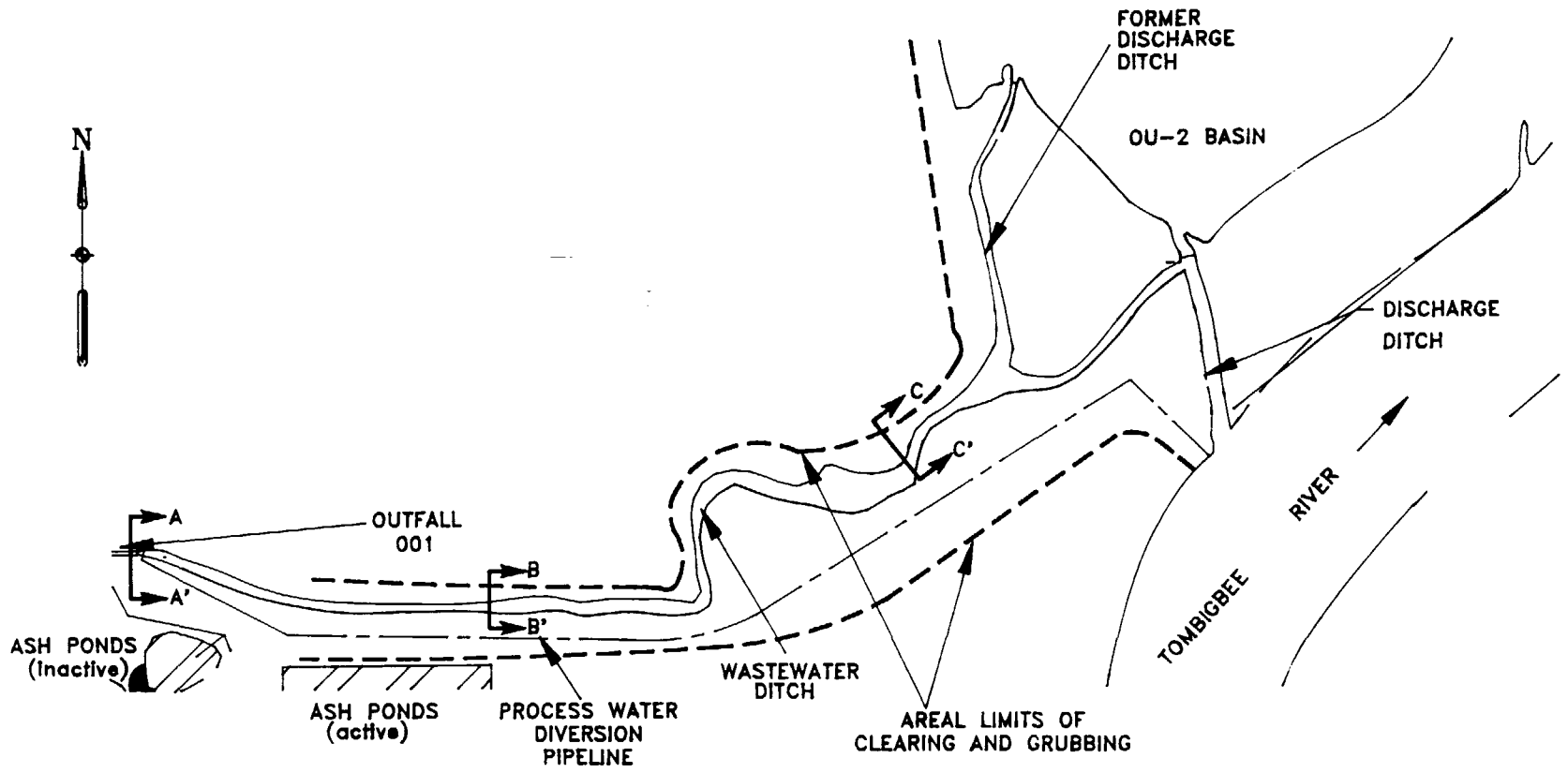
SCALE:	MADE BY: J. BICKFORD	DATE: 3/20/93	FILE NO.
1"=40'	CHECKED BY: F. Sieng	DATE: 5/3/93	90B449C

WASTEWATER DITCH SEDIMENT ALTERNATIVE C BACKFILLING

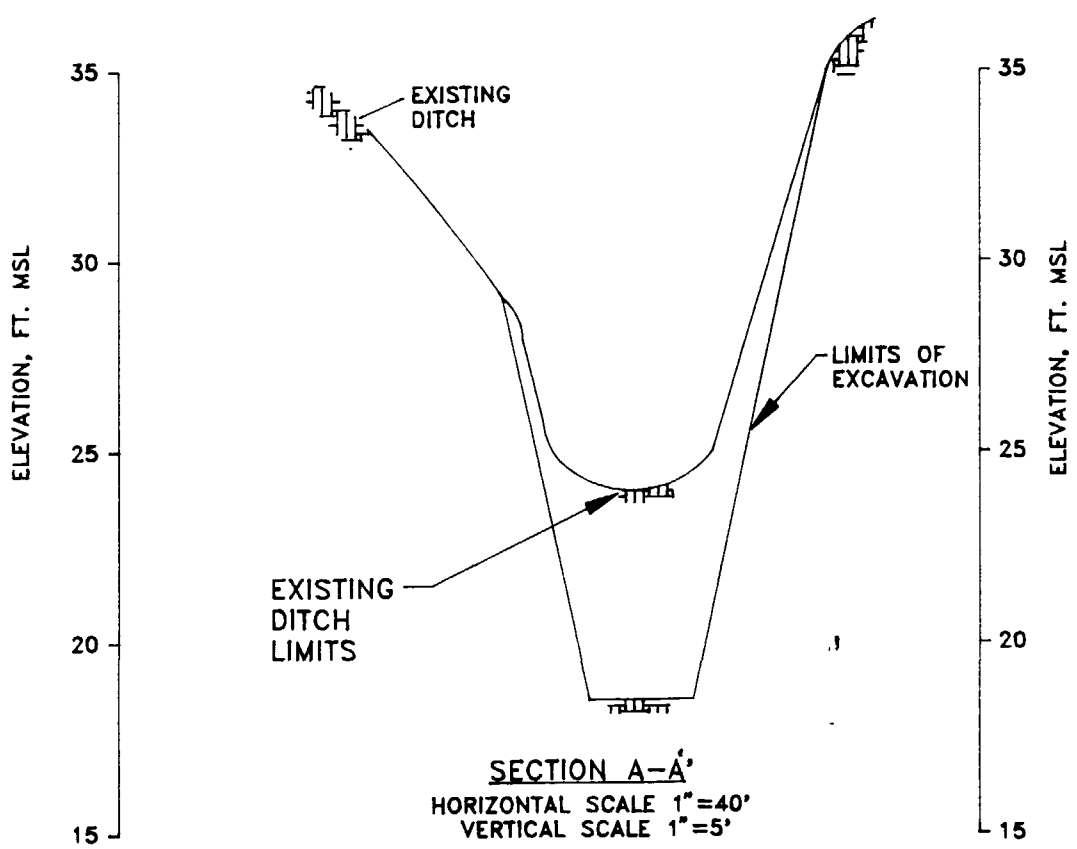
FIGURE 4-25

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CDA.DWG Last edited: 04/09/93 @ 14:32

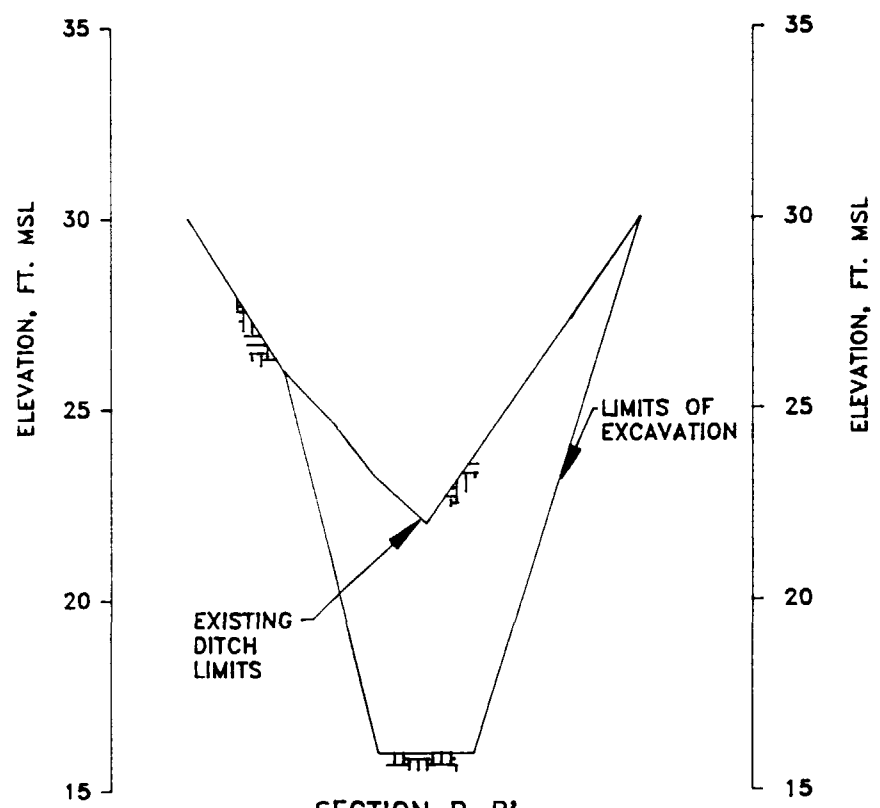
4 9 0418



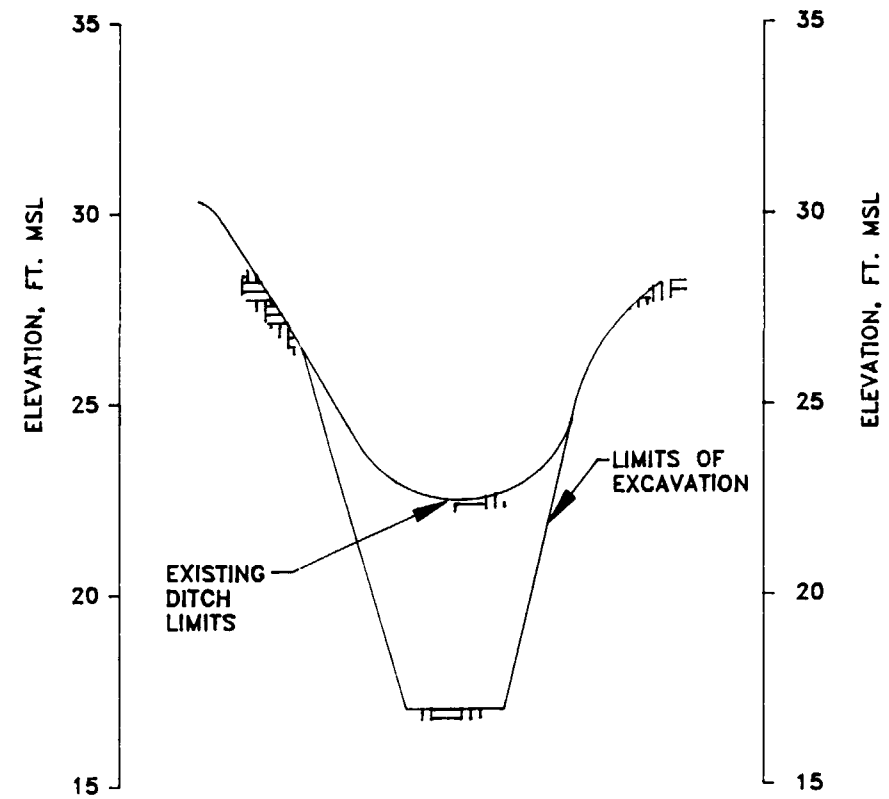
PLAN VIEW
N.T.S.



SECTION A–A'
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'



SECTION B–B'
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'



SECTION C–C'
HORIZONTAL SCALE 1"=40'
VERTICAL SCALE 1"=5'

DATE	REVISION	DRVN/CHKD

OU–2 WASTEWATER DITCH

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Baton Rouge, Louisiana

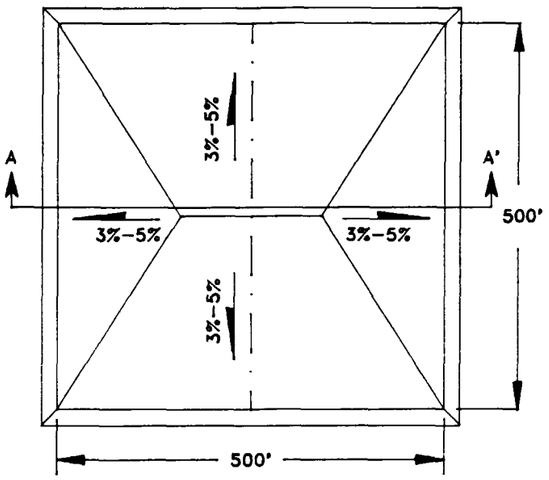
OLIN CHEMICALS

SCALE: 1"=40'	MADE BY: J. BICKFORD	DATE: 3/20/93	FILE NO. 90B449C
	CHECKED BY: R. Giang	DATE: 5/4/93	

WASTEWATER DITCH SEDIMENT ALTERNATIVES E AND G1 INVOLVING EXCAVATION

FIGURE 4-26

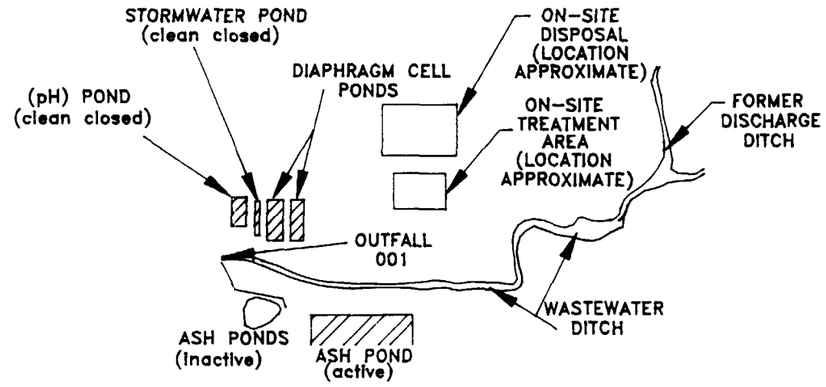
Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CDA.DWG Last edited: 04/09/93 @ 14:32



ON-SITE LANDFILL

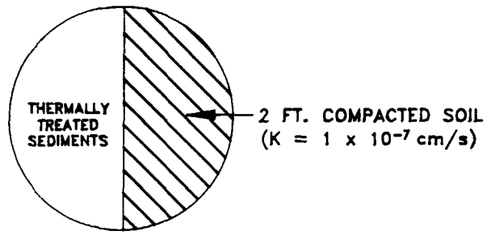
PLAN VIEW

N.T.S.



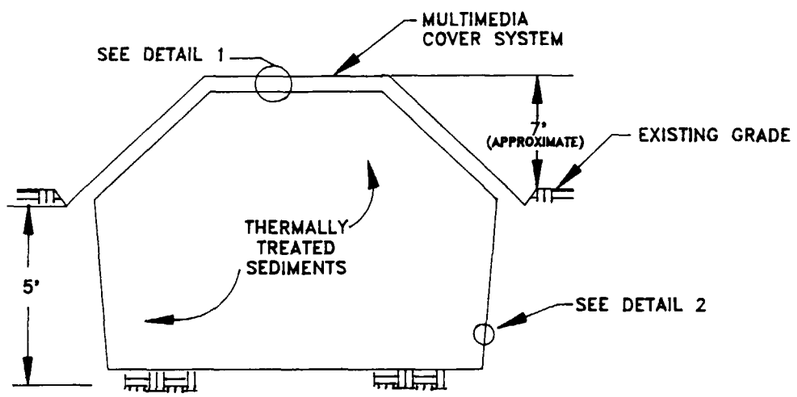
VICINITY MAP OF ON-SITE DISPOSAL

N.T.S.



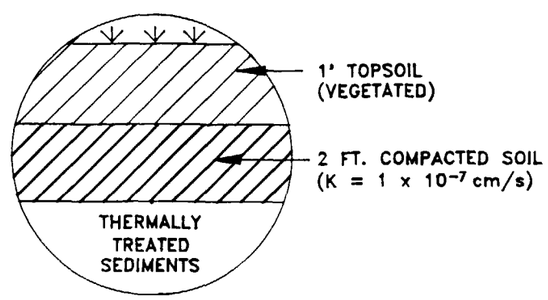
DETAIL 2

N.T.S.



SECTION A-A'

N.T.S.



DETAIL 1

N.T.S.

DATE	REVISION	DRWN/CHKD

OU-2 WASTEWATER DITCH

Woodward-Clyde Consultants
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and Environmental Scientists
Baton Rouge, Louisiana

OLIN CHEMICALS

SCALE:	MADE BY: J. BICKFORD	DATE: 3/20/93	FILE NO.
N.T.S.	CHECKED BY: F. Sierra	DATE: 5/4/93	90B449C

WASTEWATER DITCH SEDIMENT ALTERNATIVE G1
EXCAVATION/ON-SITE THERMAL TREATMENT/DISPOSAL

FIGURE 4-27

Location: B.R.,LA File name: K:\DRWG\OLIN\90B449C\0B449CCA.DWG Last edited: 04/08/93 @ 08:32

Section 5

5.0
REFERENCES

Betz Environmental Engineers and J. B. Converse and Company, Inc. 1977. Environmental Impact Assessment for Proposed Chlor-Alkali Expansion, McIntosh, Alabama.

BCM Converse, Inc. (BMC). 1992. Remedial Investigation Feasibility Study. Remedial Investigation Report Addendum. Ecological Assessment of the Floodplain. Submitted to Ciba-Geigy Corporation, McIntosh, Alabama. November.

Center for Subsurface Modeling Support (CSMS). 1992. PESTAN, Pesticide Analytical Model, Version 5.0. Developed by V. Ravi and J. A. Johnson. Dynamac Corporation, Center for Subsurface Modeling Support. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma.

Chapman, P. M. 1989. Current approaches to developing sediment quality criteria. Environmental Toxicology and Chemistry. 8:589-599.

DeJarnette, S. S. 1989. Geohydrology and susceptibility of major aquifers to surface contamination in Alabama. Area 10. U.S. Geological Survey Water Resources Investigation Report. 88-40077. 23 pp.

Driscoll, F. G. 1986. Groundwater and wells. Johnson Division. St. Paul, MN. Table 5-1, p. 67.

ERM. 1989. Remedial investigation and risk assessment for Olin Corporation, McIntosh, Alabama. November.

Fitchko, J. 1989. Criteria for contaminated soil/sediment cleanup. Pudvan Publishing Company, Inc. Northbrook, Illinois.

Freeze, R. A., and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc.

International Ground Water Modeling Center (IGWMC). 1991. SOLUTE. A program package of analytical models for SOLUTE transport in groundwater. Version 2.03. Developed by M. S. Beljin. Colorado School of Mines.

Jeng, C. Y., D. H. Chen, and C. L. Yaws. 1992. Data compilation for soil coefficient pollution engineering, Volume 24, No. 12. pp 54-60.

Loux, N.T., C.R. Chafin, and S.M. Hassan, 1990. Statistics of Aquifer Material Properties and Empirical pH-dependent Partitioning Relationships for As(III), As(V), Ba(II), Be(II), Cd(II), Cr(VI), Cu(II), Hg(II), Ni(II), Pb(II), Sb(V), Se(VI), Tl(I) and Zn(II). U.S. EPA, Environmental Research Laboratory. Athens, Georgia. March.

Marcus, W. A. 1991. Managing contaminated sediments in aquatic environments: Identification, regulation, and remediation. Environmental Law Report 21:10020-10032

May, T. W., and G. L. McKinney. 1981. Cadmium, lead, mercury, arsenic, and selenium concentrations in freshwater fish, 1976-77 — National Pesticide Monitoring Program. Pesticide Monitoring Journal 15:14-38.

Montgomery, J. H. and L. M. Welkom. 1990. Groundwater Chemicals Desk Reference. Lewis Publishers.

Newell, A. J., D. W. Johnson, and L. K. Allen. 1987. Niagara River biota contamination project: Fish flesh criteria for piscivorous wildlife. New York State Department of Environmental Conservation, Technical Report 87-3, Division of Fish and Wildlife, Bureau of Environmental Protection. v+182 p.

Soil and Material Engineers, Inc. (S&ME). 1982. Hydrogeology of the Olin Chemical Group, McIntosh, Alabama Plant. November.

4 9 0422

Summer, K., S. Gherini, C. Cheu. 1980. Methodology to Evaluate the Potential for Groundwater Contamination from Geothermal Fluid Releases, Industrial Environmental Research Laboratory, U. S. Environmental Protective Agency (EPA). Cincinnati, Ohio.

Truitt, C. L. 1987. Engineering considerations for capping subaqueous dredged material deposits-design concepts and placement techniques: Environmental effects of dredging, technical notes. EEDP-09-1, U. S. Army Engineer Waterways Experiment Station, Vicksburg, Mississippi.

U. S. Environmental Protection Agency (EPA). 1986. Guidelines for ground-water classification under the EPA ground-water protection strategy. Office of Ground-water Protection. Draft. December.

U. S. Environmental Protection Agency (EPA). 1988a. Guidance for conducting remedial investigations and feasibility studies under CERCLA. Interim final. Office of Solid Waste and Emergency Response (OSWER). Directive 9355.3-0.1.

U. S. Environmental Protection Agency (EPA). 1988b. CERCLA compliance with other laws manual. Draft. OSWER Directive 9355.3-02. March.

U. S. Environmental Protection Agency (EPA). 1989. Guide to treatment technologies for hazardous wastes at Superfund sites.

U. S. Environmental Protection Agency (EPA). 1990. Background Document for EPA's Composite Model for Landfills (EPA CML), Office of Solid Waste. Washington, D.C.

U. S. Environmental Protection Agency (EPA). 1991a. Risk assessment guidance for Superfund: Volume I: Human health evaluation manual, part C. Risk evaluation of remedial alternatives. Interim. December.

U. S. Environmental Protection Agency (EPA). 1991b. Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions. OSWER Directive 9355.0-30. April.

U. S. Environmental Protection Agency (EPA). 1992. Hydrologic evaluation of landfill performance (HELP) model. Department of the Army. Internal Working Document EL-9

U. S. Fish and Wildlife Service. 1992. Inflated Heelsplitter, (Potamilus inflatus) Recovery Plan. U. S. Fish and Wildlife Service. Jackson, Mississippi. 15 pp.

Walton, W. C. 1988. Practical Aspects of Groundwater Modeling. National Water Well Association. Ohio.

Walton, W. C. 1989. Analytical groundwater modeling. Lewis Publishers.

Woodward-Clyde Consultants (WCC). 1991. Work Plan. Remedial Investigation (RI)/Feasibility Study (FS). McIntosh Plant Site, Olin Corporation, McIntosh, Alabama. May.

Woodward-Clyde Consultants (WCC). 1992. Treatability study work plan/sampling and analysis plan. Remedial investigation (RI)/feasibility study (FS). McIntosh plant site. Olin Corporation. McIntosh, Alabama. October.

Woodward-Clyde Consultants (WCC). 1993. Draft remedial investigation report, McIntosh plant site, Olin Corporation, McIntosh, Alabama. February.

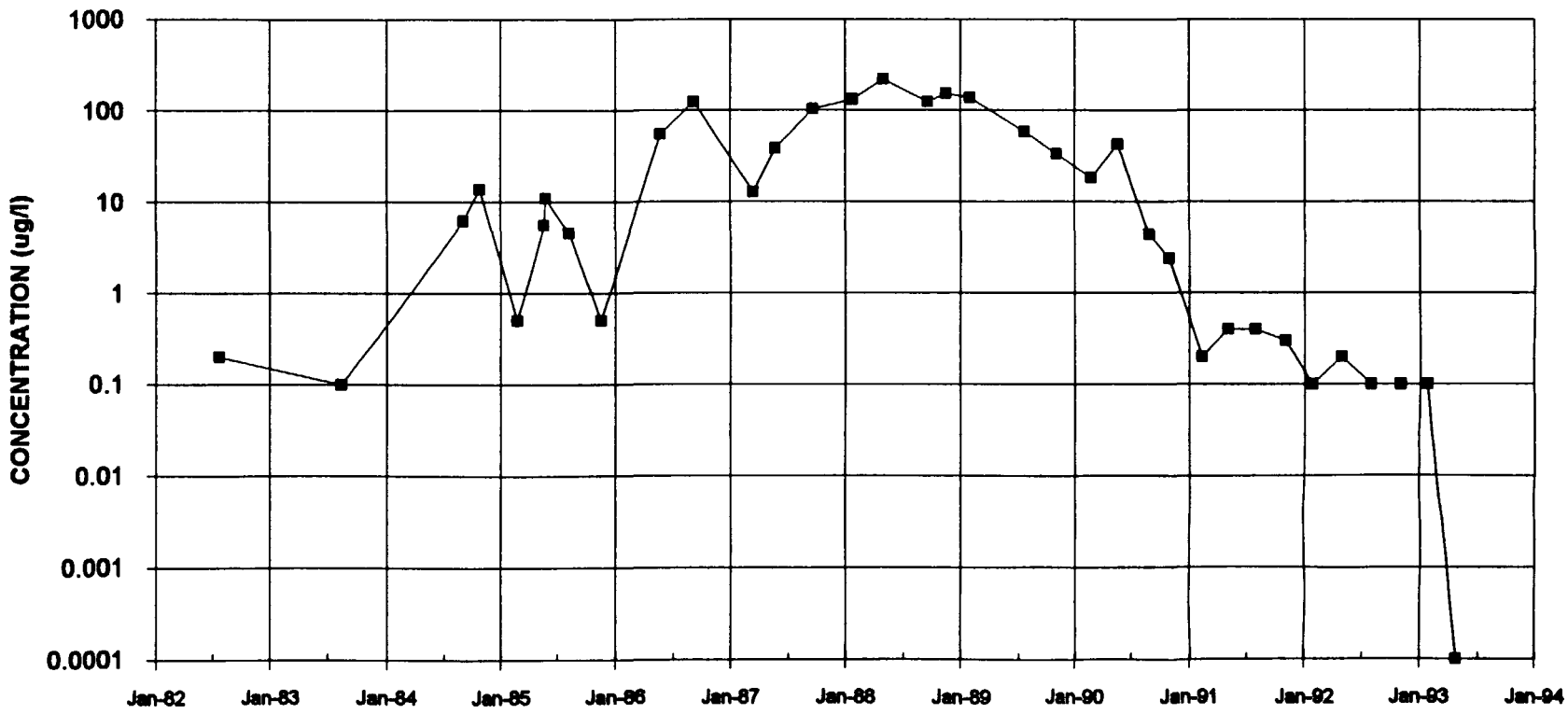
Appendix A

APPENDIX A

HYDROGRAPHS, GROUNDWATER CALCULATIONS AND ANALYTICAL MODELING RESULTS

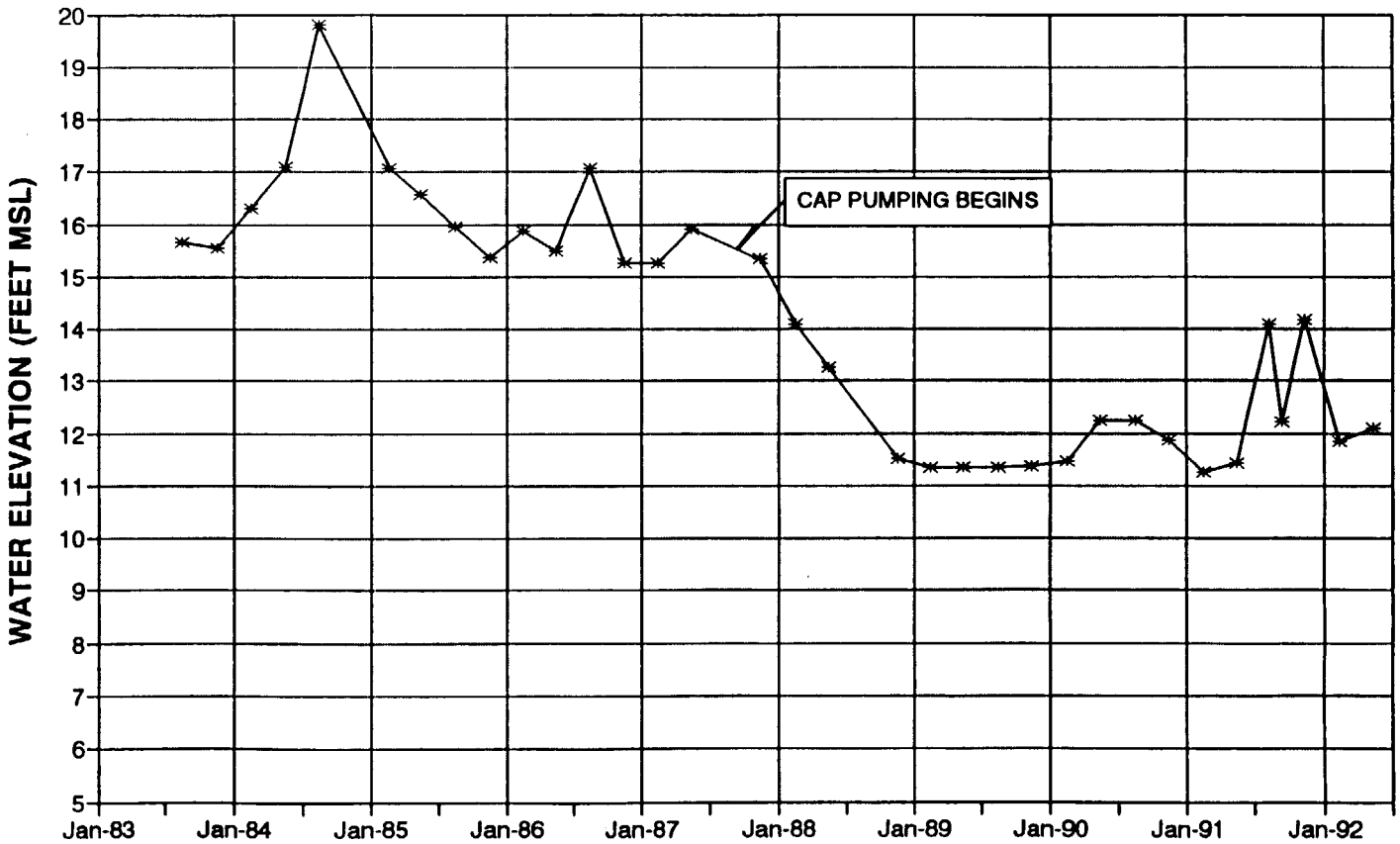
TIME VS. CONCENTRATION CURVE

MONITOR WELL E-1



HYDROGRAPHS

MONITOR WELL BR-10



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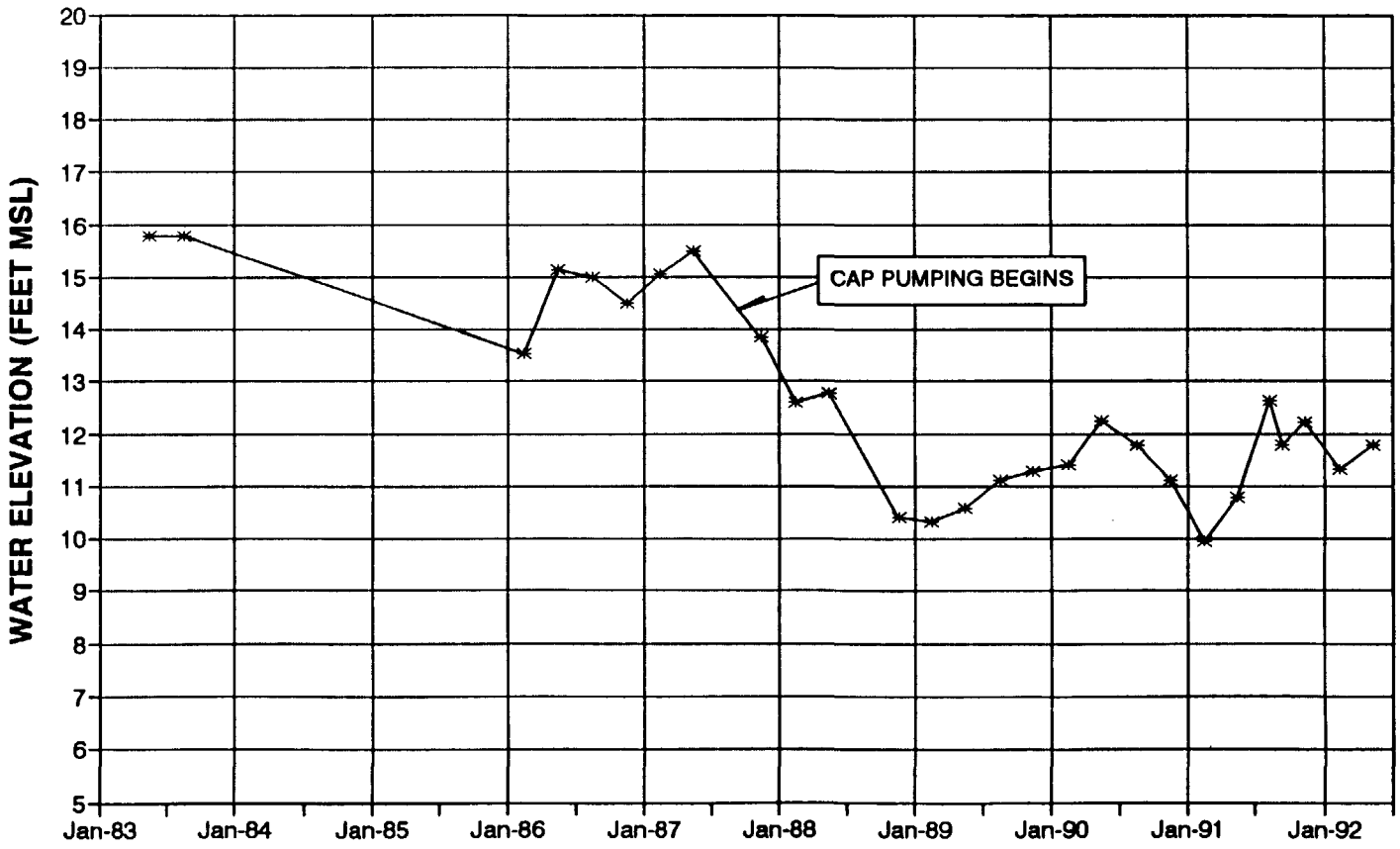

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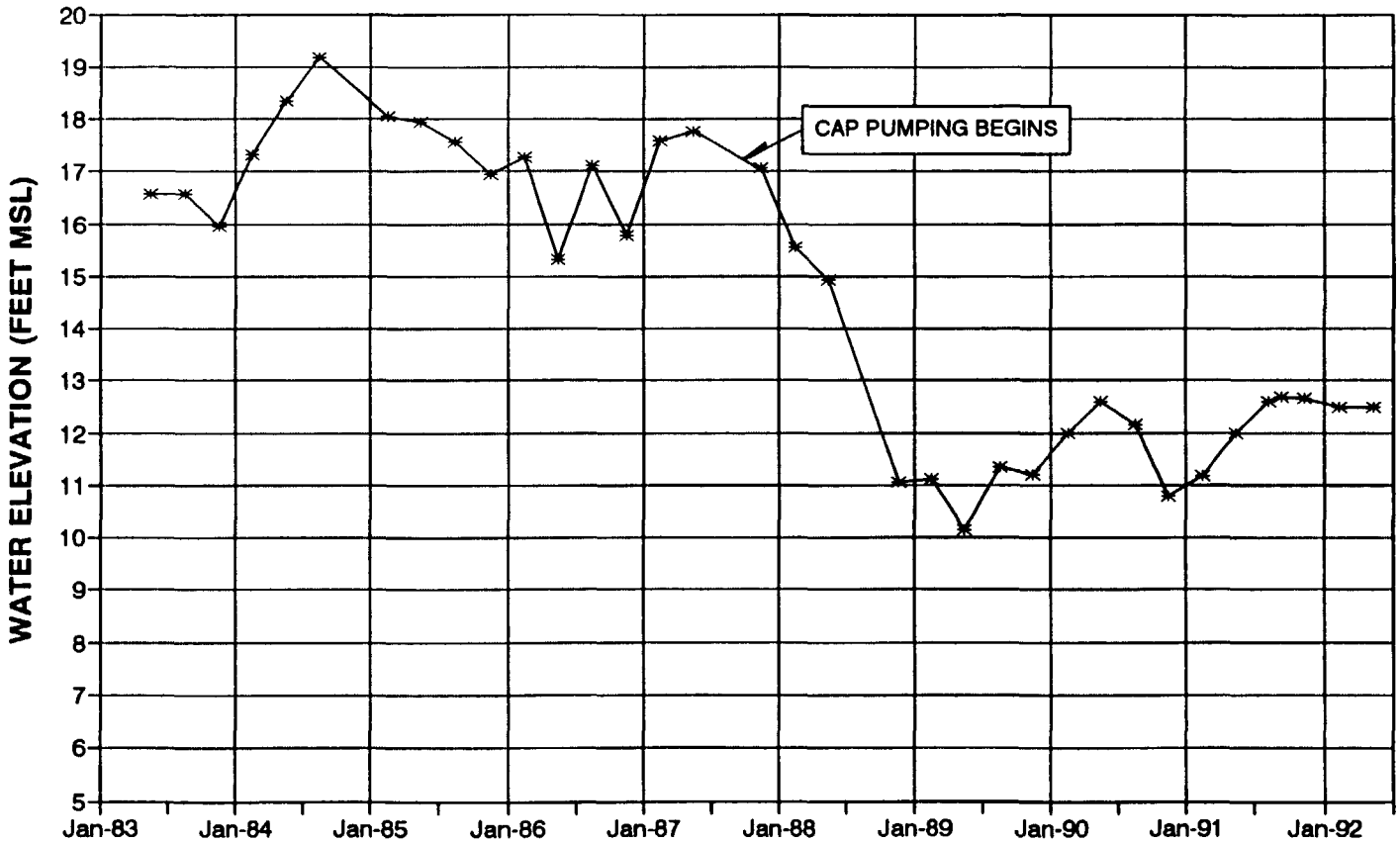
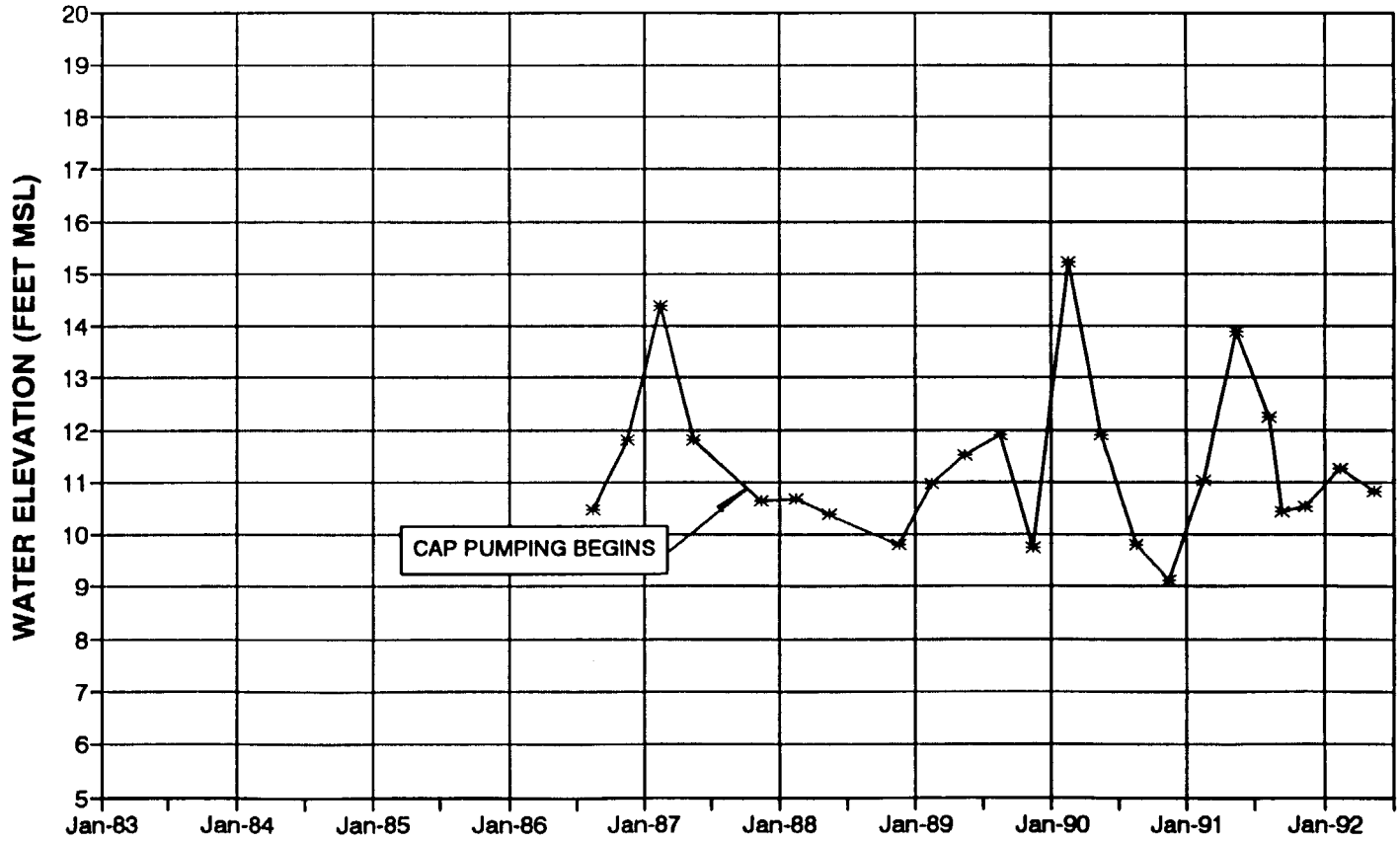
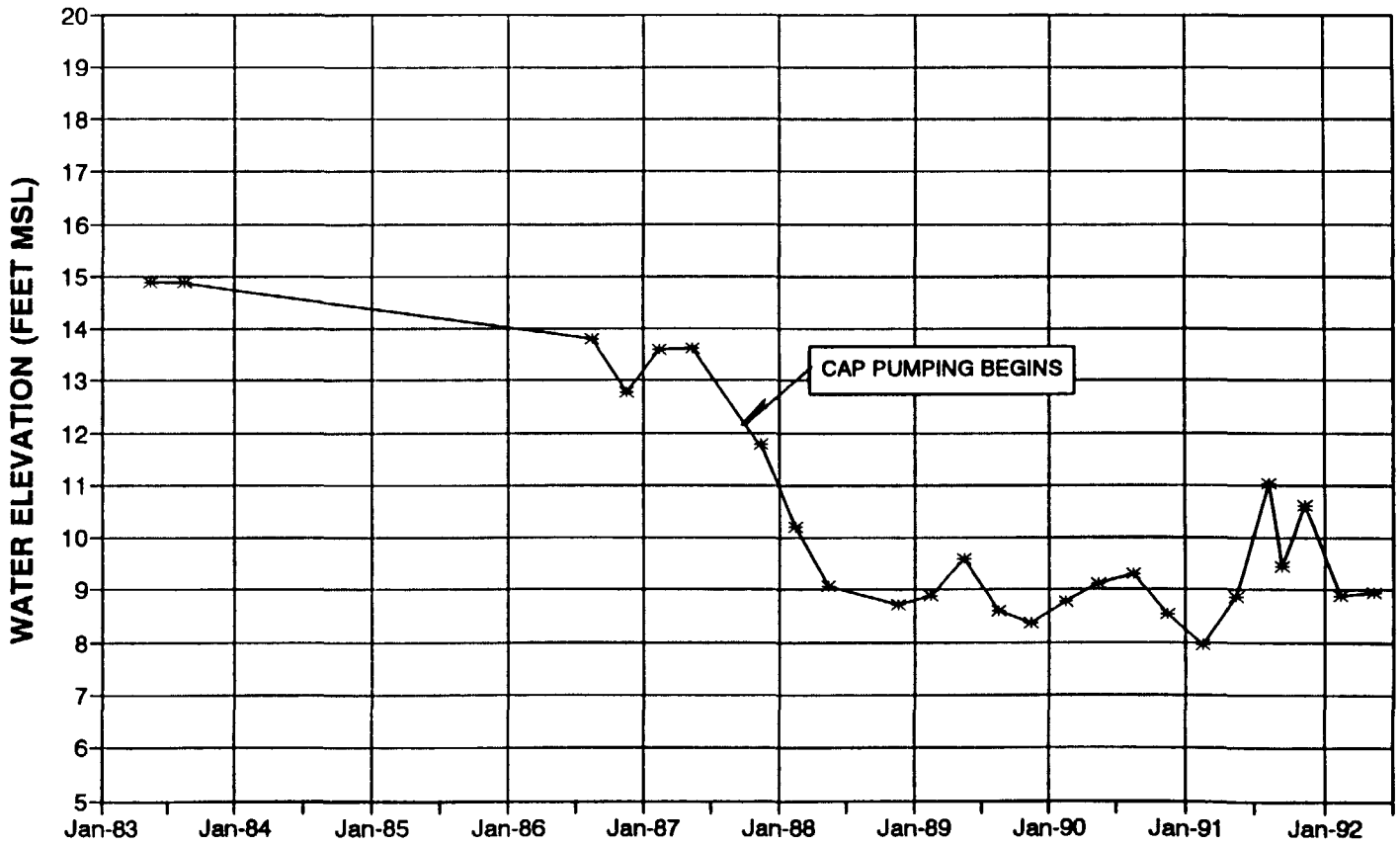


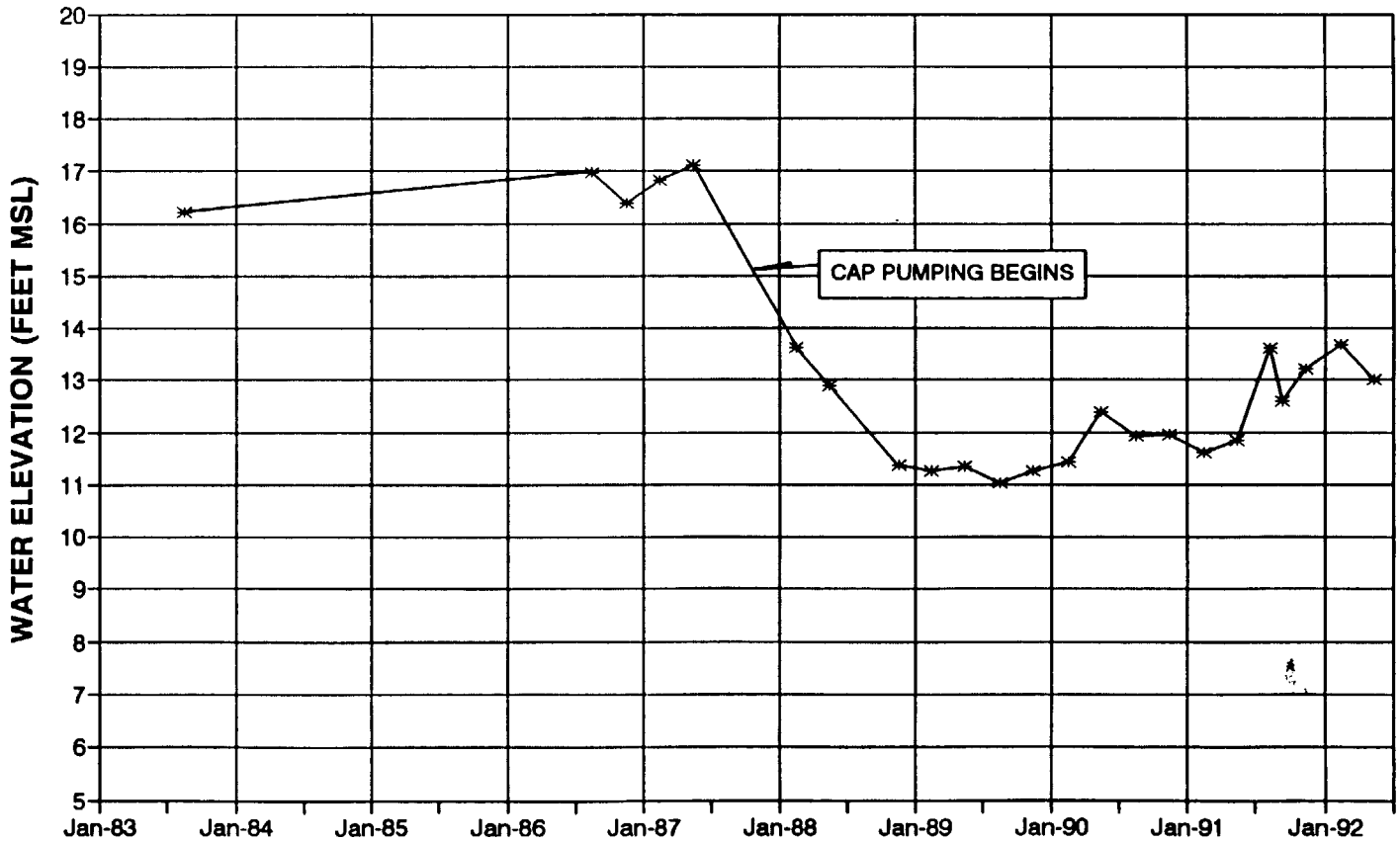
MONITOR WELL PL-10S



MONITOR WELL WP-2A



MONITOR WELL WP-9A



EVALUATION OF POTENTIAL IMPACT TO THE SURFACE WATER FROM DISCHARGE OF OU-1 GROUNDWATER

EVALUATION OF POTENTIAL IMPACT TO THE SURFACE WATER FROM DISCHARGE OF OU-1 GROUNDWATER

OBJECTIVE

Currently, the RCRA corrective action program (CAP) controls contaminant migration from any known past or present sources. Olin is committed by a legally enforceable RCRA post-closure permit to operate the CAP until the RCRA permit levels (maximum contaminant levels or MCLs) are achieved at the RCRA compliance boundary. Discontinuing the CAP after meeting the MCLs, may allow some groundwater that is currently being captured by the CAP to discharge to surface water. The objective of this analysis is to assess whether there would be any impact to surface water as a result of this discharge. Surface water is considered impacted if concentrations in the groundwater at the discharge point are above the ambient water quality criteria (AWQC). Monitor well PL10S is the compliance well located closest to a potential surface water discharge location (the Tombigbee River). The analysis will therefore be conducted for migration from the eastern end of the mercury plume in the vicinity of PL10S to the river.

The following table summarizes the maximum concentrations of the principal contaminants detected during the RI sampling (that have both MCL and AWQC standards), the MCL, AWQC and the ratio for the MCL to the AWQC (chronic criteria for freshwater aquatic life).

PARAMETER	MCL	AWQC	MCL/AWQC
Chlorobenzene	100	250	0.4
Chloroform	100	1240	0.08
1,2-Dichlorobenzene	600	763	0.8
1,3-Dichlorobenzene	600	763	0.8
1,4-Dichlorobenzene	75	763	0.1
Lead	15	1.3	11.5
Mercury	2	0.012	167

Although this list does not include all of the constituents detected in the groundwater, it does list the dominant contaminants and those that would be expected to persist as the CAP continues. Inspection of this table indicates that mercury and lead are the only constituents whose MCLs exceed the AWQC. Because mercury has a lower AWQC than lead, it has the greatest potential to exceed these criteria at the discharge point. Mercury also has the greatest lateral extent. Therefore, to be conservative, the analysis of potential impact to surface was conducted for mercury only.

ASSUMPTIONS

- Thickness of the plume is equal to the thickness of the Alluvial Aquifer, approximately 50 feet.

- The boundaries of the plume are the same as the area defined by the 2 µg/l isoconcentration line presented on Figure 1-14 of this FS report. The plume is divided in half by an approximately north-south oriented groundwater divide. Only the eastern half of the plume is considered to have the potential to move toward the Tombigbee River. The approximate location of the groundwater divide was estimated from the pre-corrective action potentiometric surface presented in Figure 3-10 of the final RI report (potentiometric map, upper zone Alluvial Aquifer, September 1986) (WCC, 1993).

- Concentration of mercury is 2 µg/l uniformly throughout the plume.

- Groundwater flow direction is approximately to the east, towards the river, or conservatively assumed to be in the direction of the shortest distance between the plume and the river.

- Groundwater in the Alluvial Aquifer discharges directly into the Tombigbee River, and as stated, the river is assumed to be affected by the mercury plume if concentrations at the discharge point are greater than the AWQC of 0.012 µg/l.

METHOD

Use the model SOLUTE to simulate the transport of mercury towards the river and estimate the concentration at the discharge point due to the plume traveling the shortest distance between the eastern end of the plume and the Tombigbee River.

SOLUTE MODELING

One-dimensional transport through the Alluvial Aquifer was simulated using the ONED3 model included in the publicly available software package SOLUTE (IGWMC, 1991).

Input parameters:

Groundwater (seepage) velocity: The seepage velocity was calculated using the following equation:

$$V = \frac{Ki}{\theta} \qquad (1)$$

where:

K = the hydraulic conductivity, estimated as 300 feet/day in the potential soil action level report (Appendix H of this FS report).

i = average hydraulic gradient, estimated using potentiometric maps drawn from four quarters of water elevation data (1986-1987) as 0.0021.

θ = effective porosity, assumed to be 0.30 for the Alluvial Aquifer (the approximate porosity for sand, from Table 5.1 in Driscoll, 1986).

From Equation 1, the groundwater (seepage) velocity is estimated as 2.1 ft/day.

Longitudinal Dispersivity: The longitudinal dispersivity was assumed to be one-tenth of the travel distance (Walton, 1988). The travel distance was taken as 1,160 feet (the shortest distance between the eastern extent of the plume in the vicinity of PL10S and the Tombigbee River), therefore the longitudinal dispersivity was estimated as 116 feet.

Retardation Factor: The retardation factor, R, was approximated using the following equation:

$$R = 1 + \frac{\rho_b K_d}{\theta} \qquad (2)$$

where:

ρ_b = The bulk density (ρ_b, weight of dry soil divided by the field or net volume of soil) was calculated from the relationship:

$$\rho_b = \rho_s \, (1-\theta) \qquad (3)$$

ρ_s = particle mass density (g/cc), estimated to be 2.65 g/cc (Freeze and Cherry, 1979)

θ = effective porosity, assumed to be 0.30 for the Alluvial Aquifer (the approximate porosity for sand, from Table 5.1 in Driscoll, 1986).

K_d = distribution coefficient, estimated using the relationship between K_d and pH provided by Loux et al. (1990):

$$Log\ K_d = 0.122 \times pH + 1.42 \quad (4)$$

The pH of the groundwater was estimated using the pH of monitor well PL10S. The average pH of six quarters of RCRA monitoring data from PL10S in 1992-1993 is 5.32, therefore the distribution coefficient (K_d) is calculated as 117 g/g/g/cc.

From Equation 2 the retardation factor is calculated as 724.

Initial Concentration: This is the initial concentration between the current downgradient edge of the plume and the river. A value of 0 mg/l was entered, based on concentrations in well BA1.

Concentration at source: A value of 1 mg/l (as opposed to 2 µg/l) was entered to simplify the results in the output file. The solute output file results were thus interpreted as relative concentration values rather than absolute concentrations.

Initial Time: This is the start of the simulation. A value of 0 days was entered.

Length of Time Steps: A value of 20,000 days (approximately 55 years) was entered. This is the interval at which the model results are printed out.

Distance (from the source): The shortest distance measured between the eastern end of the mercury plume (which is close to the location of PL10S) and the Tombigbee River, along an approximate east-west line, which is 1,160 feet.

Duration of the Solute Pulse: This represents the duration of the source. A very large value was assigned to this parameter.

Half-Life: Biochemical decay was assumed zero. The effect of fresh water infiltrating the soils and diluting the plume as it travels to the Tombigbee River was considered as a first order dilution process with a half-life given by the following equation:

$$t_{1/2} = \frac{\ln 0.5}{I/(b\,\theta)} \qquad (5)$$

where:

I = the infiltration, using the same value estimated for the CPC plant area for the potential soil action levels report as 7.31×10^{-4} ft/day.

b = the thickness of the aquifer, assumed as 50 feet.

θ = effective porosity, assumed to be 0.30 for the Alluvial Aquifer (the approximate porosity for sand, from Table 5.1 in Driscoll, 1986).

This approach is analogous to the approach used in U.S.EPA, 1990. Therefore, the half-life was calculated using Equation 5 as 14,233 days (39 years).

Half-Life at Source: The concentration at the source is likely to reduce in time due to flow of clean water through it (i.e., due to a flushing action). The reduction in the concentration can be simulated as a first order process with a half-life given by:

$$t_{1/2} = \frac{\ln 0.5}{(K\,i\,A)/(R\,\theta\,vol)} \qquad (6)$$

where:

K = the same value used {300 feet/day) in the potential soil action level report (Appendix H of this FS report)}

i = average hydraulic gradient, estimated using potentiometric maps drawn from four quarters of water elevation data (1986-1987) as 0.0021.

θ = effective porosity, assumed to be 0.30 for the Alluvial Aquifer (the approximate porosity for sand, from Table 5.1 in Driscoll, 1986).

A = area of the aquifer perpendicular to the groundwater flow direction, calculated as the thickness of the aquifer (50 feet) times the width of the front of the plume (approximately 1,850 feet), or 92,500 ft^2.

R = the retardation, calculated above as 724.

vol = volume of aquifer, calculated as the area of the plume on the horizontal plane (approximately 6,243,000 ft^2) times the thickness of the aquifer (50 feet), and estimated as 312,150,000 ft^3.

Using these parameters, the half-life at the source is calculated as 805,985 days (2,208 years) from Equation 6. These calculations are based on the concept of mass balance.

Results:

The application of the ONED3 model indicated that the highest concentration of mercury detected at the Tombigbee River resulting from the mercury plume in the Alluvial Aquifer would be 0.0000494 µg/l after 658 years (Attachment A). In order to perform a sensitivity analysis the program was run with the same parameters, but conservatively using only half of the infiltration. For this conservative case, the modeling results indicated that the highest concentrations would be 0.00126 µg/l after 877 years (Attachment B). Even though both of these results are conservative because they do not consider the effects of lateral dispersion and spreading of the plume, both modeling results indicated that the concentration of mercury at the point of discharge into the river would not exceed the AWQC of 0.012 µg/l.

REFERENCES

Driscoll, F.G. 1986. Groundwater and Wells. Johnson Division, St. Paul, Minnesota.

Freeze, R. A., and J. A. Cherry. 1979. Groundwater. Prentice-Hall, Inc.

International Ground Water Modeling Center. 1991. SOLUTE, A Program Package of Analytical Models for Solute Transport in Groundwater. Version 2.03. Developed by M. S. Beljin, Hydrolink, Inc., Cincinnati, Ohio.

Loux, N.T., C.R. Chafin, and S.M. Hassan. 1990. Statistics of Aquifer Material Properties and Empirical pH-dependent Partitioning Relationships for As(III), As(V), Ba(II), Be(II), Cd(II), Cr(VI), Cu(II), Hg(II), Ni(II), Pb(II), Sb(V), Se(VI), Tl(I) and Zn(II). U.S. EPA, Environmental Research Laboratory. Athens, Georgia. March.

U. S. Environmental Protection Agency (EPA). 1990. Background Document for EPA's Composite Model for Landfills (EPA CML), Office of Solid Waste. Washington, D.C.

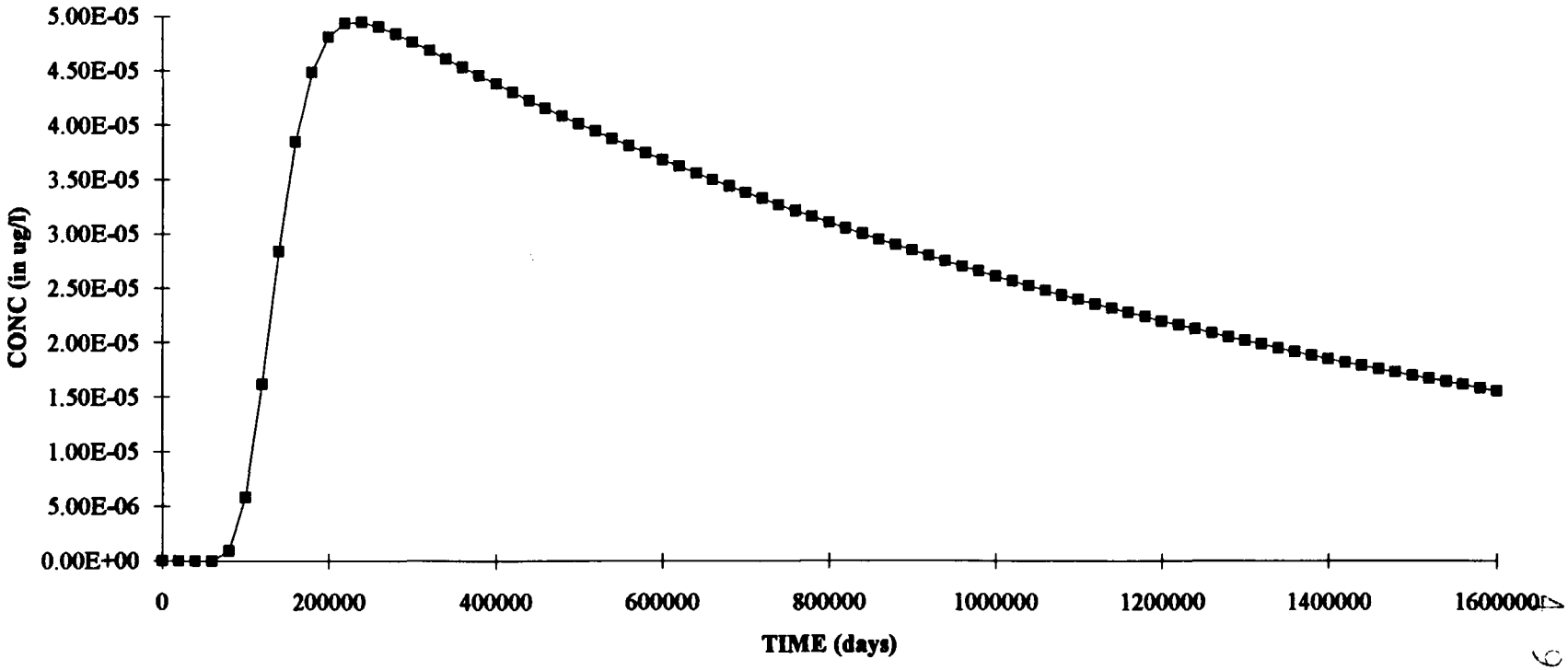
Walton, W. C. 1988. Practical Aspects of Groundwater Modeling. National Water Well Association. Ohio.

Woodward-Clyde Consultants (WCC). 1993. Remedial investigation report. McIntosh plant site, Olin Corporation, McIntosh, Alabama. July.

ATTACHMENT A

SOLUTE OUTPUT RESULTS, BASE CASE

CONCENTRATION OF MERCURY
BASE CASE



Woodward-Clyde

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8. CONCENTRATION AT SOURCE..... = 1 [mg/l]
9. INITIAL TIME..... = 0 [d]
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16. HALF-LIFE at Source..... = 805985 [d]

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40000	9.70E-12	840000	3.00E-05
60000	2.55E-08	860000	2.94E-05
80000	9.07E-07	880000	2.89E-05
100000	5.83E-06	900000	2.85E-05
120000	1.62E-05	920000	2.80E-05
140000	2.84E-05	940000	2.75E-05
160000	3.84E-05	960000	2.70E-05
180000	4.48E-05	980000	2.66E-05
200000	4.81E-05	1000000	2.61E-05
220000	4.93E-05	1020000	2.57E-05
240000	4.94E-05	1040000	2.52E-05
260000	4.90E-05	1060000	2.48E-05
280000	4.84E-05	1080000	2.44E-05
300000	4.76E-05	1100000	2.40E-05
320000	4.68E-05	1120000	2.35E-05
340000	4.61E-05	1140000	2.31E-05
360000	4.53E-05	1160000	2.28E-05
380000	4.45E-05	1180000	2.24E-05
400000	4.37E-05	1200000	2.20E-05
420000	4.30E-05	1220000	2.16E-05
440000	4.23E-05	1240000	2.12E-05
460000	4.15E-05	1260000	2.09E-05
480000	4.08E-05	1280000	2.05E-05
500000	4.01E-05	1300000	2.02E-05
520000	3.95E-05	1320000	1.98E-05
540000	3.88E-05	1340000	1.95E-05
560000	3.81E-05	1360000	1.92E-05
580000	3.75E-05	1380000	1.88E-05
600000	3.68E-05	1400000	1.85E-05
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640000	3.56E-05	1440000	1.79E-05
660000	3.50E-05	1460000	1.76E-05
680000	3.44E-05	1480000	1.73E-05
700000	3.38E-05	1500000	1.70E-05
720000	3.32E-05	1520000	1.67E-05
740000	3.27E-05	1540000	1.64E-05
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780000	3.15E-05	1580000	1.59E-05
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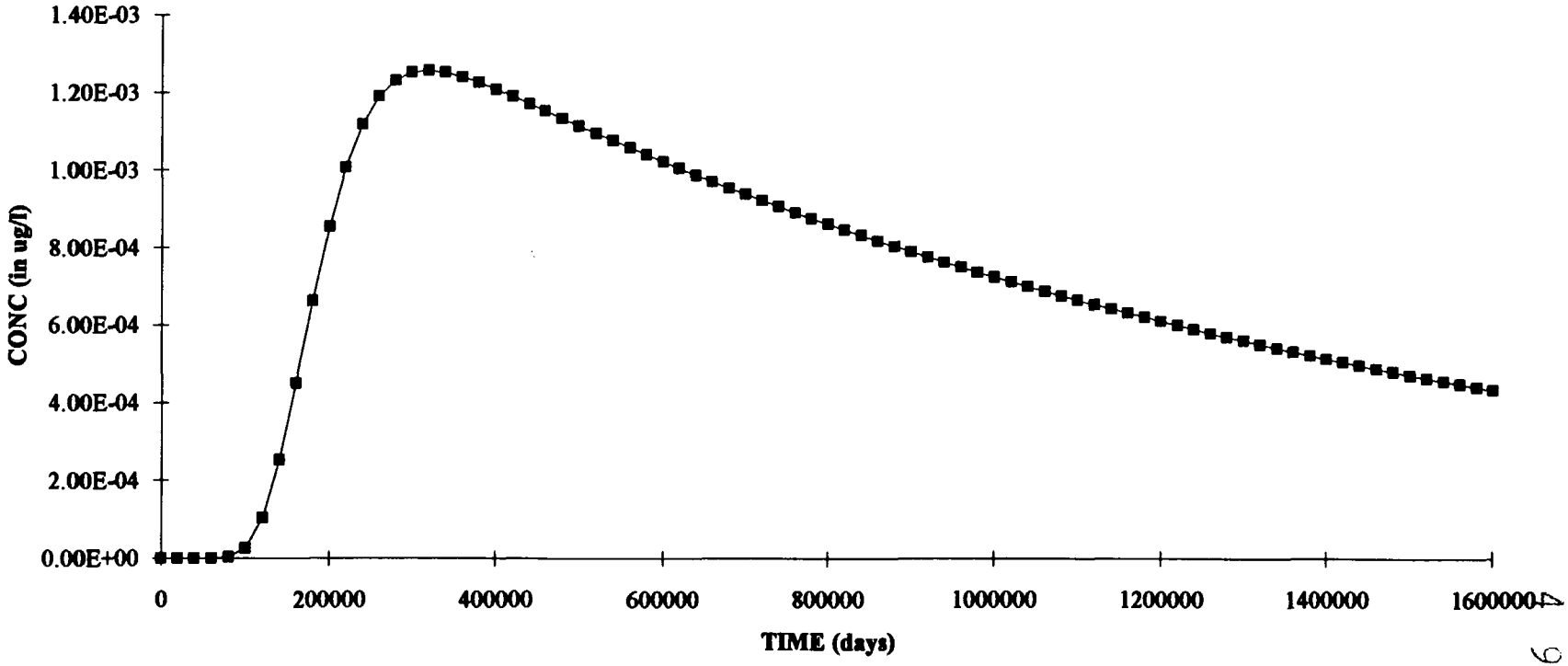
ATTACHMENT B

SOLUTE OUTPUT RESULTS, SENSITIVITY ANALYSIS

CONCENTRATION OF MERCURY
SENSITIVITY ANALYSIS



Woodward-Clyde

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8. CONCENTRATION AT SOURCE..... = 1 [mg/l]
9. INITIAL TIME..... = 0 [d]
10. LENGTH OF TIME STEP..... = 20000 [d]
11. NUMBER OF TIME STEPS (max 80).... = 80
12. NUMBER OF OBS. POINTS (max 5).... = 1
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16. HALF-LIFE at Source..... = 805985 [d]

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40000	1.24E-11	840000	8.31E-04
60000	5.05E-08	860000	8.17E-04
80000	2.74E-06	880000	8.03E-04
100000	2.61E-05	900000	7.89E-04
120000	1.04E-04	920000	7.76E-04
140000	2.51E-04	940000	7.63E-04
160000	4.50E-04	960000	7.50E-04
180000	6.61E-04	980000	7.37E-04
200000	8.53E-04	1000000	7.24E-04
220000	1.01E-03	1020000	7.12E-04
240000	1.12E-03	1040000	7.00E-04
260000	1.19E-03	1060000	6.88E-04
280000	1.23E-03	1080000	6.76E-04
300000	1.25E-03	1100000	6.65E-04
320000	1.26E-03	1120000	6.53E-04
340000	1.25E-03	1140000	6.42E-04
360000	1.24E-03	1160000	6.31E-04
380000	1.23E-03	1180000	6.21E-04
400000	1.21E-03	1200000	6.10E-04
420000	1.19E-03	1220000	6.00E-04
440000	1.17E-03	1240000	5.89E-04
460000	1.15E-03	1260000	5.79E-04
480000	1.13E-03	1280000	5.69E-04
500000	1.11E-03	1300000	5.60E-04
520000	1.09E-03	1320000	5.50E-04
540000	1.08E-03	1340000	5.41E-04
560000	1.06E-03	1360000	5.32E-04
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640000	9.87E-04	1440000	4.96E-04
660000	9.70E-04	1460000	4.88E-04
680000	9.54E-04	1480000	4.79E-04
700000	9.38E-04	1500000	4.71E-04
720000	9.22E-04	1520000	4.63E-04
740000	9.06E-04	1540000	4.55E-04
760000	8.90E-04	1560000	4.48E-04
780000	8.75E-04	1580000	4.40E-04
800000	8.60E-04	1600000	4.32E-04

CALCULATION OF VERTICAL SEEPAGE OF DENSE BRINE

WCC modeled the seepage of the brine plume through the Miocene Confing Unit and into the lower Miocene Aquifer. WCC used a linear form of Darcy's law adjusted for differences in density between brine (based on the highest measured TDS values) and fresh water. Based on the selected model, the calculated time for the brine to migrate vertically through the approximate 80 foot thick Miocene Confining Units is approximately 3400 years. The model selected did not take into account horizontal velocity, lateral dispersion, adsorption, or retardation.

The velocity gradient was considered to exist only in the vertical downward direction. The model includes the effects of fluid density differences based on salinity. The relative permeability and viscosity of the brine and fresh waters were assumed to be equivalent. The model assumptions included the following pressure head values at two elevations:

Point 1: The brine/fresh water interface exists at the upper aquifer/Miocene Confing Unit interface. The head in the upper aquifer at this position was estimated to be +11 feet msl based on the historical potentiometric surface of the alluvial aquifer.

Point 2: The Miocene Confing Unit is 80 feet thick. The head at the base of the Miocene Confing Unit was estimated to be -13 feet msl based on historical water elevations in Miocene Aquifer wells.

Darcy's law is generalized form may be written as:

$$velocity = -\frac{k\,\rho}{\mu}\frac{d}{dl}\left[\frac{p}{\rho} + g\,z\right]$$

where k is the intrinsic permeability of the medium, μ is the viscosity of the fluid, p is the pressure, ρ is the density of the fluid, g is the acceleration due to gravity, and z is the elevation from the datum or base elevation.

The seepage velocity through the clay was calculated from:

$$\textit{seepage velocity} = \frac{kg}{\phi \mu L} \left[\rho_s (h_1 + z_1) - \rho_f (h_2 + z_2)\right]$$

The seepage velocity was calculated to be 2.3 x 10^{-8} cm/sec. Based on the calculated seepage velocity, the breakthrough time of the plume front is calculated as 3400 years.

The modeling does not consider the effects of horizontal velocity within the aquitard, lateral dispersion, adsorption, or retardation. Each of these physical and chemical mechanisms will work to decrease the concentration of brine transitting the Miocene Confing Unit. The modeling calculated a travel time of between 3400 and 6800 years for any brine to reach the lower aquifer. It is anticipated that if the other mechanisms are also accounted for that it is very unlikely that brine will reach the lower aquifer in sufficient quantity, concentration, and rate to noticebly impact the Miocene aquifer. Details of modeling calculations are shown in the attached calculations.

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Project Notes

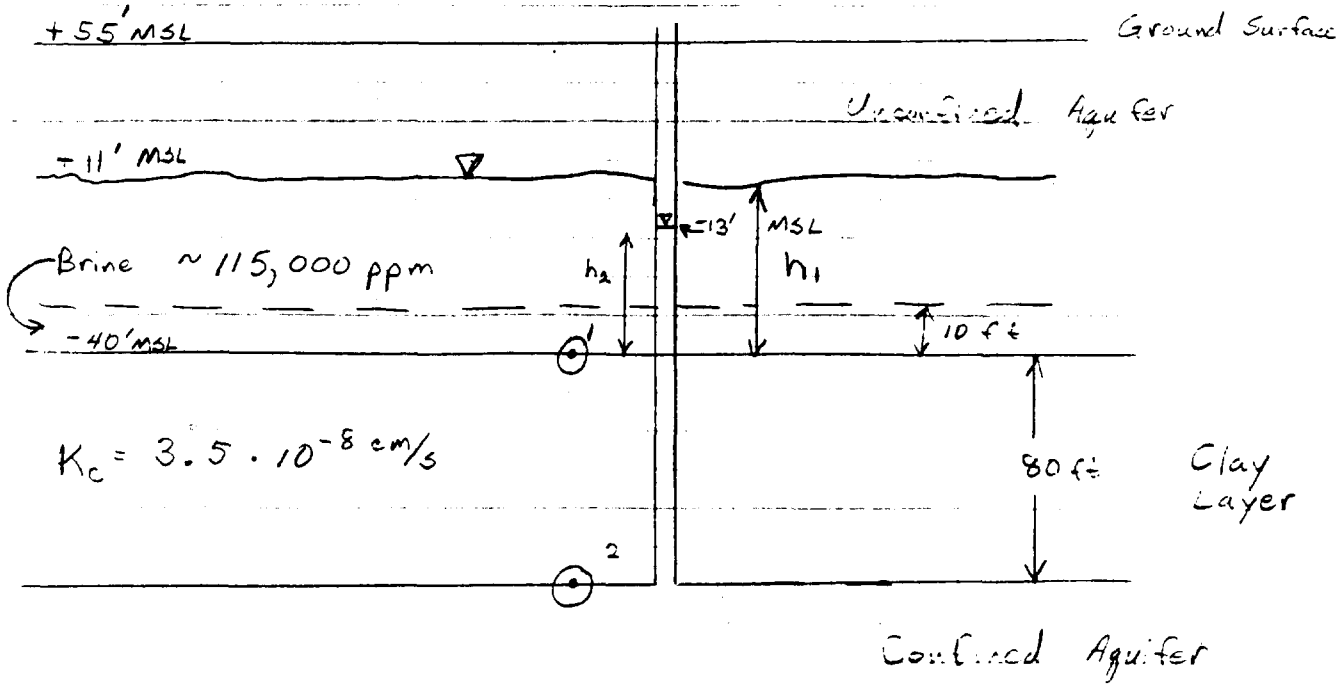
Subject: Brine Breakthrough of Clay Layer

4 C 446

Project Name: Olin McIntosh RI/FS
Project No.: 90B449C
Task No.: 9 File No.:
Sheet 1 of 5

L. T. Warren Date: 9/23/93
Checked By: C. Wa[illegible] Date: 10/12/93

GIVEN:



REQUIRED: Determine amount of time for brine to travel through clay layer and contact underlying fresh water aquifer.

SOLUTION:

Assumptions

1. Flow is only in the vertical direction, and Darcy's Law applies.
2. Intrinsic permeability and viscosity are the same for brine and fresh water. Density difference between brine and fresh water must be considered in calculating Darcy flow. (P. 402, Bouwer)
3. Vertical permeability of clay layer is much smaller than

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Project Notes

Subject: Brine Breakthrough of Clay Layer
By: T. Warren Date: 9/23/93
Checked By: [illegible] Date: 10/[illegible]

Project Name: Olin McIntosh RI/FS
Project No.: 90B449C
Task No.: 9 File No.:
Sheet 2 of 5

overlying aquifer. Therefore, the potentiometric height of brine plume and fresh water in upper aquifer can be used to approximate the pressure at point ①. (P. 54, Bouwer)

④ h_1 = 51 feet (Fig. 3-11, Fig. 5-1, RI/FS, July 93)

h_2 = 27 feet (Fig. 3-12, Fig. 5-1, RI/FS, July 93)

Values determined to maximize the potentiometric difference between the upper aquifer and lower aquifer in the area of the brine plume at the same point in time (Sep. 91).

⑤ ρ_s = 1.08 g/cm³ (Perry's Handbook of Chem Eng.)

ρ_f = 1.00 g/cm³ (P. 402, Bouwer)

⑥ Clay permeability is not affected by intrusion of brine.

⑦ Dispersion, diffusion and osmotic pressure effects are negligible.

⑧ Brine / Fresh Water interface is at top of clay layer initially.

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Project Notes

Subject: Brine Breakthrough of Clay Layer

By: T. Warren Date: 9/23/93

Checked By: C. [illegible] Date: 10/12/93

Project Name: Olin McIntosh RI/FS

Project No.: 90 B 449C

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Sheet 3 of 5

Darcy velocity:

$$v = K \frac{(h_1 + z_1) - (h_2 + z_2)}{L}$$ (P. 37, Bouwer)

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where

v = Darcy velocity (length/time)

h_1 = pressure head at point 1.

h_2 = pressure head at point 2.

z_1 = elevation head at point 1.

z_2 = elevation head at point 2.

L = distance between points 1 and 2.

K = hydraulic conductivity (length/time)

Intrinsic permeability: (P. 45, Bouwer)

$$k = \frac{K \mu}{\rho g}$$

where k = permeability (length^2)

K = hydraulic conductivity

μ = viscosity (g/cm·s or P)

ρ = density of fluid

g = acceleration due to gravity, 980 cm/sec^2

$\mu = 10^{-2}$ g/cm·s (P. 44, Bouwer)

Rearranging

$$K = \frac{k g \rho}{\mu}$$

Substituting

$$v = \frac{k g}{\mu L}\left[\rho_1(h_1 + z_1) - \rho_2(h_2 + z_2)\right]$$

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Project Notes

Subject: Brine Breakthrough of Clay Layer
By: T. Warren Date: 10/14/93
Checked By: C Warren Date: 10/18/93

Project Name: Olin McIntosh RI/FS
Project No.: 90R449C
Task No.: 9 File No.:
Sheet 4 of 5

Determining permeability in clay:

$$k = \frac{(3.5 \cdot 10^{-8}\ cm/s)(10^{-2}\ g/cm \cdot s)}{(1.00\ g/cm^3)(980\ cm/sec^2)} = 3.5714 \cdot 10^{-13}\ cm^2$$

Pressure and elevation head in Unconfined Aquifer:

$$\rho_1 (h_1 + z_1) = \rho_1 h_1 + \rho_1 z_1$$

$$\rho_1 h_1 = [(1.00\ g/cm^3)(51\ ft - 10\ ft) + (1.08\ g/cm^3)(10\ ft)]$$
$$= 51.8\ g/cm^2\ ft$$

$$\rho_1 z_1 = \left[\frac{(51-10)(1.00\ g/cm^3) + (10\ ft)(1.08\ g/cm^3)}{51\ ft}\right] \cdot (80\ ft)$$

$$= 81.255\ g/cm^3\ ft$$

$$\rho_1 (h_1 + z_1) = 51.8\ g/cm^3\ ft + 81.255\ g/cm^3\ ft$$
$$= 133.055\ g/cm^2\ ft$$

Pressure and elevation head in Confined Aquifer:

$$\rho_2 (h_2 + z_2) = (1.00\ g/cm^3)[(80\ ft + 27\ ft) + 0\ ft]$$
$$= 107\ g/cm^3\ ft$$

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Project Notes

Subject: Brine Breakthrough of Clay Layer
By: T. Warren Date: 10/14/93
Checked By: C Warren Date: 10/18/93

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Project No.: 90B449C
Task No. 9 File No.:
Sheet 5 of 5

$$v = \frac{kg}{\mu L}\left[\rho_1 (h_1 + z_1) - \rho_2 (h_2 + z_2)\right]$$ 4 9 0448

$$v = \frac{(3.5714 \cdot 10^{-12}\ cm^2)(980\ cm/s^2)}{(10^{-2}\ g/cm \cdot s)(80\ ft)}\left[(133.055 - 107)\ g/cm^3 \cdot ft\right]$$

$$v = \underline{1.1399 \cdot 10^{-8}\ cm/s}$$

Time for breakthrough using Darcy velocity:

$$t_D = \frac{(80\ ft)(30.48\ cm/ft)}{(1.1399 \cdot 10^{-8}\ cm/s)(60\ s/min)(60\ min/hr)(24\ hr/day)(365\ day/yr)}$$

$$t_D = \underline{\underline{6{,}783.15\ years}}$$

Seepage Velocity:

$$v_m = \frac{v}{n}$$ where n = porosity (P. 39, Bouwer)

$n_{clay} = 0.50$ (P. 22, Bouwer)

$$v_m = \frac{1.1399 \cdot 10^{-8}\ cm/s}{0.50} = \underline{2.280 \cdot 10^{-8}\ cm/s}$$

Time for breakthrough using Seepage Velocity:

$$t_m = \frac{(80\ ft)(30.48\ cm/ft)}{(2.280 \cdot 10^{-8}\ cm/s)(60\ s/min)(60\ min/hr)(24\ hr/day)(365\ day/yr)} = \underline{\underline{3{,}391.6\ yrs}}$$

SUMMARY OF ESTIMATE CONTAMINANT MASS REMOVED BY CORRECTIVE ACTION PROGRAM

CORRECTIVE ACTION WELLS
SUMMARY OF GROUNDWATER RECOVERY

Well	Pumping Rate*			Volume Pumped based on Average Pumping Rates*							Total
	max (gpm)	min (gpm)	average (gpm)	1987 (gallons)	1988 (gallons)	1989 (gallons)	1990 (gallons)	1991 (gallons)	1992 (gallons)	1993** (gallons)	**Pumped (gallons)**
CA1	150	100	125	2.20E+07	6.57E+07	6.57E+07	6.57E+07	6.57E+07	6.57E+07	2.16E+07	**3.72E+08**
CA2	100	80	90	1.58E+07	4.73E+07	4.73E+07	4.73E+07	4.73E+07	4.73E+07	1.56E+07	**2.68E+08**
CA3	110	100	105	1.84E+07	5.52E+07	5.52E+07	5.52E+07	5.52E+07	5.52E+07	1.81E+07	**3.13E+08**
CA4	60	40	50	8.78E+06	2.63E+07	2.63E+07	2.63E+07	2.63E+07	2.63E+07	8.64E+06	**1.49E+08**
CA5	180	150	165	2.90E+07	8.67E+07	8.67E+07	8.67E+07	8.67E+07	8.67E+07	2.85E+07	**4.91E+08**
			Total	9.40E+07	2.81E+08	2.81E+08	2.81E+08	2.81E+08	2.81E+08	9.24E+07	**1.59E+09**

* Pumping began in September, 1987
** Through April of 1993

CORRECTIVE ACTION WELLS
SUMMARY OF ORGANICS REMOVAL

Well	Pumping Rate*			Average Concentration in Recovery Well (Organics)							**Mass Recovered (lbs)**
	max (gpm)	min (gpm)	average (gpm)	1987 (ug/l)	1988 (ug/l)	1989 (ug/l)	1990 (ug/l)	1991 (ug/l)	1992 (ug/l)	1993** (ug/l)	
CA1	150	100	125	194.2	269.1	277.83	245.65	218.78	134.78	220.9	**702.193**
CA2	100	80	90	9.9	108.35	355.28	113.03	865.48	1395.5	18.2	**1121.272**
CA3	110	100	105	0	201.2	39.5	27.7	24.95	62.23	23.95	**167.0052**
CA4	60	40	50	167.2	111.4	90.88	58.6	79.7	57.18	49.7	**102.8362**
CA5	180	150	165	0.75	144.73	33.78	14.8	25.83	85.53	14	**223.4955**
										TOTAL	**2316.802**

* Pumping began in September, 1987
** Through April of 1993

CORRECTIVE ACTION WELLS
SUMMARY OF MERCURY REMOVAL

Well	Pumping Rate*			Average Concentration in Recovery Well (Mercury)							Mercury Recovered (lbs)
	max (gpm)	min (gpm)	average (gpm)	1987 (ug/l)	1988 (ug/l)	1989 (ug/l)	1990 (ug/l)	1991 (ug/l)	1992 (ug/l)	1993** (ug/l)	
CA1	150	100	125	0	0.35	0.17	0.13	0.15	0.1	0.1	**0.5103**
CA2	100	80	90	1.1	7.58	6.67	4.05	10.33	23.93	4.85	**21.47371**
CA3	110	100	105	1.8	4.58	1.3	2.15	3	2.8	2	**6.933399**
CA4	60	40	50	33.9	22.18	10.47	9.03	13.35	36.7	7.15	**23.06481**
CA5	180	150	165	0.3	28.95	9.2	7.65	18	16.83	16.2	**62.13809**
										TOTAL	**114.1203**

* Pumping began in September, 1987
** Through April of 1993

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EVALUATION OF EXTRACTION WITH INJECTION WELLS

The alluvial aquifer has an average conductivity of 296 ft/day and a saturated thickness which varies from 50 to 80 feet. The transmissivity of this aquifer is between 110,700 gpd/ft and 177,120 gpd/ft. This is a highly transmissive aquifer. For aquifers of high transmissivity, drawdown from an extraction is relatively small even for high pumping rates but has a large area of influence. This effect is illustrated in Figure 8.6 of Groundwater by Freeze and Cherry (a copy of the Figure is attached).

Injection wells are used for hydraulic control and to enhance flushing action. At this facility the current extraction has been demonstrated to provide adequate hydraulic control. Therefore the use of an injection system would be primarily for enhancing water movement towards an extraction well to increase the rate of contaminant removal. As can be seen from the attached diagram from Freeze and Cherry (Figure 2.2) in a transmissive aquifer the water table is not depressed greatly by pumping. The placement of an injection system will not result in the large changes in potentiometric head near the extraction well that could be expected from a low yielding formation and, therefore, will not make the same kind of relative increase in water available to the extraction well. An injection well will tend to make the capture zone around the well much more localized with a larger portion of the flow into the extraction well coming directly from the injection well. At this particular site, this is not an advantage because it will adversely affect hydraulic control. With the high transmissivity of the aquifer there is already available water which is being drawn towards through contaminated areas to the extraction wells for flushing purposes. Therefore injection wells are not needed at this site the for the purposes of flushing of contaminants nor for hydraulic control. To illustrate the above discussion some modeling was conducted using pumping rates from existing extraction wells and measured and calculated aquifer parameters. Attached as Figure 1 is a model of the drawdown of the five existing wells after a years pumping in the presence of a flat gradient. Figure 2 is the addition of a sixth extraction well (near the interior of the plume). Figure 3 is the same as Figure 2 with the addition of an injection well paired with the sixth extraction well at a distance 500 ft. Both the new extraction well and the injection well were set to rates of 100 gpm for the purposes of this model.

The model used was WELFLO. A description of the model is attached along with a table of input values for each modeling run and the model results in tabular form.

FIGURES

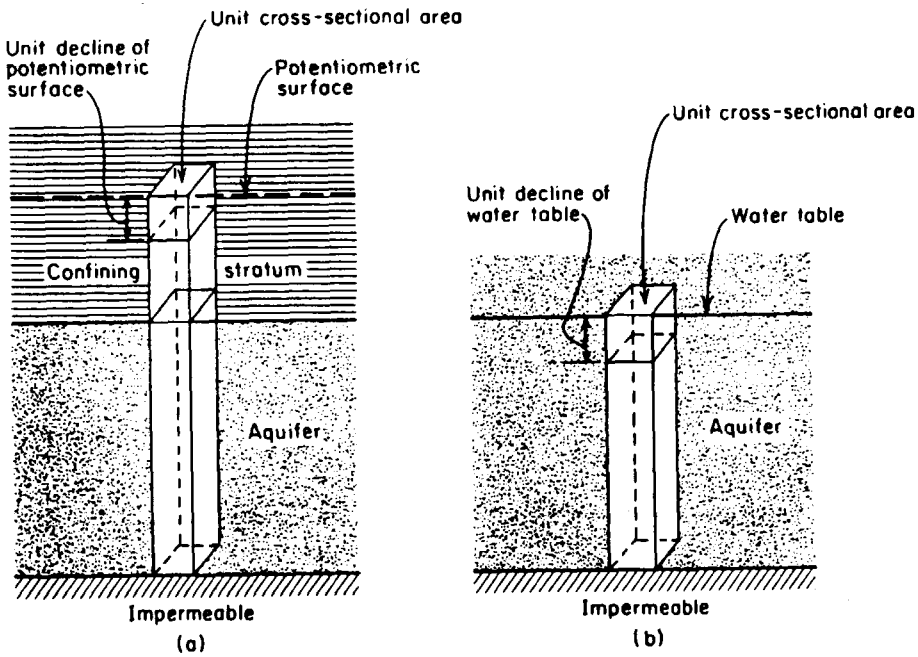

Figure 2.22 Schematic representation of the storativity in (a) confined and (b) unconfined aquifers (after Ferris et al., 1962).

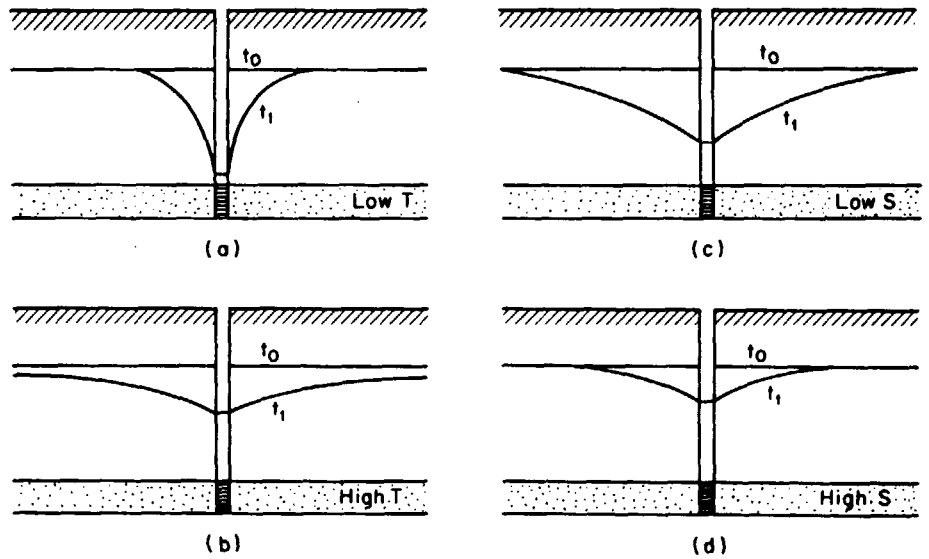

Figure 8.6 Comparison of drawdown cones at a given time for aquifers of (a) low transmissivity; (b) high transmissivity; (c) low storativity; (d) high storativity.

Source: Freeze, R. Allen, and Cherry, John A. Groundwater. (Prentice-Hall, Inc., 1979), pages 60 and 320.

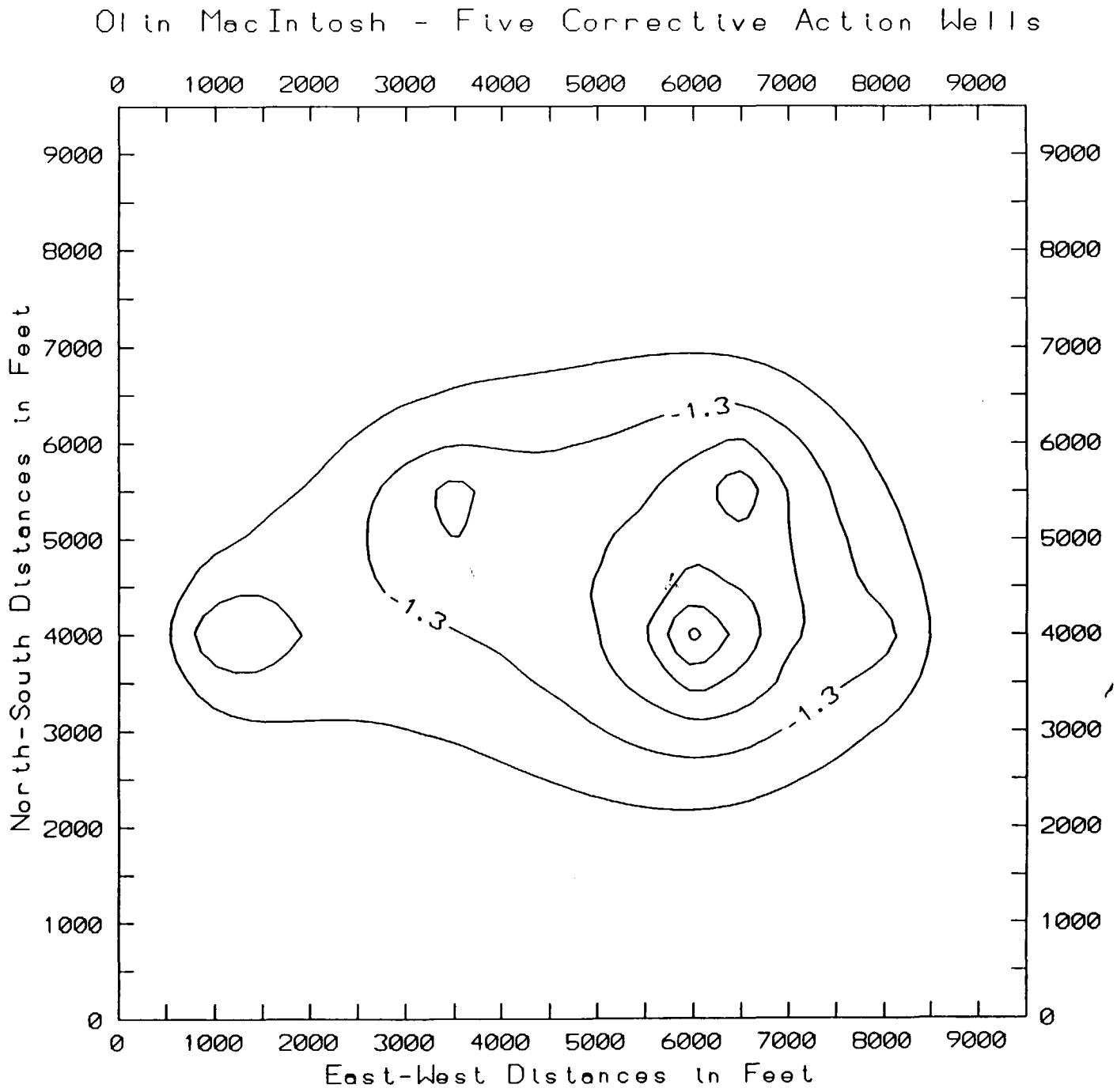
Olin MacIntosh - Five Corrective Action Wells
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
North-South Distances in Feet
East-West Distances in Feet
-1.3
-1.3
-1.3
0

FIGURE 1

Oil in MacIntosh - 6 Corrective Action Extraction Wells

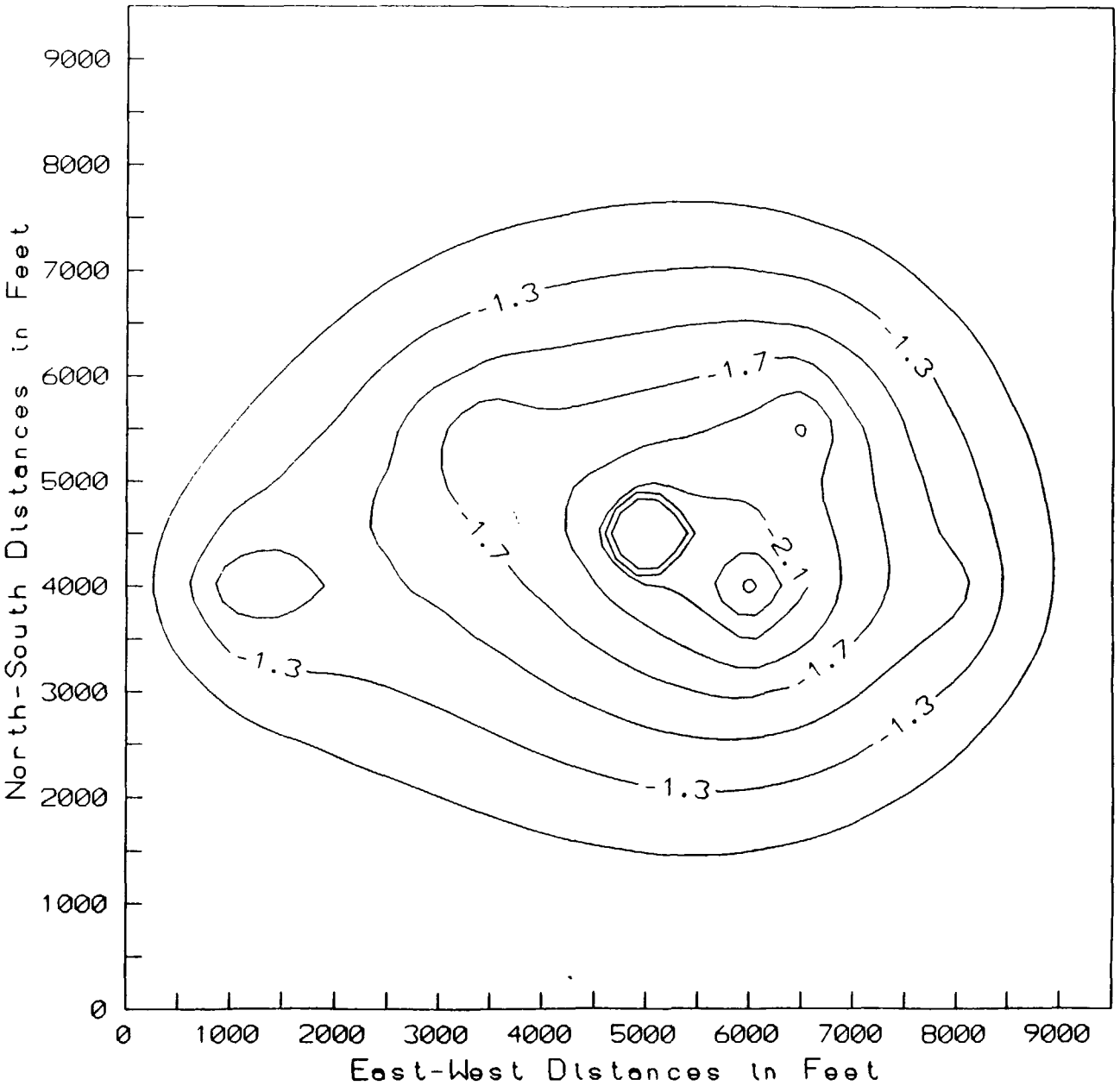

FIGURE 2

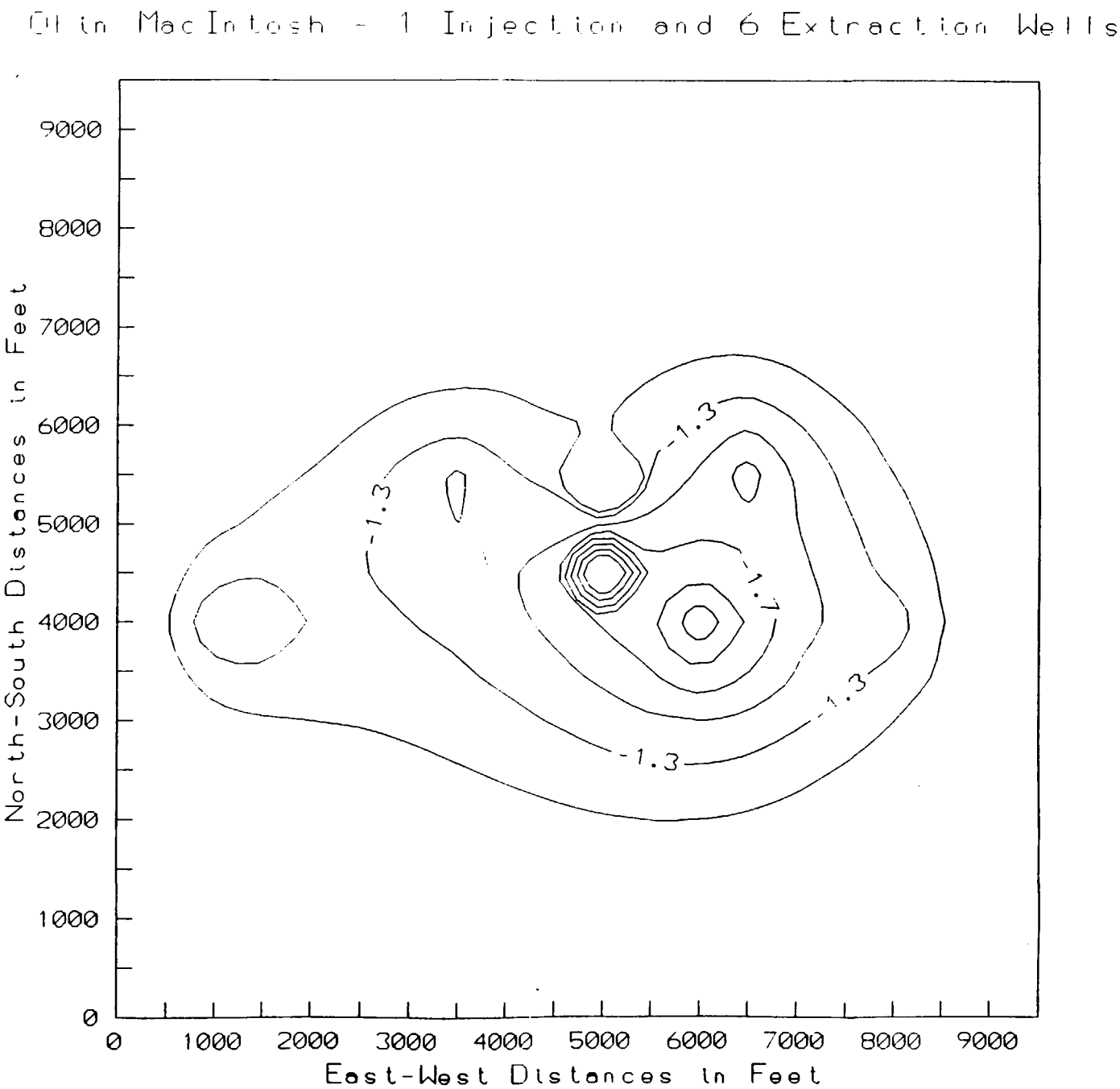
Oil in MacIntosh - 1 Injection and 6 Extraction Wells
North-South Distances in Feet
East-West Distances in Feet
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
-1.3
-1.7

FIGURE 3

WELFLO DOCUMENTATION

Analytical Groundwater Modeling

Flow and Contaminant Migration

WILLIAM C. WALTON

LEWIS PUBLISHERS

national water well association

4

Groundwater Flow Program Operation

In WELFLO (see Appendix B), the density of groundwater is assumed constant throughout the aquifer. Supported English units are: gpm, cfs, days, min, ft, sq ft, cu ft, gpd/ft, and gpd/sq ft. Unit requirements are cited in data base input statements. Some useful unit conversions are: 1 liter/s = 15.85 US gal/min, 1 m/s = 2.119×10^6 US gal/day/sq ft, 1 m^2/s = 6.954×10^6 US gal/day/ft, 1 cm/s = 2.118×10^4 US gal/day/sq ft, 1 ft/day = 7.463 US gal/day/sq ft, 1 m/day = 24.5 US gal/day/sq ft, 1 US gal/day/sq ft = 0.0408 m/day, 1 US gal/day/sq ft = 0.134 ft/day, 1 US gal/day/sq ft = 4.72×10^{-5} cm/sec, and 1 ft = 0.3048 m.

The user specifies aquifer conditions to be simulated by entering an appropriate number in response to an aquifer option prompt. The following conditions are supported: nonleaky artesian, leaky artesian, water table and nonleaky artesian fractured rock. It is assumed that aquitard storativity and delayed gravity yield are negligible. The user may specify fully or partially penetrating wells with or without wellbore storage by entering an appropriate number in response to a well option prompt. It is assumed that well discharge rates are constant if wells partially penetrate the aquifer and/or wellbore storage is simulated. The user specifies whether partial penetration impacts are to be calculated for the production well or an observation well by entering an appropriate number in response to another well option prompt.

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The general data base is user-defined at the keyboard and displayed upon the user's request on paper by the printer. In response to a series of prompts, the number of simulation periods is specified by the user (must be < 26). Graphs of well discharge (+) and well recharge (-) versus time are drawn by the user for each production and injection well and combined into simulation period pump operation schedules. Based on these graphs, the duration of each simulation period is user-defined as the longest pump operation period during each simulation period. Simulation period durations are entered in ascending order. The differences between simulation period times must be small for high precision in wellbore storage impact calculations.

Any aquifer boundaries and discontinuities, real production and/or injection wells, and any boundary or discontinuity image wells are drawn to scale on a map. An area of interest which lies entirely within aquifer boundaries and/or discontinuities is selected for drawdown calculation and display. A uniform grid is superposed over this area. Grid lines are indexed using the I (column), J (row) notation colinear with the X and Y directions, respectively. I coordinates increase left to right and J coordinates increase top to bottom. The origin of the grid is beyond the grid at the upper-left corner of the map. The X and Y coordinates of the upper-left grid node are user-defined in a manner so that confusing drawdowns or recoveries beyond boundaries and/or discontinuities are not displayed. The number of columns must be < 31 and the number of rows must be < 31. The number of columns or rows must be 10, 20, or 30 and the grid must be square if calculation results are to be used with GWGRAF. The X coordinate of the upper-left node and Y coordinate of the upper-left node are user-defined.

The number of active production, injection, and image wells during each simulation period (must be < 51), the X coordinate, Y coordinate, discharge rate, and radius of each well are user-defined. The number of observation wells located at grid nodes for which time-drawdown or recovery tables are desired (must be < 26) and the I coordinates and J coordinates of observation wells are user-defined. Depending upon aquifer conditions, appropriate values of some or most of the following aquifer system hydraulic properties are user-defined: aquifer transmissivity, aquifer storativity, aquifer specific yield, aquitard thickness, aquitard vertical hydraulic conductivity, fissure horizontal hydraulic conductivity, block vertical hydraulic conductivity, fractured rock aquifer thickness, storativity of fissured portion of fractured rock aquifer, storativity of block portion of fractured rock aquifer, and half thickness of average block unit. The user may choose to revise and print on paper the general data base.

The coordinates of grid nodes are determined with data on the known coordinates of the upper-left node. The distances between wells and grid nodes are calculated using the Pythagorean equation. Well function variables are calculated using the general data base, and associated well function values are determined using polynomial and other approximations. Individual well drawdown and/or recovery impacts at nodes are calculated using appropriate aquifer model equations and combined for the time increment in question. Drawdown or recovery inside a grid block may be calculated based on the impacts at the four surrounding block corner grid nodes with the Lagrange-interpolation equation (Kinzelbach, 1986, p.68). Nodal drawdown or recovery tables of computation results for the selected area of interest are displayed automatically on the screen and upon the user's request on paper by the printer. The user may choose to create a sequential data file of computation results for export to graphics programs GWGRAF, SURFER, and OMNIPLOT.

The well penetration data base is entered from the keyboard in response to input prompts if the user earlier chose to simulate partially penetrating wells. Drawdown with full penetration in the well in question, production well discharge rate, aquifer thickness, and well geometry are user-defined. The well partial penetration impact is then calcu-

lated using the partial penetration well function approximation. Drawdown with partial penetration impacts is displayed automatically on the screen and upon the user's request on paper by the printer. The user may choose to repeat the partial penetration subprogram to calculate partial penetration impacts in additional wells without rerunning the program.

The wellbore storage data base is entered from the keyboard in response to input prompts if the user chose to simulate wellbore storage. Constant production well discharge during the present simulation period, drawdown with or without partial penetration and without wellbore storage at the end of present simulation period, and constant well and pump geometry are user-defined. If the well in question is a production well, drawdown without wellbore storage and with a finite diameter instead of an infinitesimal diameter is calculated using tabled values of the finite diameter well function. Discharge from the aquifer with wellbore storage is then calculated using the method of successive approximations. Drawdown without wellbore storage is adjusted for wellbore storage impacts using the ratio discharge from the aquifer versus total discharge from the production well. The results of computations are displayed automatically on the screen and upon the user's request on paper by the printer.

Tables of observation well time-drawdown or recovery data are displayed automatically on the screen and upon the user's request on paper by the printer after drawdowns or recoveries for all time increments have been calculated.

5

Groundwater Flow Simulation

Although not as versatile as numerical models, analytical models are useful in simulating groundwater flow in aquifer systems with low to moderate complexities. Recognized departures from ideal homogeneous and isotropic conditions and straight-line boundary demarcations assumed in analytical models do not necessarily dictate that they be rarely used. With appropriate recognition of complicated field situations, there are many practical ways of circumventing analytical model limitations using equivalent hydraulic property or aquifer cross section, incremental, and successive approximation techniques (see Walton, 1984a, pp. 301-302).

Assuming sound professional judgment, transient groundwater flow under various well and aquifer conditions can be simulated with analytical models consisting of well functions and their associated well hydraulics equations, the method of images (see Bear, 1979, pp. 356-366; Streltsova, 1988, pp. 210-253), and the principle of superposition (see Bear, 1979, pp. 152-159). Variable production well discharge rates may be simulated by placing several production wells on top of one another at a grid node or by using the numerical pumping rate change program listed by Clark (1987, pp. 7.1-7.16). Drawdown equations with linear, parabolic, polynomial, exponential, and periodical variable discharge rates are presented by Streltsova (1988, pp. 101-152).

Such features as mines, drains, pits, ponds, mounds, and

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streams may be simulated by arrangement of closely spaced wells in lines, rectangles, circles, and irregular patterns (see Figure 1). Flow to mines and drains with fixed drawdown may be estimated by using the method of successive approximations. Drawdown due to first trial well discharges simulating mine drainage is calculated and compared to required drawdown. If the comparison is favorable, the well discharges are declared valid; otherwise, well discharges are revised and a second trial drawdown is calculated and compared to this required drawdown. This process is repeated until the comparison is favorable.

Clark (1987, pp. 2.1–2.28, 4.1–4.49, and 7.1–7.16) lists BASIC programs for calculating drawdown in nonleaky artesian and leaky artesian infinite, one-boundary, and strip aquifers with multiple discharge rates. Walton (1984b) lists eight BASIC programs for one-, two-, and three-layered aquifer systems, a circular recharge area, and stream depletion. A collection of 18 articles from the journal *Ground Water* including microcomputer program listings pertaining to pumping tests, optimal well discharge, and well drawdown is distributed by the National Water Well Association (NWWA). Sandberg et al. (1981) provide analytical model equations for simulating source/sink flow rates with drawdown as the given, steady-state drawdown around finite line sinks, finite line sinks with nonsteady conditions, and steady state flow to line sources or sinks with drawdown as the given.

Boundaries and Discontinuities

Well hydraulics equations assume that the aquifer is infinite in areal extent. Finite aquifer conditions may be simulated by replacing hydrogeologic boundaries with imaginary wells which produce the same disturbing effects as the boundaries. The image well theory may be summarized as follows: the effect of a barrier boundary on the drawdown in a well, as a result of pumping from another well, is the

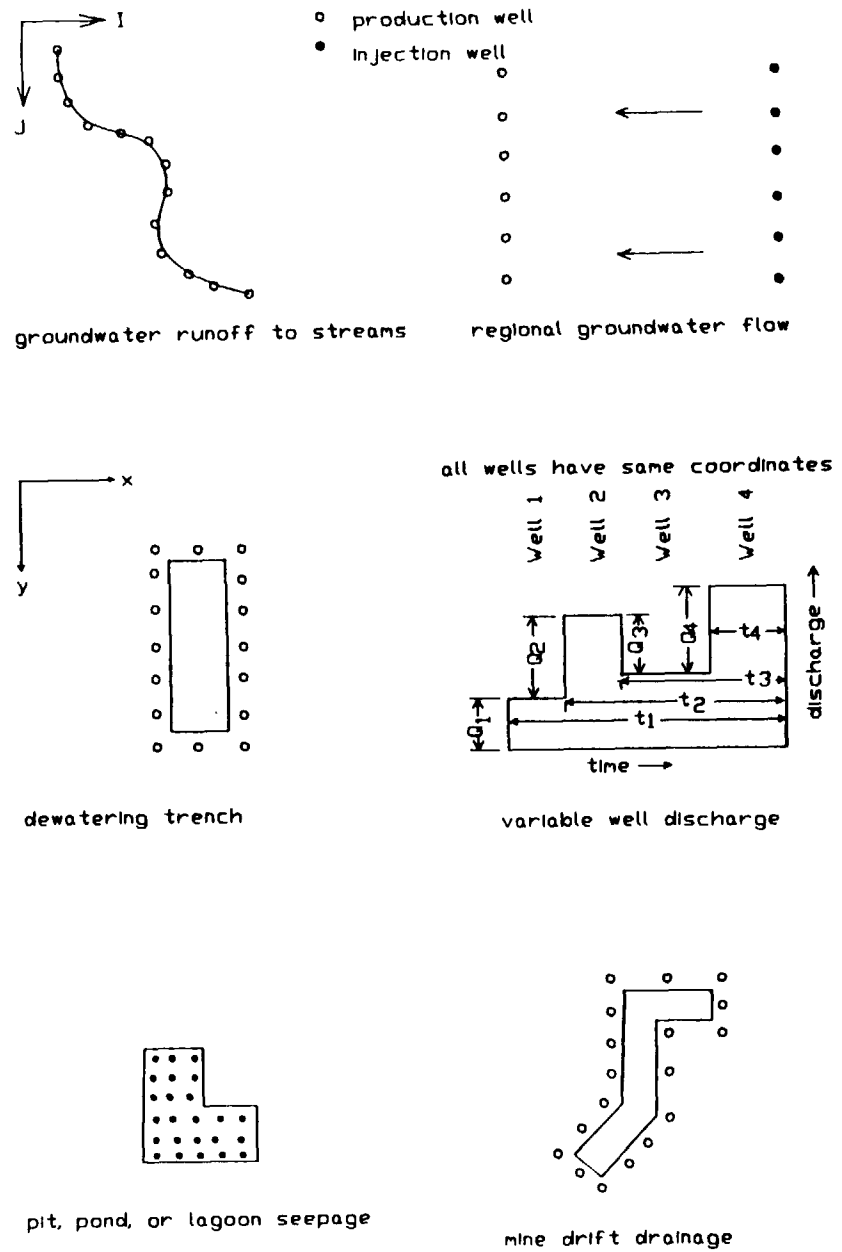

Figure 1. Groundwater flow models

same as though the aquifer were infinite and a like discharging well were located across the real boundary on a perpendicular thereto and at the same distance from the boundary as the real pumping well. For a recharge boundary, the principle is the same except the image well is assumed to be recharging the aquifer instead of pumping from it.

Boundary problems are thereby simplified to consideration of an infinite aquifer in which real and image wells operate simultaneously at the same discharge or recharge rate. Successive reflections on boundaries are considered when aquifers are delimited by two or more boundaries (see Figure 2). In the case of an aquifer discontinuity (partial boundary), an image well is placed as usual but the image well strength is calculated with the following equation (Muskat, 1937; Streltsova, 1988, pp. 246-251; Fenske, 1984, pp. 125-145):

$$Q_i = Q_p D_t \tag{24}$$

where

$$D_t = (T_p - T_d)/(T_p + T_d) \tag{25}$$

Q_i = image well strength in gpm

Q_p = production well discharge rate in gpm

T_p = aquifer transmissivity at production well in gpd/ft

T_d = aquifer transmissivity beyond discontinuity in gpd/ft

Heterogeneities and Stratification

Aquifer anisotropic and heterogeneous and aquitard stratification impacts may be simulated by using average hydraulic properties instead of complex horizontal and vertical hydraulic properties variations in conceptual models. Average hydraulic conductivities may be calculated with

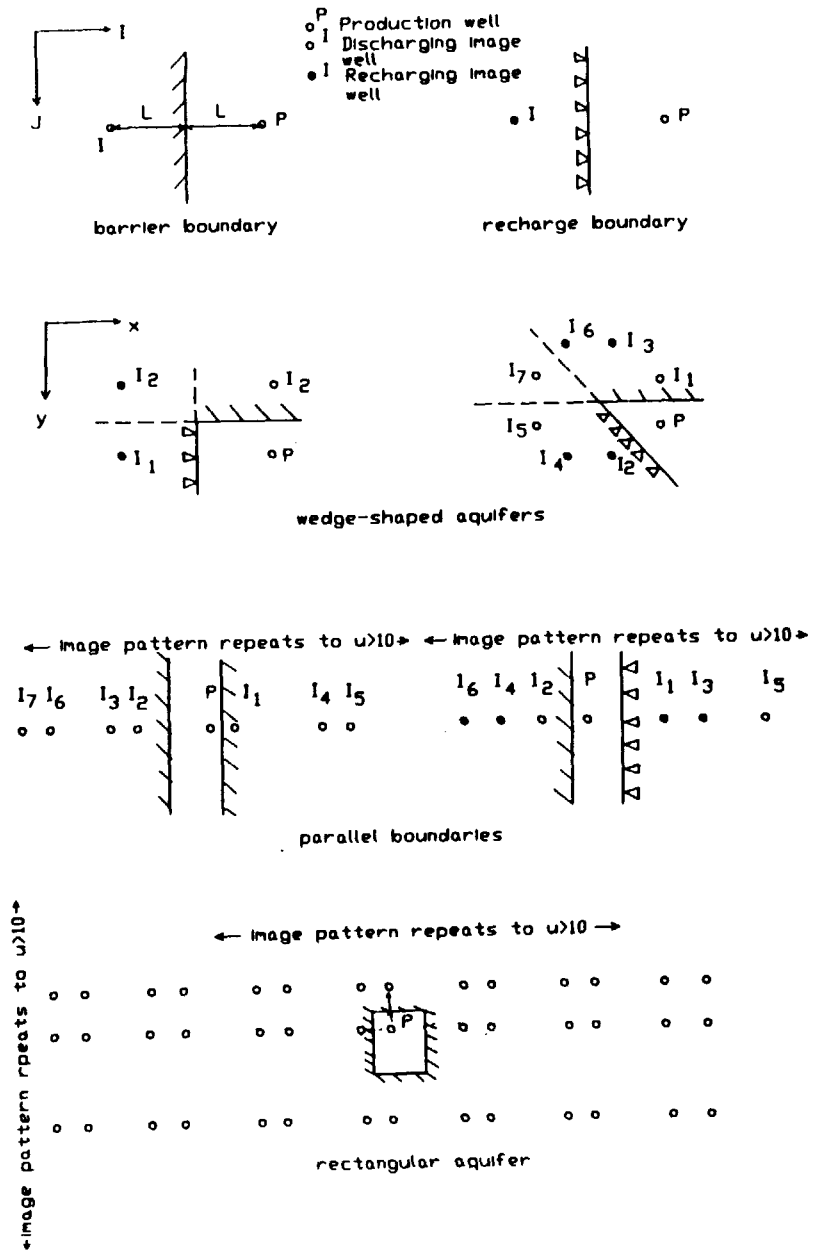

Figure 2. Aquifer boundary image-well patterns.

4 9 0 0 4 6 2

the following equations (see Raudkivi and Callander, 1976, p. 118):

$$P_{Ha} = (P_{H1}A_1 + P_{H2}A_2 + \ldots + P_{Hn}A_n)/(A_1 + A_2 + \ldots + A_n) \quad (26)$$

$$P_{Va} = (B_1 + B_2 + \ldots + B_n)/(B_1/P_{V1} + B_2/P_{V2} + \ldots + B_n/P_{Vn}) \quad (27)$$

where

P_{Ha} = average horizontal hydraulic conductivity in gpd/sq ft

P_{Hn} = horiz. hydr. conductivity of material n in gpd/sq ft

P_{Va} = average vertical hydraulic conductivity in gpd/sq ft

P_{Vn} = vert. hydr. conductivity of material n in gpd/sq ft

A_n = area underlain by material n in sq ft

B_n = thickness of layer with material n in ft

Drawdown Component Models

The total drawdown s_T at a point has all or some of the following components depending upon hydrogeologic and well conditions: the drawdown s due to laminar flow of water through the aquifer toward wells (well interference), the drawdown s_{wl} (well loss) due to the turbulent flow of water through the screen or well face and inside the casing to the pump intake, the drawdown s_p due to partial penetration of wells, the drawdown s_d due to dewatering a portion of the aquifer under water table conditions, the drawdown s_b due to barrier boundary image wells, and the buildup s_r

due to recharge boundary image wells. Stated as an equation

$$s_T = s + s_{wl} + s_p + s_d + s_b - s_r \quad (28)$$

Values of s, s_p, s_b, and s_r are calculated in WELFLO utilizing four common analytical models and associated equations.

Model 1 (Theis, 1935, pp. 519–524) assumes that flow is entirely horizontal and radial and that wells fully penetrate the aquifer. There are no vertical components of flow and no wellbore storage. The uniformly porous aquifer is overlain and underlain by aquicludes with negligible vertical hydraulic conductivity. The nonleaky artesian aquifer is homogeneous, isotropic, infinite in areal extent, and constant in thickness throughout. Wells have infinitesimal diameters and the discharge rate is constant. There are no boundaries or discontinuities. Model 1 simulates water table conditions when delayed gravity yield impacts are negligible and drawdown is small relative to the initial saturated aquifer thickness. The Model 1 equation is:

$$s = 114.6QW(u)/T \quad (29)$$

where

$$u = 1.87r^2S/(Tt) \quad (30)$$

Q = discharge rate in gpm

W(u) = well function, dimensionless

T = aquifer transmissivity in gpd/ft

r = distance from production well in ft

S = aquifer storativity as a decimal

t = time after pumping started in days

Rushton and Redshaw (1979, pp. 237-266) list a short numerical FORTRAN program which simulates water table conditions with slow gravity yield and decreased transmissivity with water table decline. A BASIC version of that program is listed by Walton (1987, pp.106-112).

Model 2 (Hantush and Jacob, 1955, pp. 95-100) assumes wells fully penetrate a leaky artesian aquifer overlain by an aquitard and underlain by an aquiclude. Overlying the aquitard are deposits (source bed) in which there is a water table. The aquifer is homogeneous, isotropic, infinite in areal extent, and constant in thickness throughout. Flow lines are assumed to be refracted a full right angle as they cross the aquitard-aquifer interface. The aquitard is assumed to be more or less incompressible so that water released from storage therein is negligible. Drawdown in the source bed is negligible, production and observation wells have infinitesimal diameters and no wellbore storage, and the discharge rate is constant. There are no boundaries or discontinuities. Neuman and Witherspoon (1969, pp.810, 821) indicate that the use of Model 2 is justified when $r/(4m)[P_cS_cm/(P_HSm_c)]^{1/2} < 0.1$ and $t < 1.08\times10^3 m_cS_c/P_c$. Under these conditions, change in storage in the source bed are negligible. The Model 2 equation is:

$$s = 114.6QW(u,r/B)/T \qquad (31)$$

where

$$B = (Tm_c/P_c)^{1/2} \qquad (32)$$

m_c = aquitard thickness in ft

P_c = aquitard vertical hydraulic conductivity in gpd/sq ft

W(u,r/B) is a dimensionless well function

Model 3 (Boulton and Streltsova, 1977, pp. 257-270) assumes a fractured rock aquifer overlain and underlain by aquicludes. The nonleaky artesian aquifer consists of porous blocks of irregular size and shape, and adjoining and interconnected fissures. The aquifer is simulated by a set of regular porous block-and-fissure units made up of a horizontal porous block and a planar fissure. The thickness of the fissure is small compared with that of the porous block. The nonleaky artesian aquifer is heterogeneous, infinite in areal extent, and constant in thickness throughout. Wells have infinitesimal diameters and no wellbore storage. The production well is cased through porous blocks. The Model 3 equation is (see Streltsova, 1988, pp. 313-319, 381-391):

$$s_f = 114.6QW_{fp}(u_f,r/m_b,b,c)/T_f \qquad (33)$$

where

$$u_f = 1.87r^2S_f/(T_ft) \qquad (34)$$

$$b = P_bS_f/(S_bP_f) \qquad (35)$$

$$c = P_b/P_f \qquad (36)$$

$$T_f = P_fm \qquad (37)$$

s_f = drawdown in fissures in ft

S_f = fissure storativity as a decimal

T_f = fissure horizontal transmissivity in gpd/ft

T_b = block vertical transmissivity in gpd/ft

S_b = block storativity as a decimal

m_b = half dimension (thickness) of average block unit in ft

m = fractured rock aquifer thickness in ft

4 6 0 4 6 3

P_b = block vert. hydr. conductivity in gpd/sq ft

P_f = fissure horiz. hydr. conductivity in gpd/sq ft

$W_{fp}(u_f, r/m_b, b, c)$ is a dimensionless well function

Moench (1984, pp. 831-846) presents an analytical solution in the Laplace plane evaluated by numerical inversion for flow to a well of finite diameter with wellbore storage in a fractured rock aquifer. Wellbore storage impacts are shown to be dominant and to overshadow double-porosity impacts during early time periods.

Values of s_p are calculated with the Model 4 equation (Hantush, 1961, pp. 83-98), assuming the well discharge rate is constant during the simulation period:

$$s_p = 114.6QW[u, r(P_V/P_H)^{1/2}/m, L/m, d/m, Lo/m, do/m]/T \quad (38)$$

where

P_V = aquifer vertical hydraulic conductivity in gpd/sq ft

P_H = aquifer horiz. hydraulic conductivity in gpd/sq ft

m = aquifer thickness in ft

L = distance from aquifer top to prod. well base in ft

d = distance from aquifer top to prod. well screen top in ft

Lo = distance from aquifer top to obs. well base in ft

do = distance from aquifer top to obs. well screen top in ft

The effects of a damaged or enhanced zone surrounding a production well (skin; see Streltsova, 1988, pp. 75-78) may be simulated through the proper selection of the effective radius of the well. Well loss may be calculated with the following equation (Jacob, 1946, pp. 1047-1070):

$$s_{wl} = CQ^2 \quad (39)$$

where

s_{wl} = drawdown component due to well loss in ft

C = well loss coefficient in sec^2/ft^5

Q = production well discharge rate in cfs

Values of s_d may be calculated with the following equation (Jacob, 1946):

$$s_a = s_o - s_o^2/(2m) \quad (40)$$

where

s_a = drawdown with dewatering effects in ft

s_o = drawdown without dewatering effects in ft

m = initial aquifer thickness in ft

Wellbore Storage

Whether or not wellbore storage should be simulated may be determined with the following equation (see Driscoll, 1986, p. 566):

$$t_s = 5.4x10^5(r_w^2 - r_c^2)/T \quad (41)$$

where

r_w = production well effective radius in ft

r_c = pump-column pipe radius in ft

T = aquifer transmissivity in gpd/ft

t_s = time after pumping started beyond which wellbore storage impacts are negligible (less

than 1% of drawdown values) in minutes

Wellbore storage is approximated in WELFLO with an iterative procedure described by Huyakorn and Pinder (1983, pp. 127–128). The procedure assumes the well discharge rate and well geometry are constant during simulation periods and drawdown under water table conditions is negligible in comparison to the aquifer thickness. The procedure uses the principle of superposition. Well discharge is the sum of the discharge derived from the aquifer and the discharge derived from storage within the wellbore. Discharge from the aquifer increases exponentially with time (Streltsova, 1988, p. 51). However, in the approximation it is assumed that discharge from the aquifer varies linearly during short pumping periods. Drawdown with wellbore storage at the end of a time increment is the drawdown with wellbore storage at the beginning of the time increment, plus the drawdown without wellbore storage during the time increment, multiplied by the average aquifer discharge, divided by the well discharge.

The equation relating the constant discharge from the production well, average discharge derived from the aquifer, and discharge derived from storage within the wellbore is as follows (see Huyakorn and Pinder, pp. 127–128):

$$Q = Q_A + \pi(r_w^2 - r_c^2)s_{ws}7.48/\Delta t \qquad (42)$$

where

Q = constant discharge from production well during simulation period in gpm

Q_A = average discharge derived from aquifer during simulation period (sum of aquifer discharges at simulation period start and end divided by 2) in gpm

r_w = production well effective radius in ft

r_c = pump column-pipe radius in ft

s_{ws} = drawdown with wellbore storage impacts during simulation period in ft

Δt = time at end of present simulation period in minutes

The successive bisection iterative procedure used in WELFLO (see Clark, 1987, pp. 3.8–3.12) starts with a first trial value of s_{ws} based on the analytically calculated drawdown without wellbore storage impacts. If needed, early drawdown in the production well due to pumping the well itself is calculated with the finite diameter well function (see Streltsova, 1988, pp. 45–49). Equation 42 is used to calculate a first trial value of Q_A. A second trial value of s_{ws} is calculated by multiplying drawdown without wellbore storage impacts by the ratio first trial value of Q_A, divided by the discharge from the well. The first and second trial values of s_{ws} are compared and if the difference exceeds an error tolerance the iteration is repeated. If the difference is less than or equal to an error tolerance, the estimated values of Q_A and s_{ws} are declared valid.

Complex wellbore storage functions may be calculated with values of s_{ws}. For example, suppose it is desirable to determine values of the leaky artesian wellbore storage function. Values of drawdown (s) without wellbore storage are calculated based on leaky artesian Model 2 Equations 31 and 32 and selected values of u and r/B. Corresponding values of drawdown with wellbore storage (s_{ws}) are then calculated using the iterative procedure and Equation 42. Corresponding values of the leaky artesian wellbore storage function $W(u,r/B,S,r/r_w)$ are finally calculated with the equation $W(u,r/B,S,r/r_w) = s_{ws}T/(114.6Q)$.

4 9 0464

Appendix B

APPENDIX B

BORING LOGS

SAMPLER SYMBOLS

Pushing Split-Spoon

No Recovery

Auger

Shelby tube (California Sampler)

Split-Spoon with blow counts

No sample taken at this interval

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

BORING: BCP1
FILE: 90B449C-3F
DATE: 8/12/92
TECHNICIAN: F. Sierra
APPROVED: VP
PAGE: 1 of 1

Hollow-stem Augered: Full Depth
No free water was encountered during hollow-stem augering.

4 9 0463

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		2.0	N/A	N/A	4	Shell and fill material
			BKG	N/A		(FILL)
		2.75	1	N/A	9	Stiff dark brown (7.5YR 4/4) Silty CLAYS, dry (CL)
						—mottled with red (10R 4/8) and no silt after 2'
		3.5	BKG	N/A	15	—with mottled pattern of gray (2.5YR N6) at 4'
5		3.5	N/A	BKG	12	—gray (2.5Y N6) with red (2.5YR 5/8) iron staining below 6'
		3.5	N/A	4	20	
10			46	N/A	1	
			186	N/A	12	Firm light brownish gray (10YR 6/2) Clayey SANDS, dry, with brown yellow (10YR 6/6) iron staining (SC)
		12 b/ft	6	N/A	13	—interbedded with clayey silt and with red (2.5YR 4/6) iron staining, 12'- 14' —no clayey silt below 14'
15		22 b/ft	6	N/A	13	
		18 b/ft	5	N/A	20	—firm light gray (10YR 7/1) fine sand, well sorted, dry, 18'- 22'
20		25 b/ft	21	N/A	22	—slightly clayey at 20'
		28 b/ft	15	1	11	—brownish yellow (10YR 5/8), coarse grained, 22'- 24'
		21 b/ft	5	1	18	—brownish yellow and light gray (10YR 7/1), 24'- 26'
25		20 b/ft	6	1	14	—brownish yellow and light gray below 26'
			5	0.5	12	
30			3	0.5	24	
						Bottom of boring at 32'. Borehole grouted full depth.

Soil samples retained for lab analysis from 2'-4', 8'-10', 12'-14' and 30'- 32'.
NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.
N/A = Not Available

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BCP2
FILE: 90B449C-3F
DATE: 8/13/92
TECHNICIAN: F. Sierra
APPROVED: VP
PAGE: 1 of 1

Hollow-stem Augered: Full Depth
No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		NR				Shells (FILL)
		2.5	5	0.5	23	Stiff gray (2.5Y N6) and red (10R 4/8) CLAYS, damp (CH)
		2.5	5	0.25	14	
5		2.5	3	0.5	17	
			2	BKG	16	
10			1	0.25	14	Firm brown (10YR 5/3) Clayey SILTS, damp, with iron stains (ML)
		NR	2	0.5		—olive yellow (2.5Y 6/8) below 10'
			4	0.5	12	—becoming clayey below 14'
15		NR	1	BKG		Loose, light gray (10YR 7/1) SILTS, damp (ML)
			1	BKG	10	
20						Bottom of boring at 20'. Borehole grouted full depth.

Soil samples retained for lab analysis from 2'-4', 8'-10', 14'-16' and 18'-20'.
10" Carbon steel casing set from 0'-9'.
NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.
N/A = Not Available

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

4 9 0469

BORING: BL1
FILE: 90B449C-3F
DATE: 8/12/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: **Full Depth**

Free water was encountered at a depth of 10' during hollow-stem augering. The water level rose to a depth of approximately 6' after an observation period of 5 minutes.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		1.5			17	Stiff reddish brown and gray (10YR 4/8) Silty CLAYS (FILL)
						—with ash and gravel at 1'
		1.5			23	Stiff reddish brown and gray (10YR 4/8) Sandy CLAYS (FILL)
		1.25				
		1.0			24	—with gravel, 2'- 4'
5						—red (2.5R 4/8), 4'- 6.25'
		1.0			24	Very loose black (2.5YR 2.5/0) Ash FILL and Sandy GRAVEL (FILL)
		<0.25			24	—wet at 8'
10		<0.25			24	
		<0.25			24	
		<0.25			10	
15		<0.25			10	Soft white (5Y 8/1) LIME waste material, damp (FILL)
		0.5			24	
20						Red and gray (2.5YR 5/8) CLAYS (CH)
						Bottom of boring at 20'. Drilled to 18' and pushed a split spoon from 18'- 20' Borehole grouted to full depth.

Soil sample retained for lab analysis from 16'- 18'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BL2
FILE: 90B449C-3F
DATE: 8/16/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: Full Depth

Free water was encountered at a depth of 8' during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					24	Stiff brown (7.5YR 5/4) Sandy CLAYS, dry (FILL)
					21	Black Ash material, dry (FILL)
						—with coal, wood and gravel to 2'
					20	
5						—with a clay lense at 5'
					10	—damp at 5.8' —wet at 6'
					11	
10					18	—with black and white lime waste at 10'
						Soft brown (7.5YR 5/4) CLAYS, wet (FILL)
					20	White Lime, black ash and fiberous geotextile fabric (5Y 8/1) (FILL)
					16	—damp at 12'
15						Stiff yellowish red (5YR 5/8) CLAYS, damp to dry (CH)

Bottom of boring at 16'.
Drilled to 14' and pushed a split spoon from 14'- 16'
Borehole grouted to full depth.

Soil sample retained for lab analysis from 12'- 14'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

4 9 0470

BORING: BLD1
FILE: 90B449C-3F
DATE: 8/20/92
TECHNICIAN: J. Davis
APPROVED: VR
PAGE: 1 of 1

Hollow-stem Augered: **Full Depth**

No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					21	Stiff yellowish red (5YR 4/6) Sandy CLAYS with rocks and concrete chips, dry (FILL)
					11	—with a dark brown organic layer, 2.3'- 2.6'
5					12	Stiff yellowish red (5YR 5/6) CLAYS (FILL)
					23	
					12	—with rocks and concrete below 9'
10						Bottom of boring at 10'. Borehole grouted full depth.

Soil samples retained for lab analysis from 0'- 1' and 1'- 10'.

Unified Soil Classifications based on visual observations.

FEB 15 93 ENVSOH 0B449 665NCF

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III

LOCATION: Olin Chemicals
McIntosh, Alabama

CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BMC1
FILE: 90B449C-3F
DATE: 8/21/92
TECHNICIAN: M. Schwartz
APPROVED: N.P.
PAGE: 1 of 1

Dry Augered: **Full Depth**

No free water was encountered during dry augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0						Asphalt
						Concrete
						SANDS with shells and rock fragments, dry (FILL)
						Medium to stiff gray, red and brown CLAYS, dry (CH)
5						Bottom of boring at 5.5'. Borehole grouted full depth.

Soil sample retained for lab analysis from 1.5'- 5.5'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III

LOCATION: Olin Chemicals
McIntosh, Alabama

CLIENT: Olin Chemical Corporation
Charleston, Tennessee

4 9 0471

BORING: BMC2
FILE: 90B449C-3F
DATE: 8/21/92
TECHNICIAN: M. Schwartz
APPROVED: VP.
PAGE: 1 of 1

Dry Augered: **Full Depth**

No free water was encountered during dry augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0						Asphalt
						Concrete
						SANDS with shells and rock fragments, dry (FILL)
						Medium to stiff gray, red and brown CLAYS, dry (CH)
5						Bottom of boring at 5.5'. Borehole grouted full depth.

Soil sample retained for lab analysis from 1.5'- 5.5'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: **RI/FS Phase III**

LOCATION: **Olin Chemicals**
McIntosh, Alabama

CLIENT: **Olin Chemical Corporation**
Charleston, Tennessee

BORING: **BMC3**
FILE: **90B449C-3F**
DATE: **8/21/92**
TECHNICIAN: **M. Schwartz**
APPROVED: VP.
PAGE: **1 of 1**

Dry Augered: **Full Depth**

No free water was encountered during dry augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0						Asphalt
						Concrete
						SANDS with shells and rock fragments, dry (FILL)
						Medium to stiff gray, red and brown CLAYS, dry (CH)
5						Bottom of boring at 5.5'. Borehole grouted full depth.

Soil sample retained for lab analysis from 1.5'- 5.5'.

Unified Soil Classifications based on visual observations.

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BMC4
FILE: 90B449C-3F
DATE: 8/25/92
TECHNICIAN: M. Schwartz
APPROVED: VP.
PAGE: 1 of 1

Dry Augered: **Full Depth**

No free water was encountered during dry augering.

4 9 0472

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0						Asphalt
						Concrete
						SANDS with shells and rock fragments (FILL)
						Medium to stiff gray, red and brown CLAYS, dry (CH)
5						Bottom of boring at 5.5'. Borehole grouted full depth.

Soil sample retained for lab analysis from 1.5'- 5.5'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: **RI/FS Phase III**
LOCATION: **Olin Chemicals McIntosh, Alabama**
CLIENT: **Olin Chemical Corporation Charleston, Tennessee**

BORING: **BMC5**
FILE: **90B449C-3F**
DATE: **8/25/92**
TECHNICIAN: **M. Schwartz**
APPROVED: VP.
PAGE: **1 of 1**

Dry Augered: **Full Depth**

No free water was encountered during dry augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0						Asphalt
						Concrete
						SANDS with shells and rock fragments (FILL)
						Medium to stiff gray, red and brown CLAYS, dry to damp (CH)
5						Bottom of boring at 5.5'. Borehole grouted full depth.

Soil sample retained for lab analysis from 1.5'- 5.5'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT:	RI/FS Phase III	BORING:	BSB2
LOCATION:	Olin Chemicals McIntosh, Alabama	FILE:	90B449C-3F
		DATE:	8/13/92
		TECHNICIAN:	J. Davis
CLIENT:	Olin Chemical Corporation Charleston, Tennessee	APPROVED:	VP.
		PAGE:	1 of 1

Hollow-stem Augered: **Full Depth**

No free water was encountered during hollow-stem augering.

4 9 0474

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					16	Stiff yellowish red (5YR 4/6) Silty CLAYS, damp (FILL)
					10	—with rocks, shells and wood, 0.5'- 2' —dry below 2'
5					24	
					20	
					17	Very stiff dark red (10R 3/6) CLAYS, dry (CL)
10						Bottom of boring at 10'. Borehole grouted full depth.

Soil sample retained for lab analysis from 8'- 10'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

BORING: BSL1
FILE: 90B449C-3F
DATE: 8/19/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: Full Depth

Free water was encountered at a depth of 5.0' during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					14	Soft dark brown (7.5YR 3/3) Silty CLAYS, damp (FILL)
					23	Soft very dark gray (5YR 3/1) FILL material with shells, rocks and wood (FILL)
5		NR				
					20	Dark brown (7.5YR 3/3) CLAYS, dry (FILL)
10		NR				—with a layer of black (7.5YR 2/0) ash, 9.5'- 10'
						Bottom of boring at 12'. Borehole grouted full depth.

NR = No Recovery
Soil sample retained for lab analysis from 0'- 7'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT:	RI/FS Phase III	BORING:	BMC6
LOCATION:	Olin Chemicals McIntosh, Alabama	FILE:	90B449C-3F
		DATE:	8/25/92
		TECHNICIAN:	M. Schwartz
CLIENT:	Olin Chemical Corporation Charleston, Tennessee	APPROVED:	VP.
		PAGE:	1 of 1

Dry Augered: **Full Depth**

No free water was encountered during dry augering.

4 9 0473

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0						Asphalt
						Concrete
						SANDS with shells and rock fragments (FILL)
						Medium to stiff gray, red and brown CLAYS, dry (CH)
5						Bottom of boring at 5.5'. Borehole grouted full depth.

Soil sample retained for lab analysis from 1.5'- 5.5'.

Unified Soil Classifications based on visual observations.

LOG OF BORING

PROJECT:	RI/FS Phase III	BORING:	BSL1
LOCATION:	Olin Chemicals McIntosh, Alabama	FILE:	90B449C-3F
		DATE:	8/19/92
		TECHNICIAN:	J. Davis
CLIENT:	Olin Chemical Corporation Charleston, Tennessee	APPROVED:	VP
		PAGE:	1 of 1

Hollow-stem Augered: **Full Depth**

Free water was encountered at a depth of 5.0' during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					14	Soft dark brown (7.5YR 3/3) Silty CLAYS, damp (FILL)
					23	Soft very dark gray (5YR 3/1) FILL material with shells, rocks and wood (FILL)
5		NR				
					20	Dark brown (7.5YR 3/3) CLAYS, dry (FILL)
10		NR				—with a layer of black (7.5YR 2/0) ash, 9.5'- 10'
						Bottom of boring at 12'. Borehole grouted full depth.

NR = No Recovery

Soil sample retained for lab analysis from 0'- 7'.

Unified Soil Classifications based on visual observations.

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

BORING: BSL2
FILE: 90B449C-3F
DATE: 8/19/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: Full Depth
No free water was encountered during hollow-stem augering.

4 9 0475

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					14	Soft dark brown (7.5YR 3/3) and black (5YR 3/1) Silty CLAYS, damp, with rocks, wood and shells (FILL)
					12	
					17	
5						—dark brown (7.5YR 3/3) clay layer, 5.5'- 6.0'
		NR				
		NR				
10					12	—stiff dark brown (7.5YR 3/3) clay layer, 11.5'- 11.7'
						Strong brown (7.5YR 5/6) SANDS, dry (SP)
						Bottom of boring at 12'. Borehole grouted full depth.

NR = No Recovery
Soil sample retained for lab analysis from 0'- 12'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BSL3
FILE: 90B449C-3F
DATE: 8/20/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: Full Depth

No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					13	Soft to stiff dark brown (7.5YR 3/3) Silty CLAYS, dry (FILL)
					16	Stiff very dark gray (5YR 3/1) Sandy CLAYS, dry, with wood, shells and plastic (FILL)
						—with black striations, 2'- 8'
5					24	
					21	
					15	
10					17	—dark gray (5YR 4/1), 10.6'- 11'
						Very stiff yellowish red (5YR 5/6) CLAYS, dry (CH)
						Bottom of boring at 12'. Borehole grouted full depth.

Soil sample retained for lab analysis from 0.3'- 12'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

Appendix C

4 9 0477

APPENDIX C

RESISTIVITY SURVEY

4 9 0478

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5.0	REFERENCES	C-4

LIST OF ATTACHMENTS

Attachment C-1	Final Result Models
Attachment C-2	Data Sheets

APPENDIX C
RESISTIVITY SURVEY

1.0 INTRODUCTION

A resistivity survey was conducted at the old plant (CPC) landfill within the Olin McIntosh Plant Site. The purpose of the resistivity survey was to assess whether geophysical methods could be used to aid in the characterization of a layer of loose saturated silt/clay material. This layer had been identified in borings completed during Phase III drilling operations. The geophysical study was intended to provide information on the thickness of this saturated zone.

The geophysical investigation consisted of a feasibility study of the proposed method and an implementation phase. This appendix provides a brief description of the method used, specifics of the field program, and geophysical results.

2.0 ELECTRICAL RESISTIVITY SOUNDING METHOD

Electrical, or direct current (DC) resistivity provides a means of measuring the electrical resistivity of subsurface soil, rock, and groundwater. A DC resistivity sounding, using the Schlumberger electrode array, provides a resistivity versus depth profile of the subsurface that can be used to characterize:

- Electrical properties of lithologic layers
- The depth to water table

The method for obtaining a DC resistivity profile involves inducing electrical current into the ground using a pair of surface electrodes. The resulting potential field (voltage) is measured at the surface between a second pair of electrodes. Subsurface resistivities are calculated from the separation and geometry of the electrode positions, the applied current, and the measured voltage. A schematic of the method is shown in Figure 1.

In general, soil and rock act as electrical insulators and are highly resistive. The flow of current is conducted primarily through moisture-filled pore spaces. The observed resistivity is predominantly controlled by porosity and permeability of soil and rock, the amount of pore water, and the concentration of dissolved solids in pore water.

In general, electrical resistivity sounding methods are more responsive to resistive layers than conductive layers. This is because, when using electrical sounding methods, current flows perpendicular to thin resistive layers and parallel to thin conductive layers (Fitterman, 1988). Therefore, a greater percentage of the resistive layer is sampled, resulting in a more accurate bulk resistivity of the layer. As a result of this, uncertainty can arise in modeling the interface between a resistive layer and a conductive layer. The absolute thicknesses of the modeled layers will be resolved, but the elevation of the interface can have some uncertainty.

Data collected can be modeled using an interactive resistivity interpretation program to estimate the resistivity profile. Modeling of sounding data produces a 2-dimensional profile of resistivity versus depth, similar in appearance to a lithologic log.

3.0 ELECTRICAL RESISTIVITY FIELD PROGRAM

The field program was initiated with a feasibility study of the resistivity method for the stated objectives of the project. The feasibility study was conducted on February 15, 1993. Six resistivity soundings were completed in the feasibility study. Three of the soundings were located near borings completed during the Phase III work so stratigraphic correlations could be made.

After feasibility data were examined and borehole correlations made, the feasibility study was deemed successful, and full implementation of the method was conducted. Data were collected on February 16 and 17, 1993, and on March 26, 1993. Several sounding locations were reoccupied on March 26, 1993 to augment some sounding data sets previously collected that displayed erratic data.

A total of 24 resistivity soundings were completed during the field investigation period as shown on Figure 2. Locations of each sounding were chosen based on survey

objectives, site conditions, and proximity to existing wells or borings that could provide subsurface control.

Field data were collected using an ABEM Terrameter resistivity meter. Each sounding consisted of at least 11 current electrode pairs incrementally spaced over a distance of 99 feet or 118 feet from the center of the array. Two or three potential electrode pair spacings were used at each site to measure the resulting voltage. The number of potential electrode pairs implemented depended upon the observed electrical properties of the subsurface and the discretion of the field scientists. Good electrical contact between the soil and electrodes was enhanced by saturating the soil around the electrodes with salt water.

Processing of the resistivity data involved plotting apparent resistivities against the electrode spacings on log-log graph paper. These data points defined a curve that was used to determine changes in resistivity with depth. The curves were then analyzed using a combination of forward modeling and inverse modeling.

Modeling was performed utilizing an interactive computer program, RESIXP, developed by Interpex Limited. The program completes the calculations for a forward and inverse model, but the interpreting geophysicists must integrate the geology of the area to choose a final model of the resistivity data. Forward modeling was done by estimating the electrical properties of the subsurface and calculating a sounding curve from the model. All curves were calculated in a manner described by Davis et al. (1980). Each sounding curve was compared to the field data. Iteration of this process occurred until a reasonable match between the calculated curve and the field data was achieved. Direct inversion was then performed to estimate the layered earth model directly from the data curve. This was done using a method similar to that of Koefoed (1976). Final inversion produced the model which best fit the data curve using ridge regression (Inman, 1975). The inverse model is a geoelectric cross section produced from the field data. Because the solution to the inverse model is not unique, it was compared with the forward model and analyzed by the senior geophysicists. A working knowledge of the geology of the surveyed area was necessary for the selection of the most probable model. Final resultant models are shown in Attachment C-1 to this Appendix. Data sheets summarizing each sounding are included in Attachment C-2.

4.0 RESISTIVITY RESULTS

Data from resistivity soundings provided additional information for characterizing the subsurface within the old plant (CPC) landfill. In general, results of the resistivity modeling indicate that the saturated silt/clay layer exhibits very low resistivity in comparison to overlying and underlying units. On the soundings where the saturated layer is interpreted to exist, the raw data curve has the shape of an inverse bell curve (e.g., soundings B2T1 and B2T2 in Attachment C-1). Soundings in which the saturated layer does not appear to exist have no layers with extremely low resistivities. Based on modeling results, the saturated layer has a resistivity of 2 to 12 ohm-feet, whereas the overlying and underlying units have varying resistivities from 45 ohm-feet to more than 400 ohm-feet.

The saturated layer is not uniformly present across the entire site. To better define the variation, a contour map was completed of the saturated layer thickness. The map is based on the limited boring control present in the area, as well as the best-fit modeled thicknesses resulting from the resistivity soundings. Data plotting and contouring was accomplished using the computer software GEOSOFT. Inputs to the contouring include the station coordinates and values, a spacing for gridding the raw data, and a contour interval. Color enhancing is accomplished based on the gridded values from the raw data. The final contour map is depicted in Figure 3. The map represents an estimate of the saturated silt/clay layer thickness with the available data.

5.0 REFERENCES

Davis, P., S. Greenhalgh, and N. Merrick. 1980. Resistivity sounding computation with any array using a single digital filter. Bull. Aust. Soc. Explor. Geophys., V. 11. pp. 54-62.

Fitterman, D. V. 1988. Equivalence behavior of three electrical sounding methods as applied to hydrological problems. Paper presented at the 50th Annual Meeting of the European Association of Exploration Geophysicists, 1988, The Hague, the Netherlands.

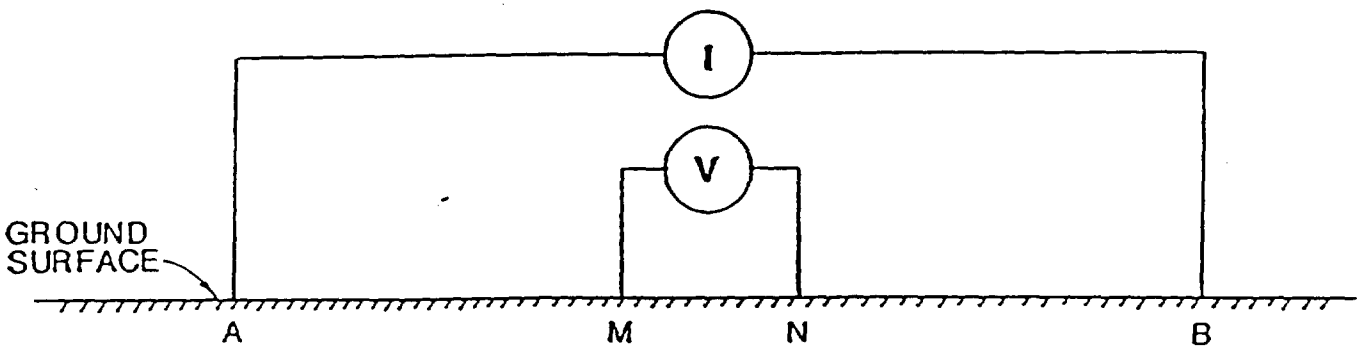
Inman, J. R. 1975. Resistivity inversion with ridge regression. Geophysics, V. 40, No. 5. pp. 798-817.

Koefoed, O. 1976. Progress in the direct interpretation of resistivity soundings: an algorithm. Geophysical Prospecting, V. 24, No. 2. pp. 233-240.

4 9 0401

FIGURES

4 9 0482



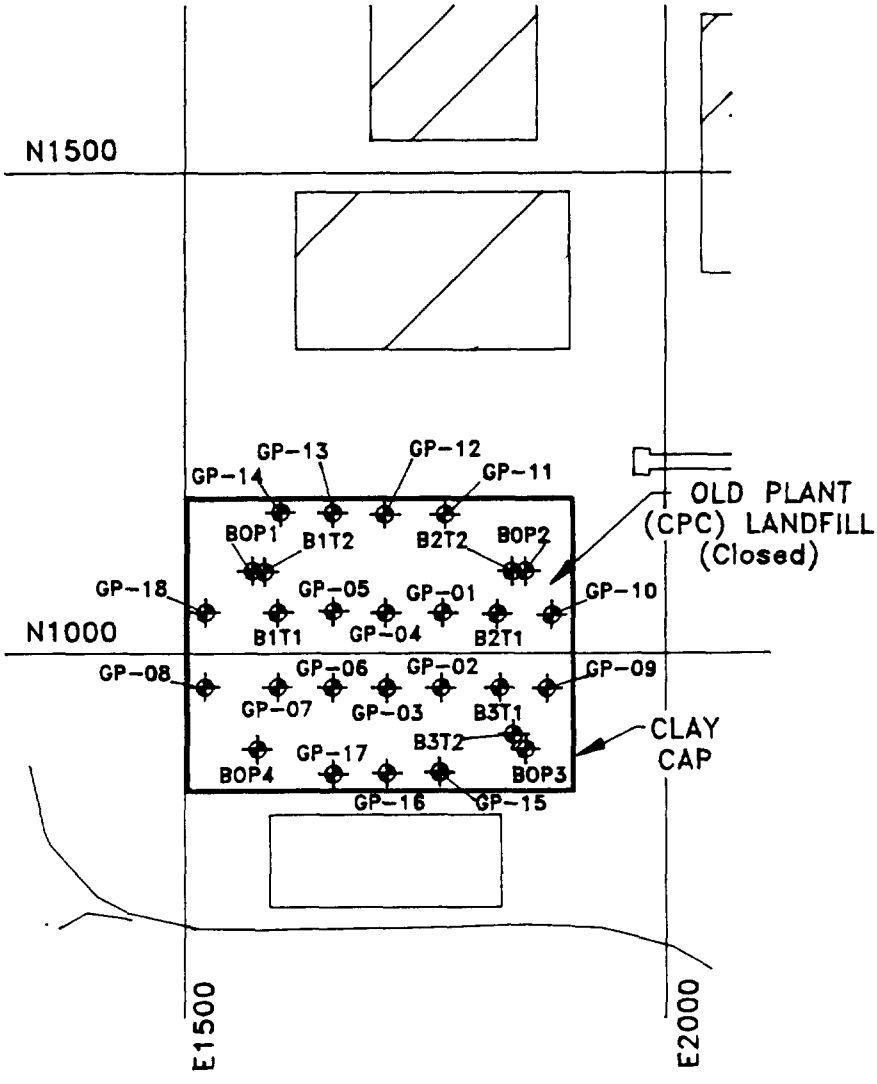
LEGEND

I – Current Electrodes
V – Potential (Voltages) Electrodes
MN – Potential Electrode Spacing
AB – Current Electrode Spacing

FIGURE 1

Job No. : 90B449C	DC RESISTIVITY SOUNDING USING SCHLUMBERGER ELECTRODE ARRAY
Prepared by : J.J.N.	
Date : 4/11/93	

4 9 0483



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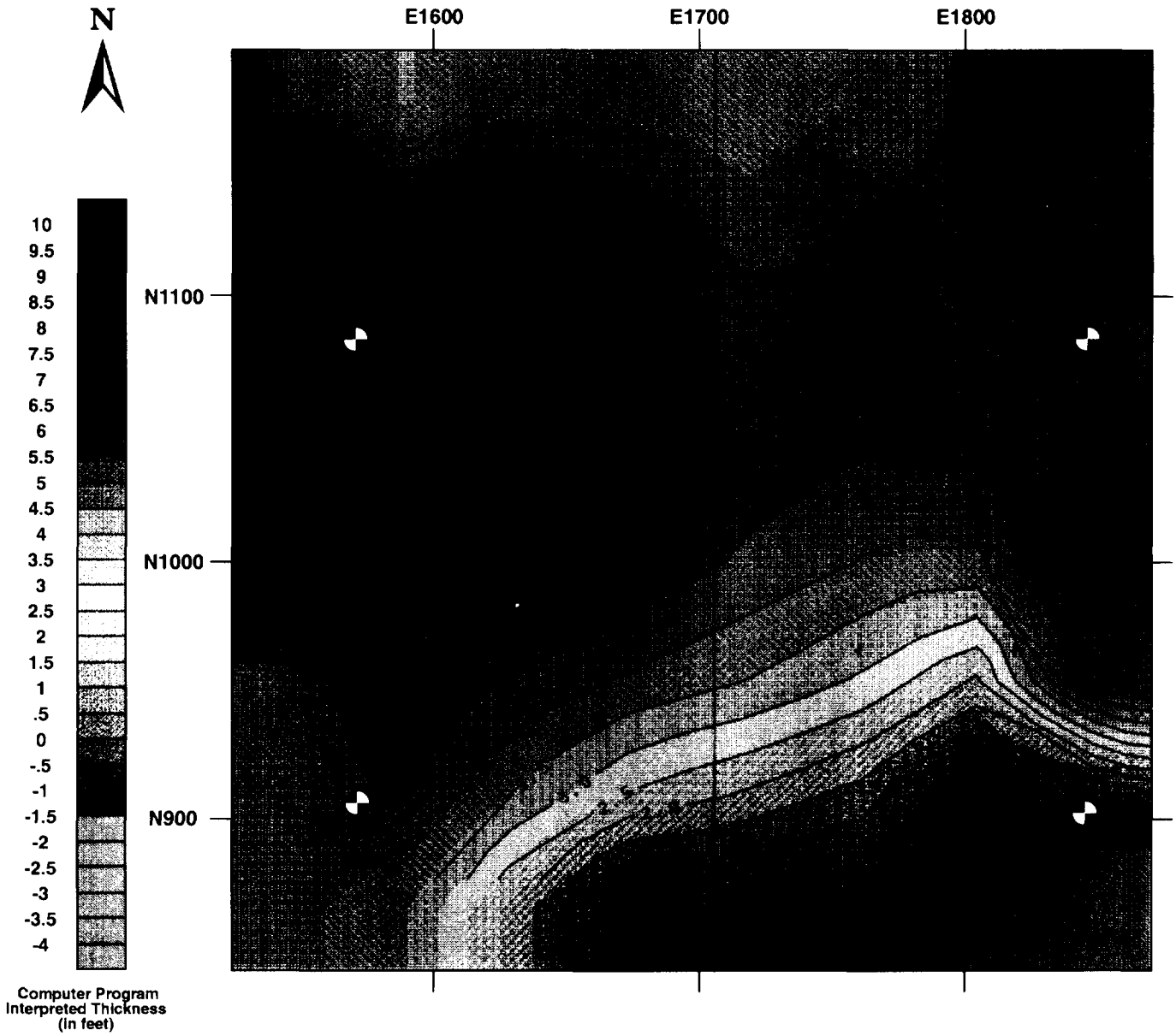
SOIL BORING LOCATION

SCALE

0 200 400 FEET

Location: B.R.,LA File name: K:\DRWG\OLIN\0B449C23.DWG Last edited: 04/12/93 ● 09:13

RI/FS McINTOSH PLANT SITE OLIN CHEMICAL CORPORATION CHARLESTON, TENNESSEE	**Woodward-Clyde Consultants** Consulting Engineers, Geologists and Environmental Scientists Baton Rouge, Louisiana	OLD PLANT (CPC) LANDFILL BORING LOCATIONS	FILE NO. 90B449C
	SCALE: NOTED; DRAWN BY: A. LONDON; DATE: 10/12/92; CHKD. BY: MJS; DATE: 4-15-93		FIG. NO. 2



LEGEND

- = Boring Location
- + = Resistivity Sounding Location
- 4.0 = Estimated thickness of loose, saturated silt/clay layer (feet)

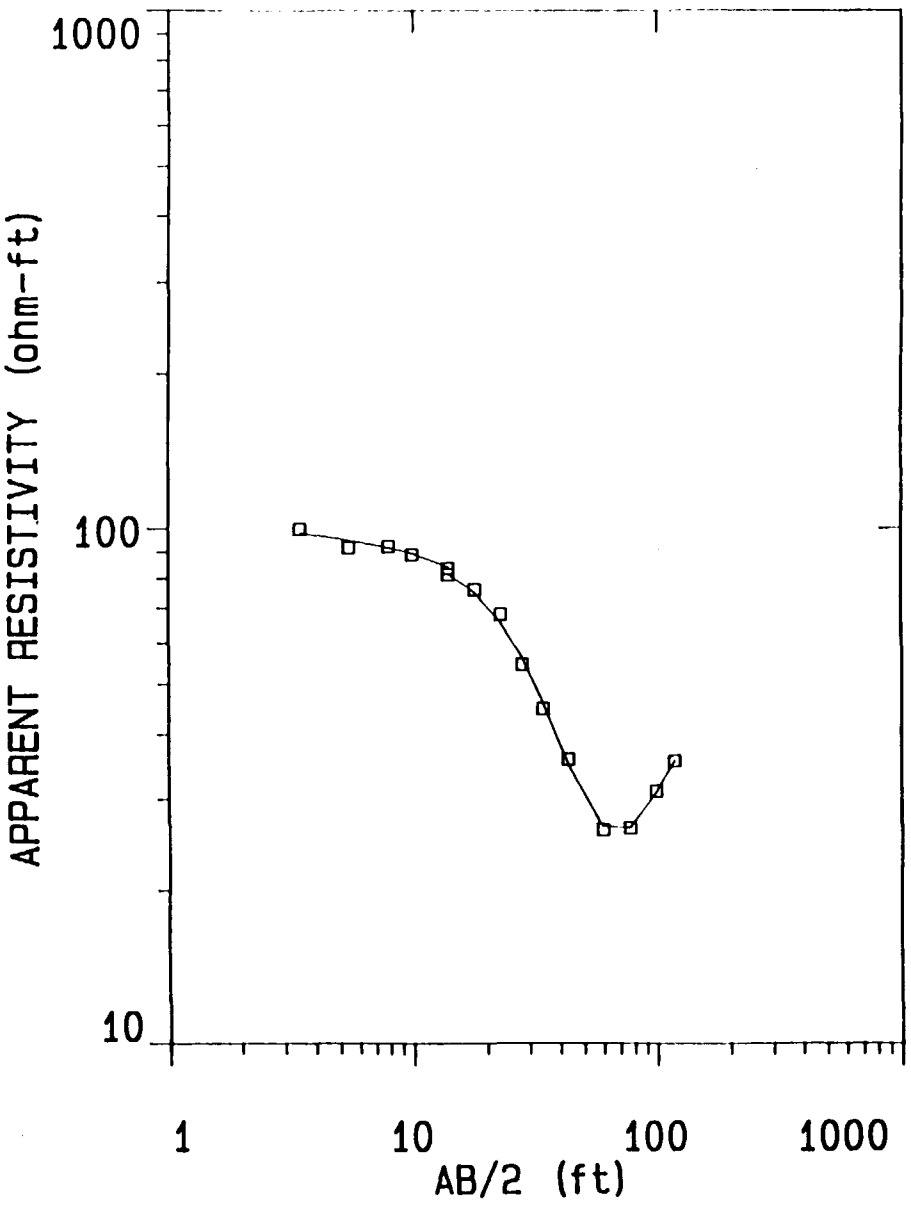
Notes:
The estimated thicknesses are based on the four Phase III borings and modeling results from the resistivity survey. The contour lines were interpreted between data points, and conditions may vary. It is assumed that the modeling results accurately depict the thickness of the layer across the landfill area.
A computer contouring program was used to obtain an objective depiction of trends in the data. This program, however, will commonly extrapolate contours beyond the limits of the data.

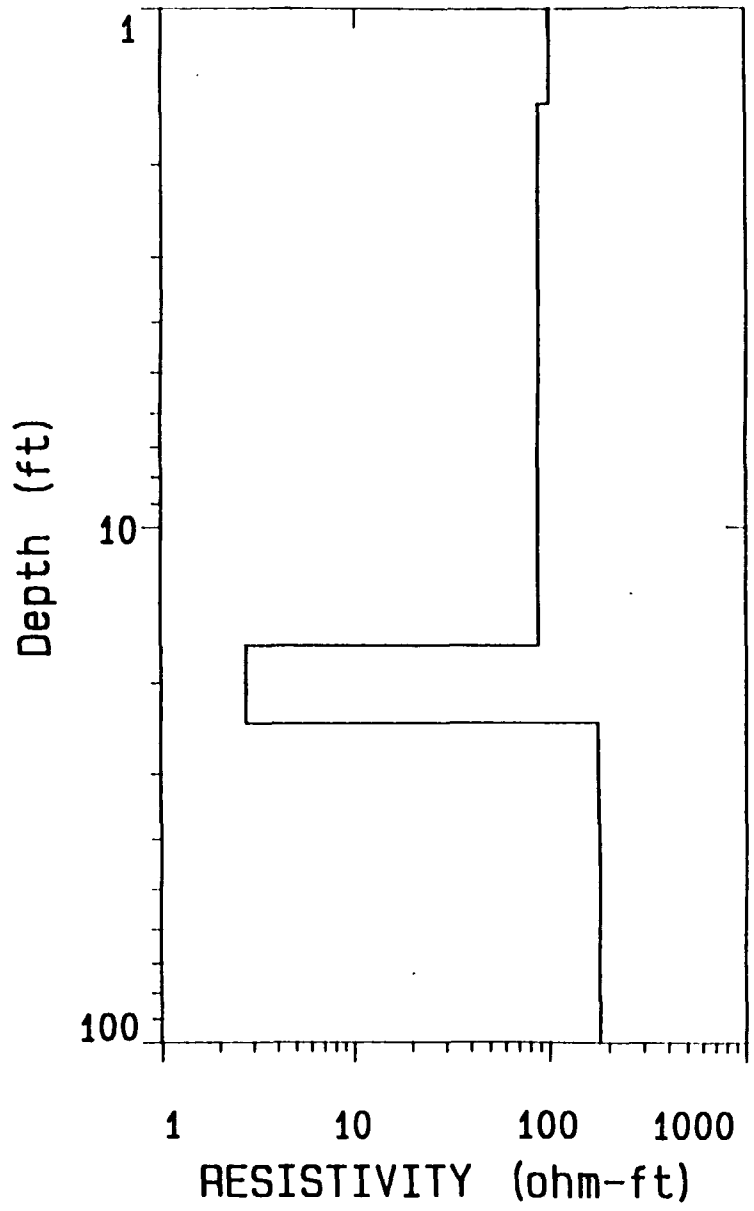
RI/FS McINTOSH PLANT SITE Olin CHEMICALS CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Engineering & sciences applied to the earth & its environment		ESTIMATED THICKNESS OF LOOSE SATURATED SILT/CLAY LAYER OLD PLANT (CPC) LANDFILL (CLOSED)	FILE NO. 90B449C
	SCALE: AS NOTED	DRAWN BY: D.OLSON DATE: 05/04/93 CHKD. BY: W.BEAL DATE: 05/04/93		FIG. NO. 3

4 9 0405

ATTACHMENT C-1

FINAL RESULT MODELS





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by: WOODWARD-CLYDE	CPC Landfill
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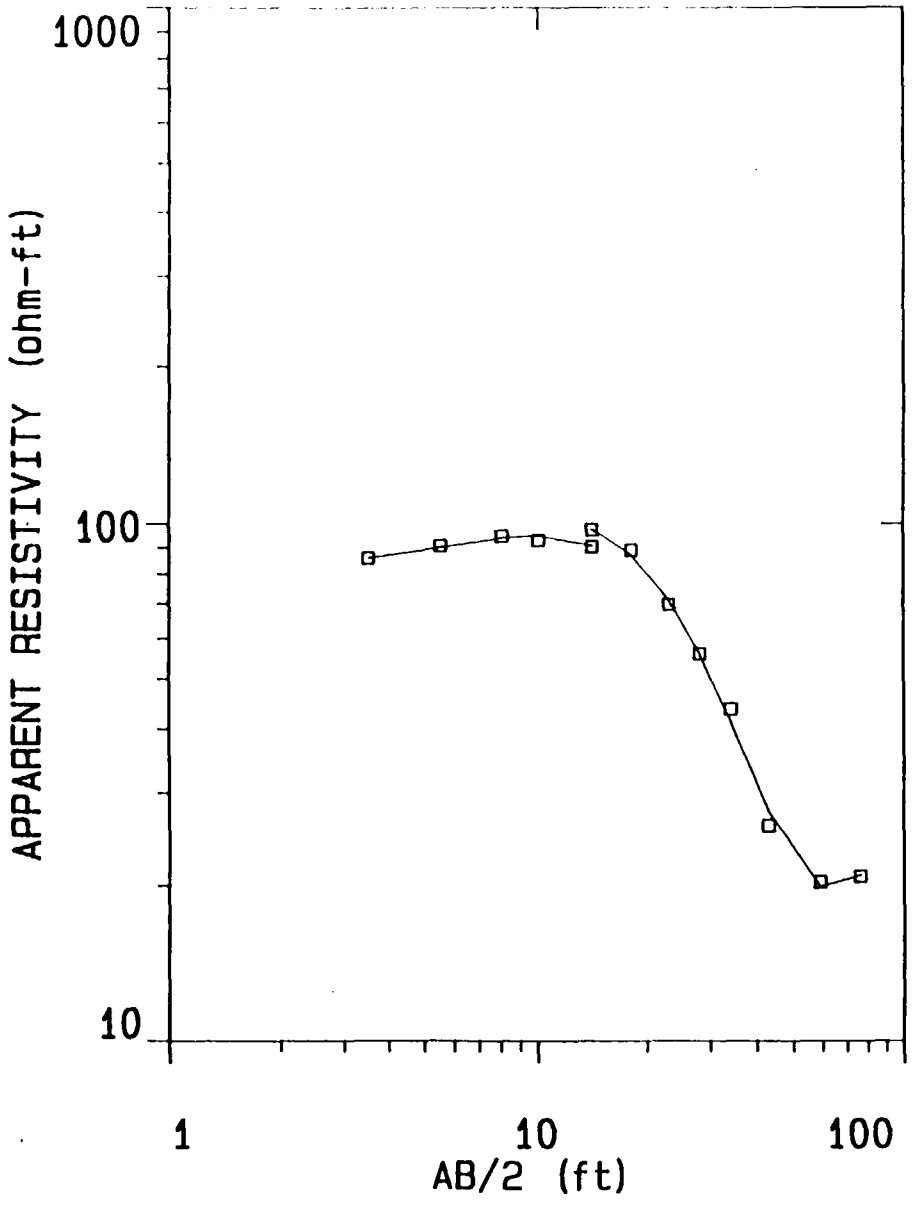
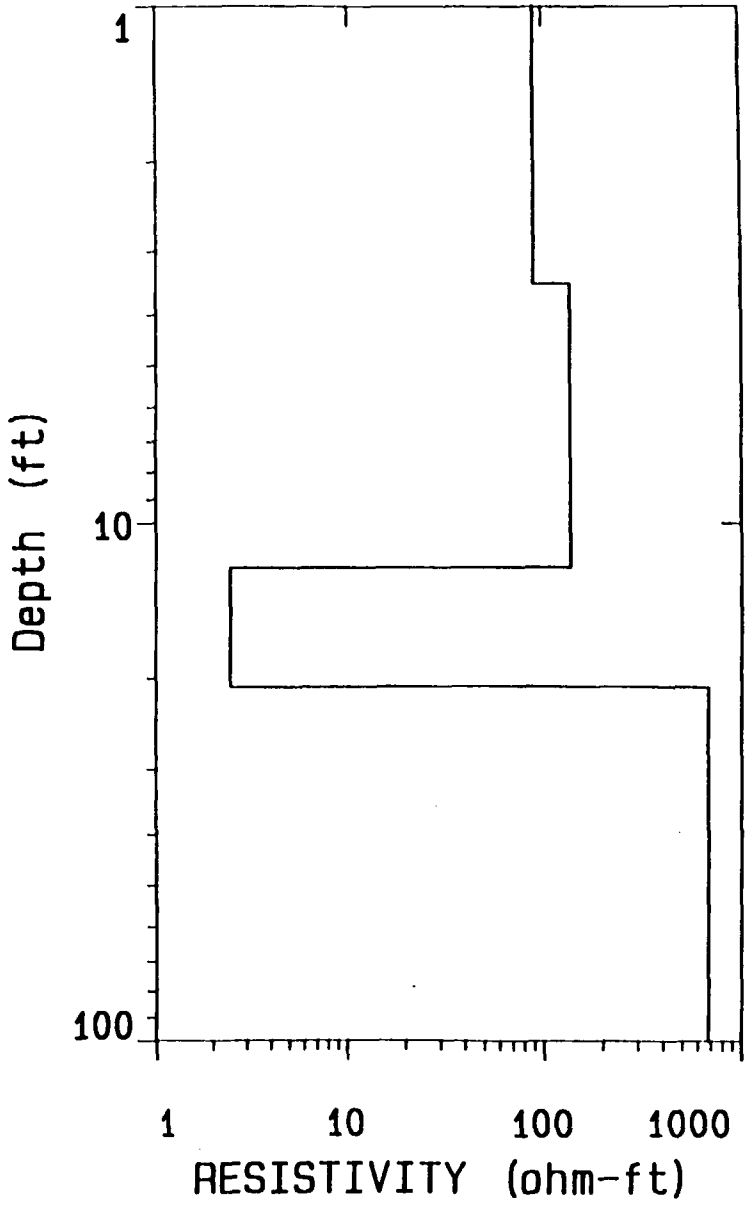
Equipment: Abem / Sounding: B1T1	Azimuth: n/a

4 9 0436





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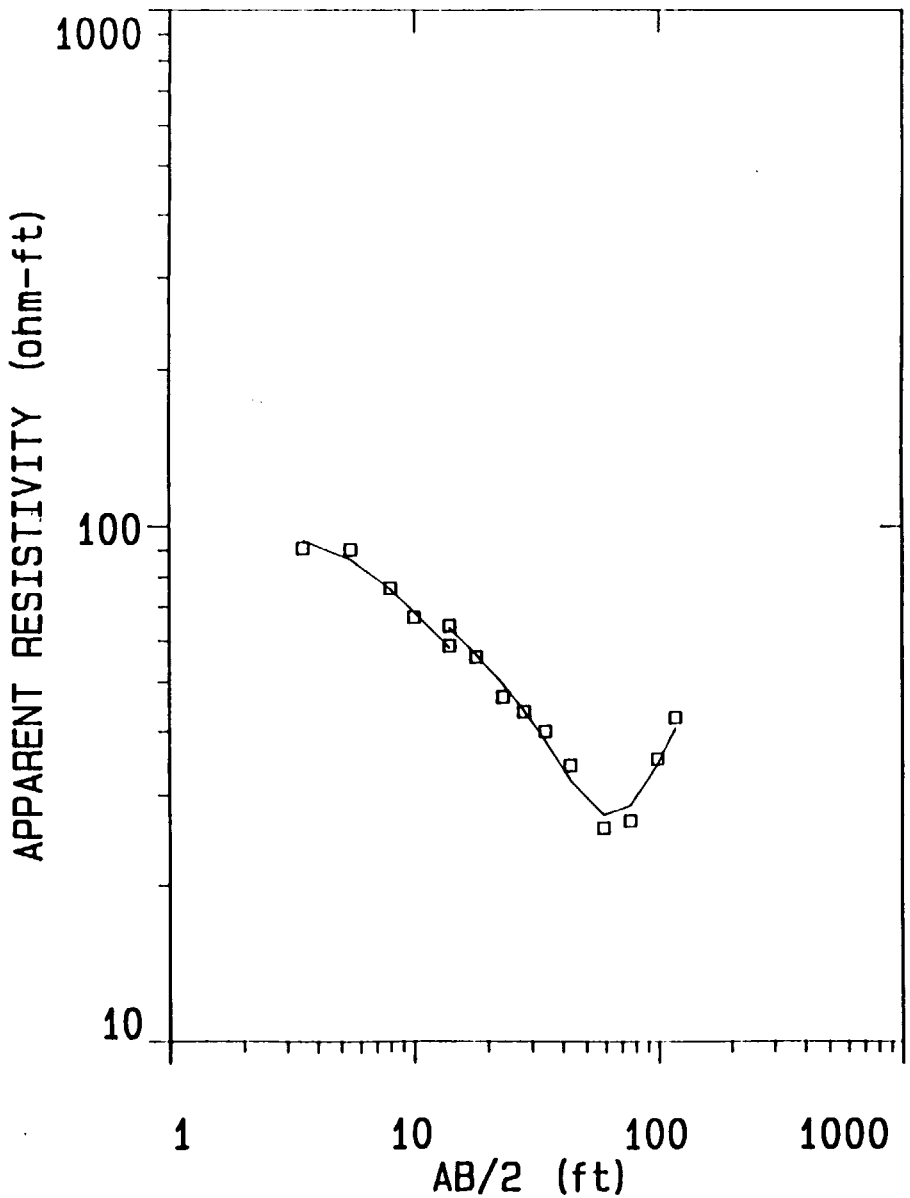

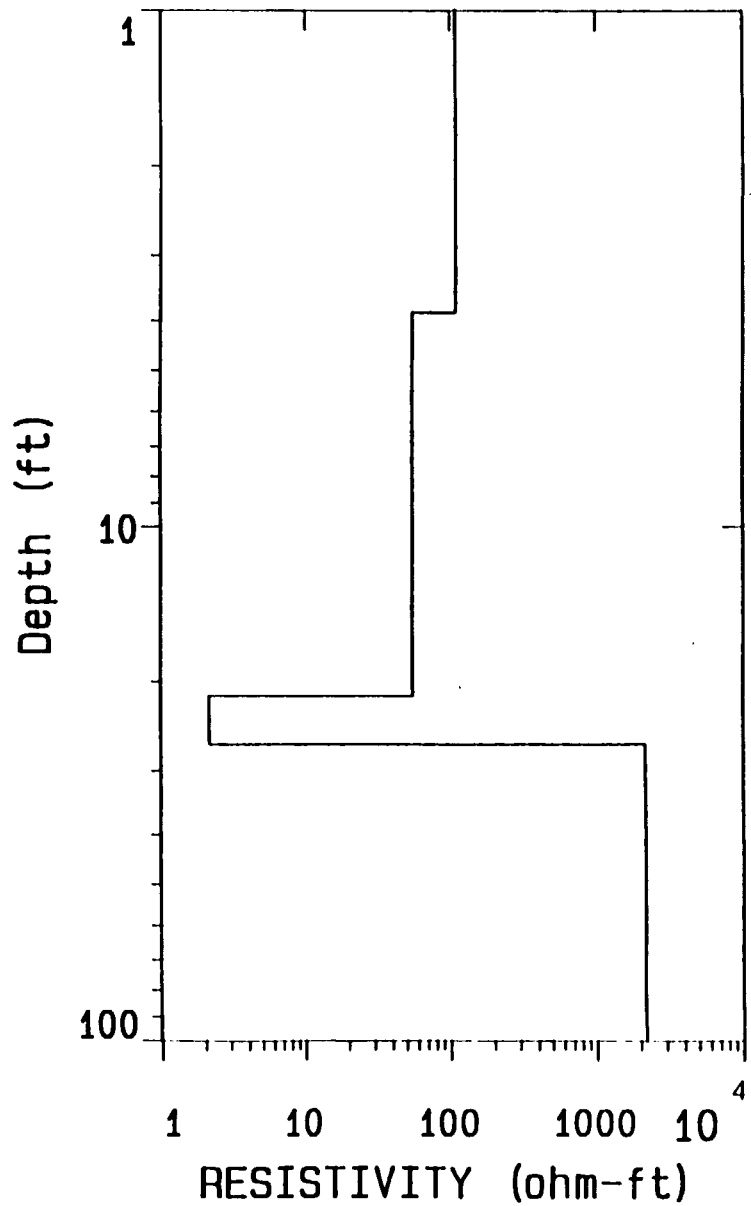

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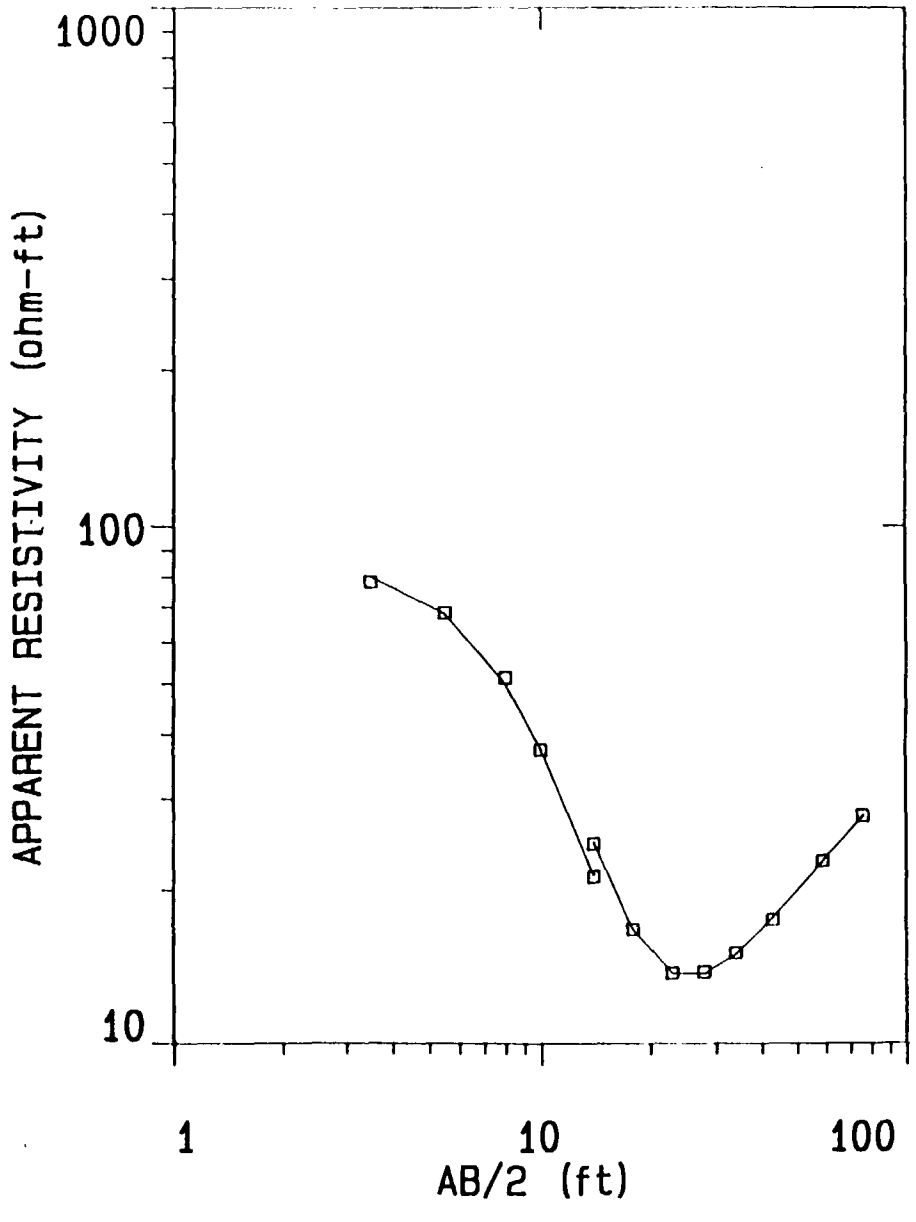
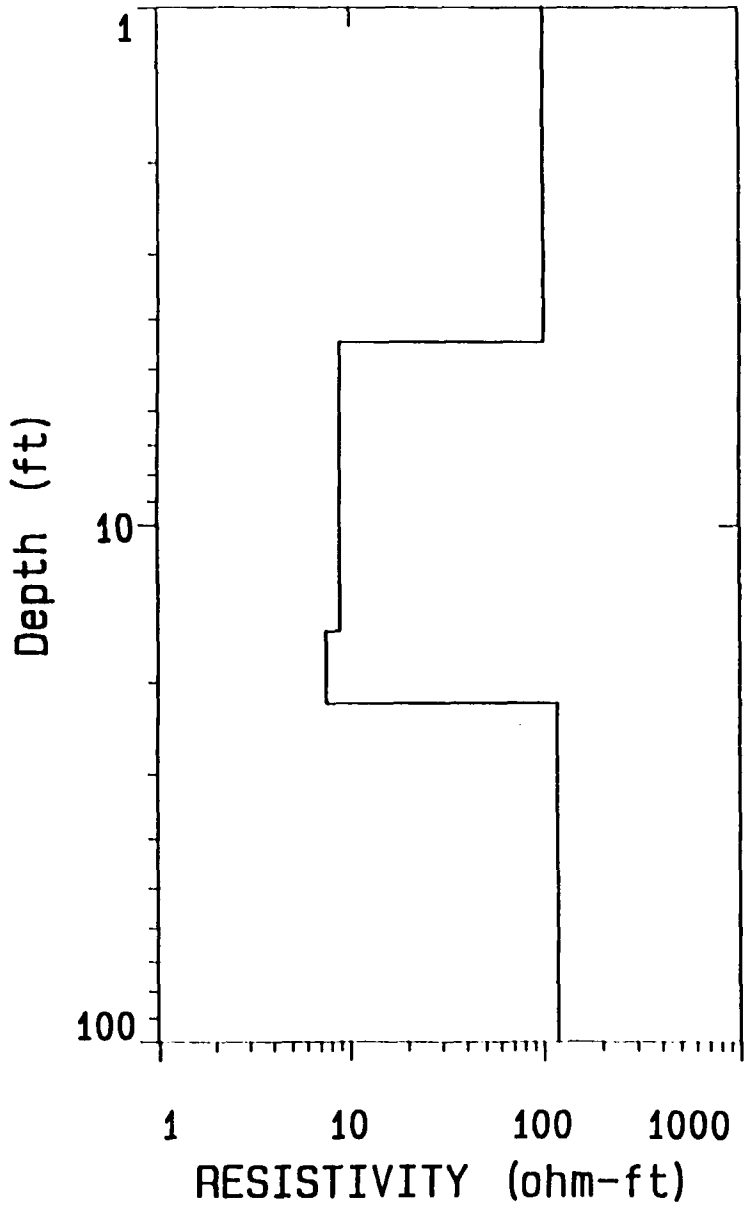
4 9 0487





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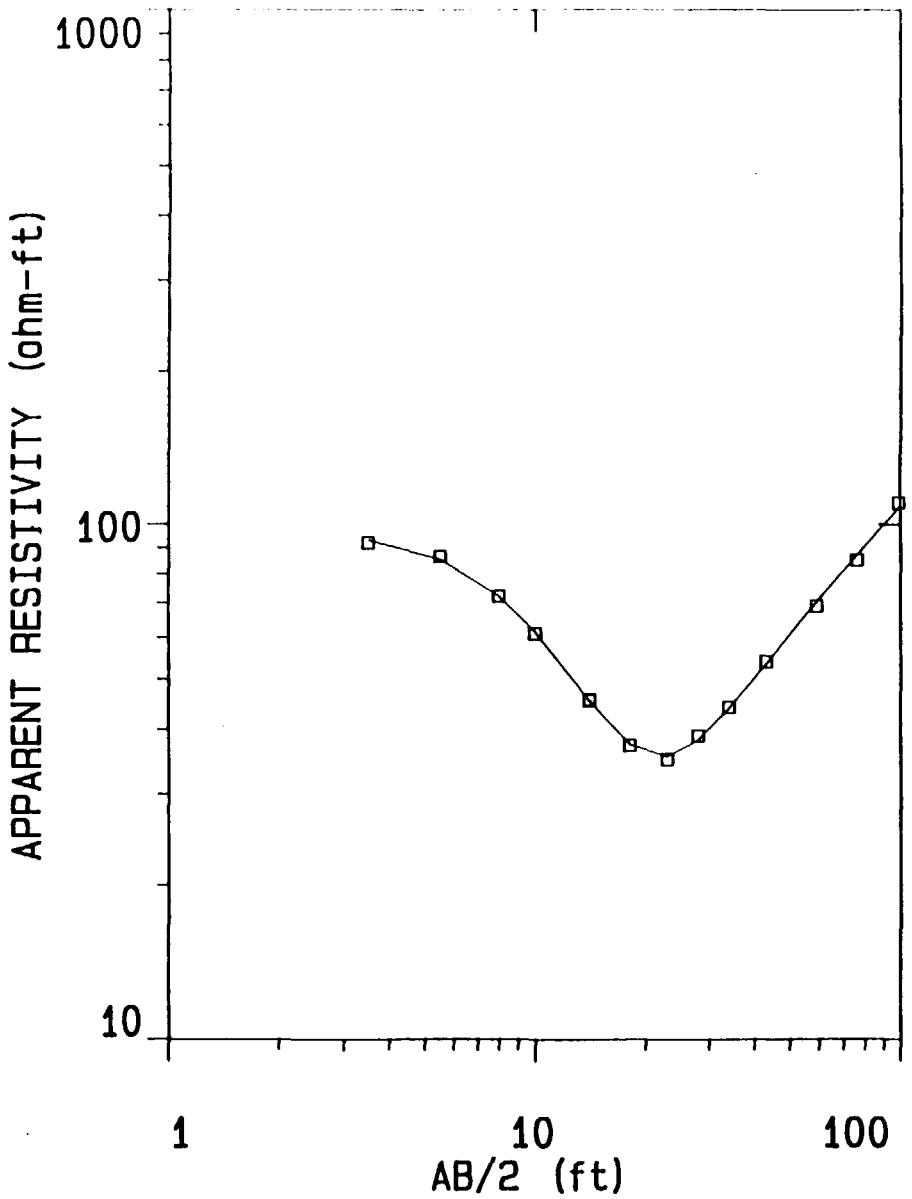

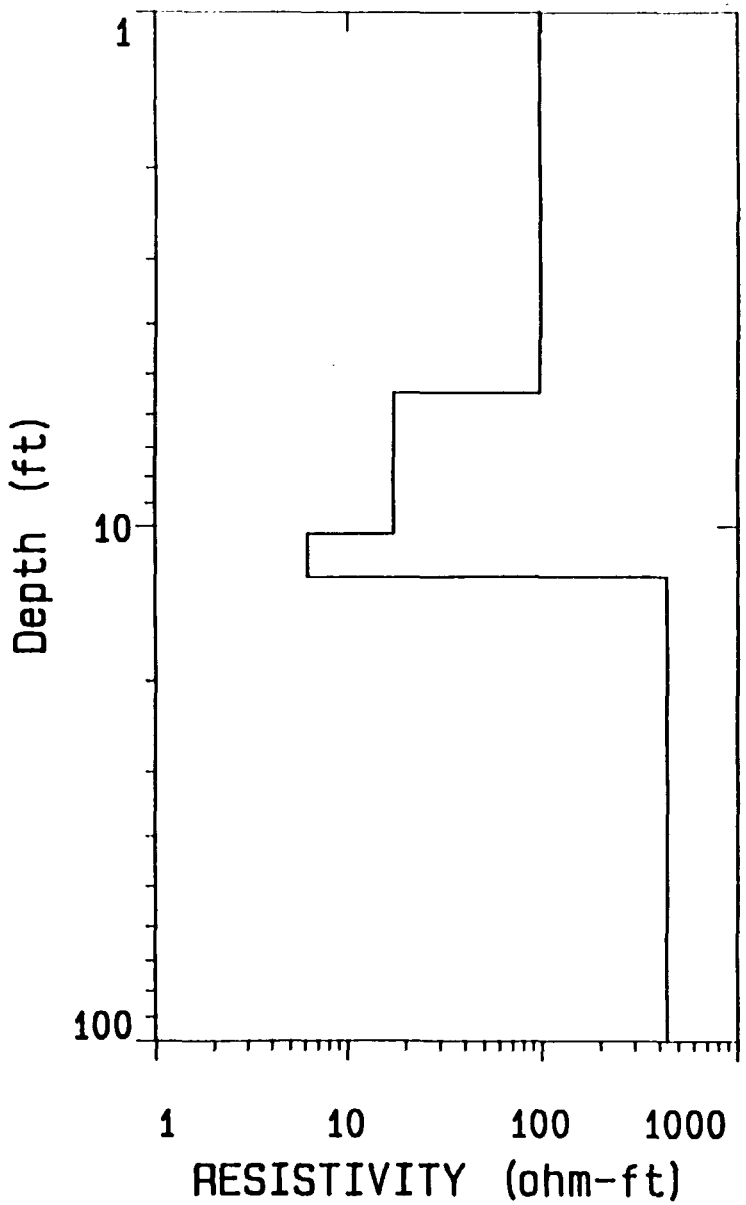

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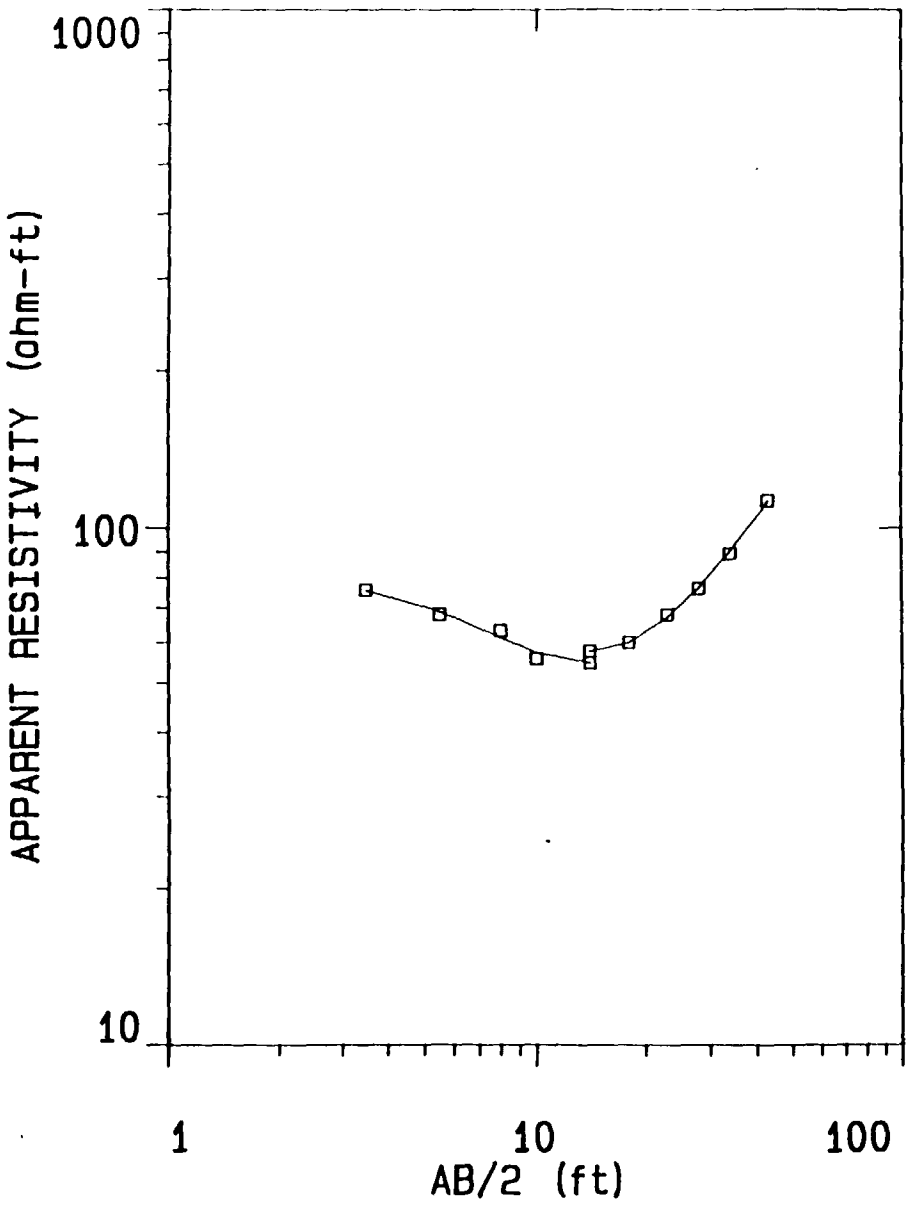

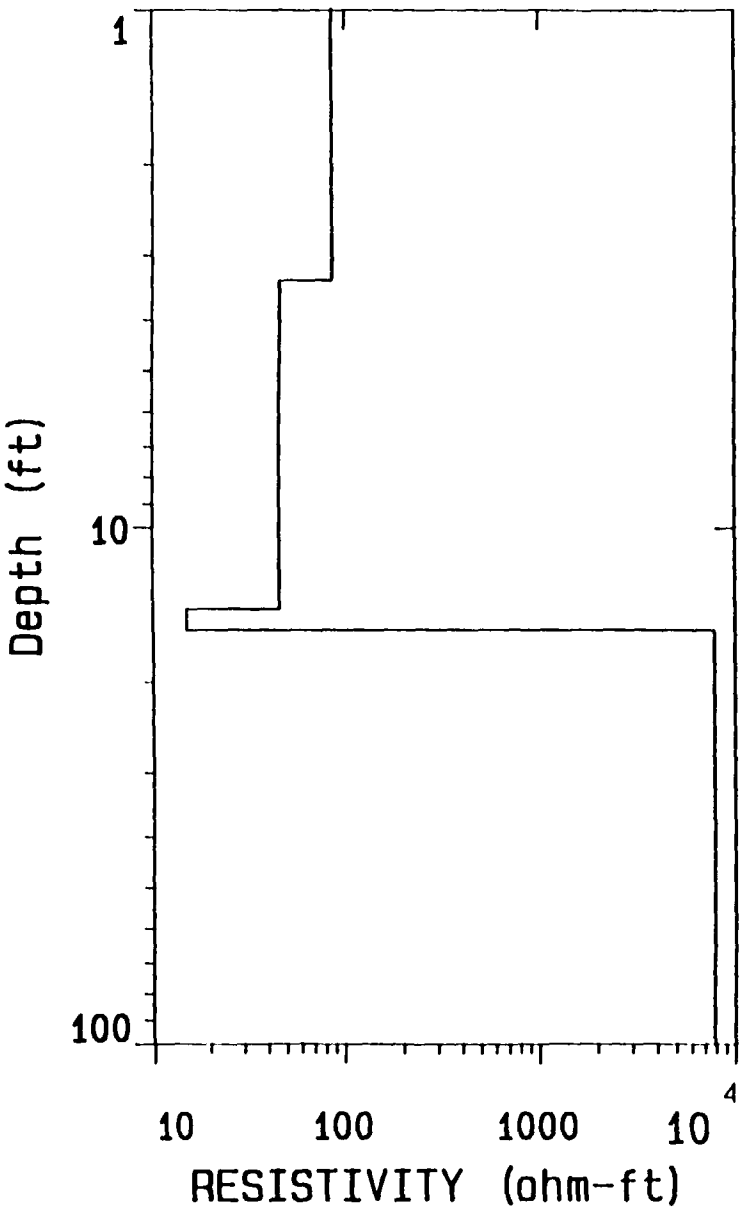

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by: WOODWARD-CLYDE	CPC Landfill
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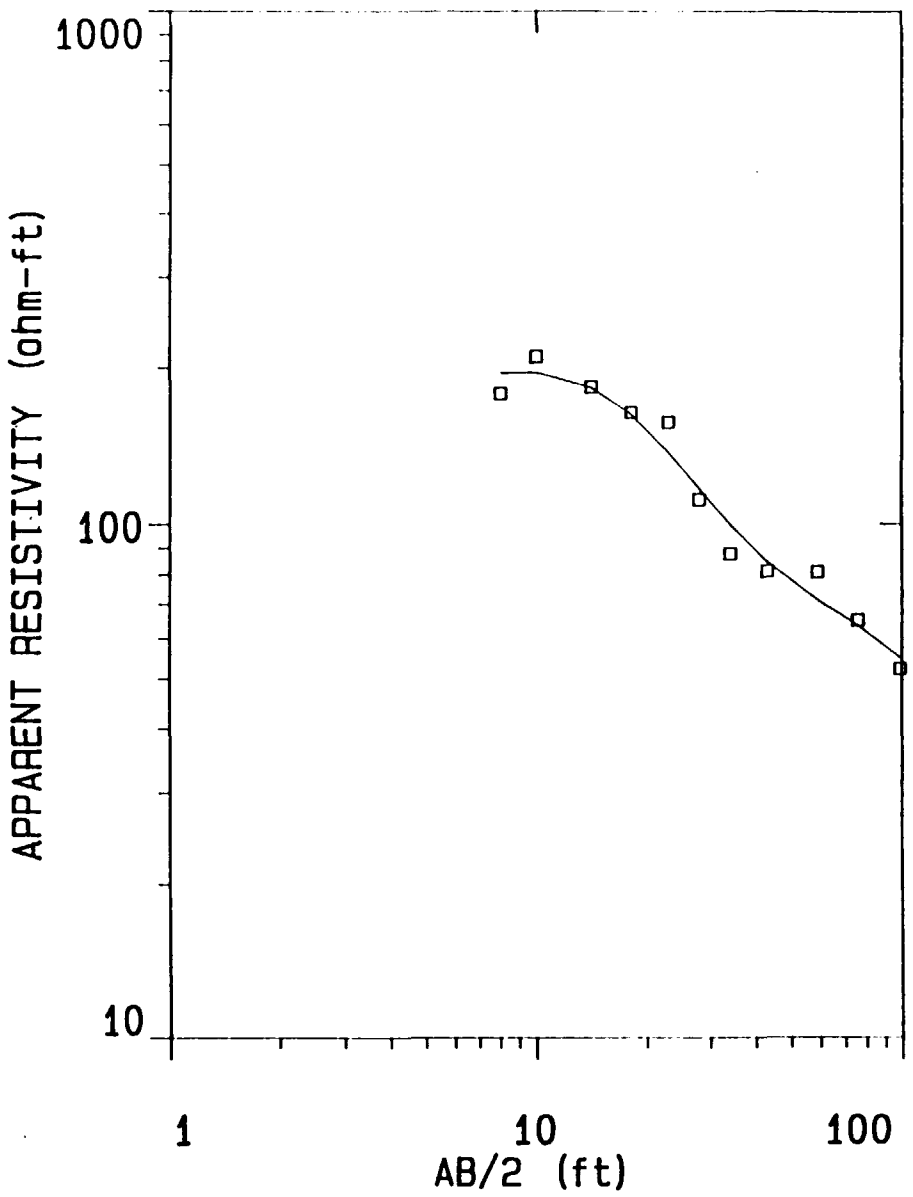

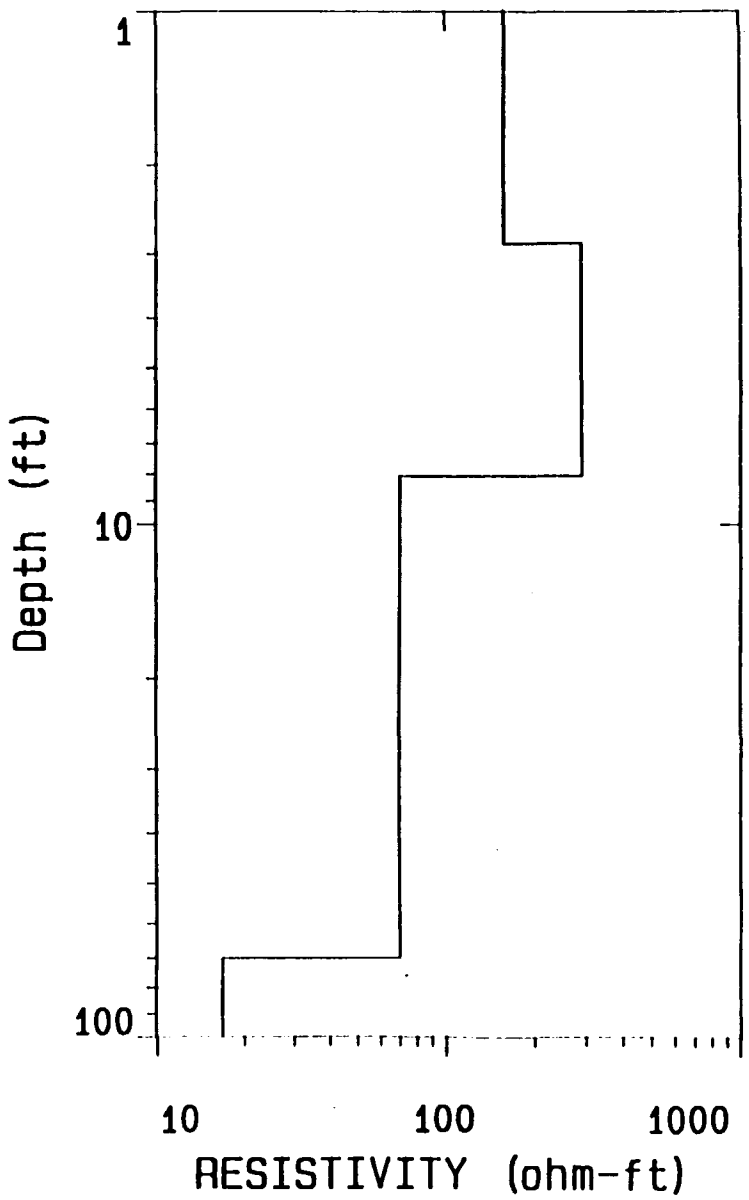

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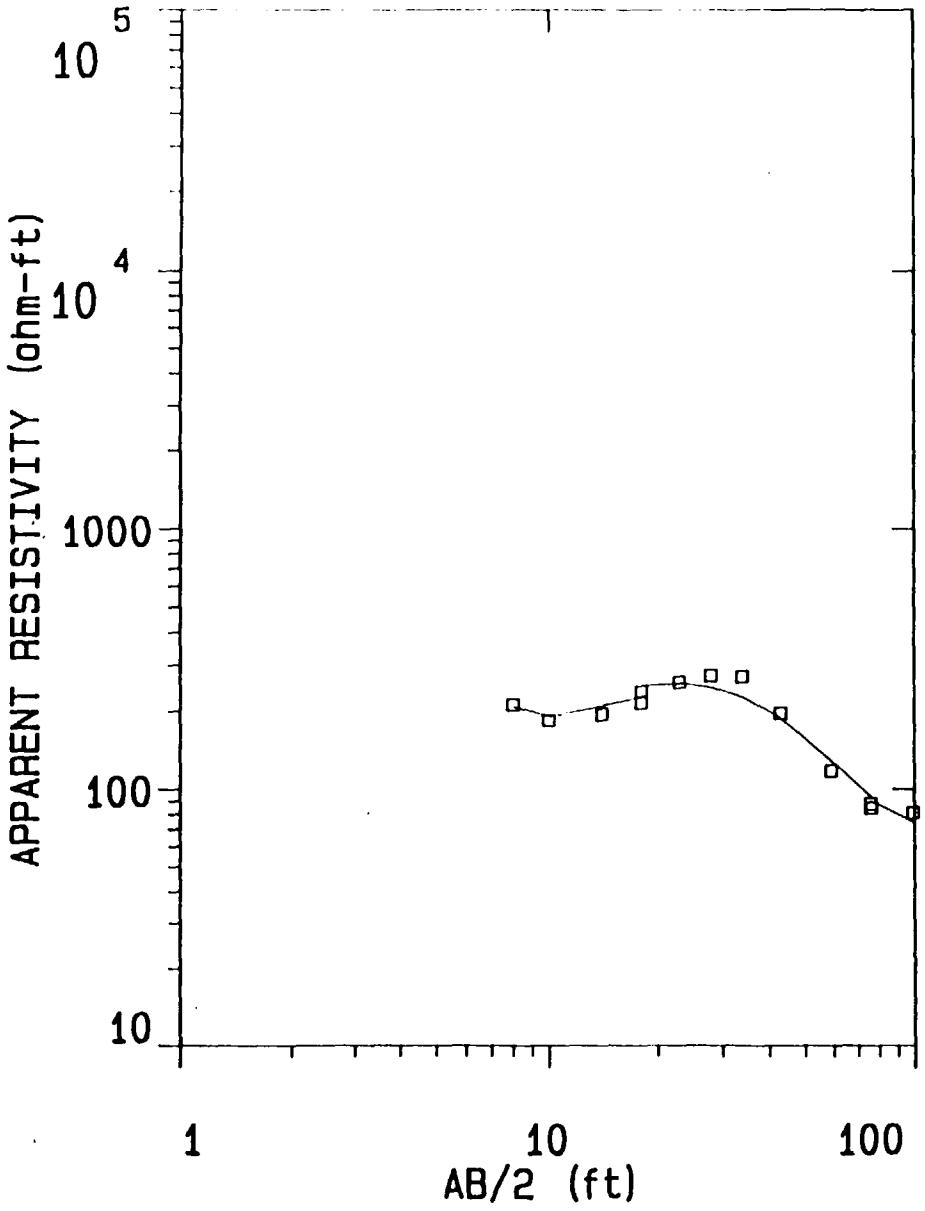
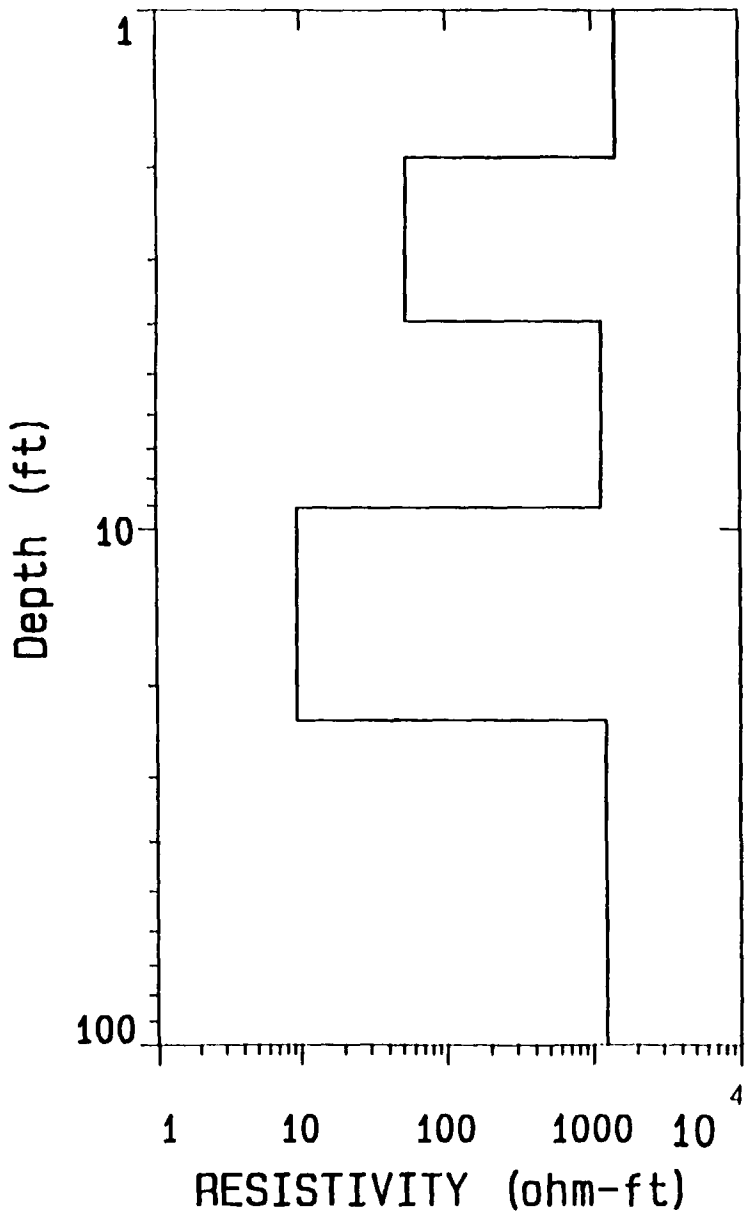
4 9 0489





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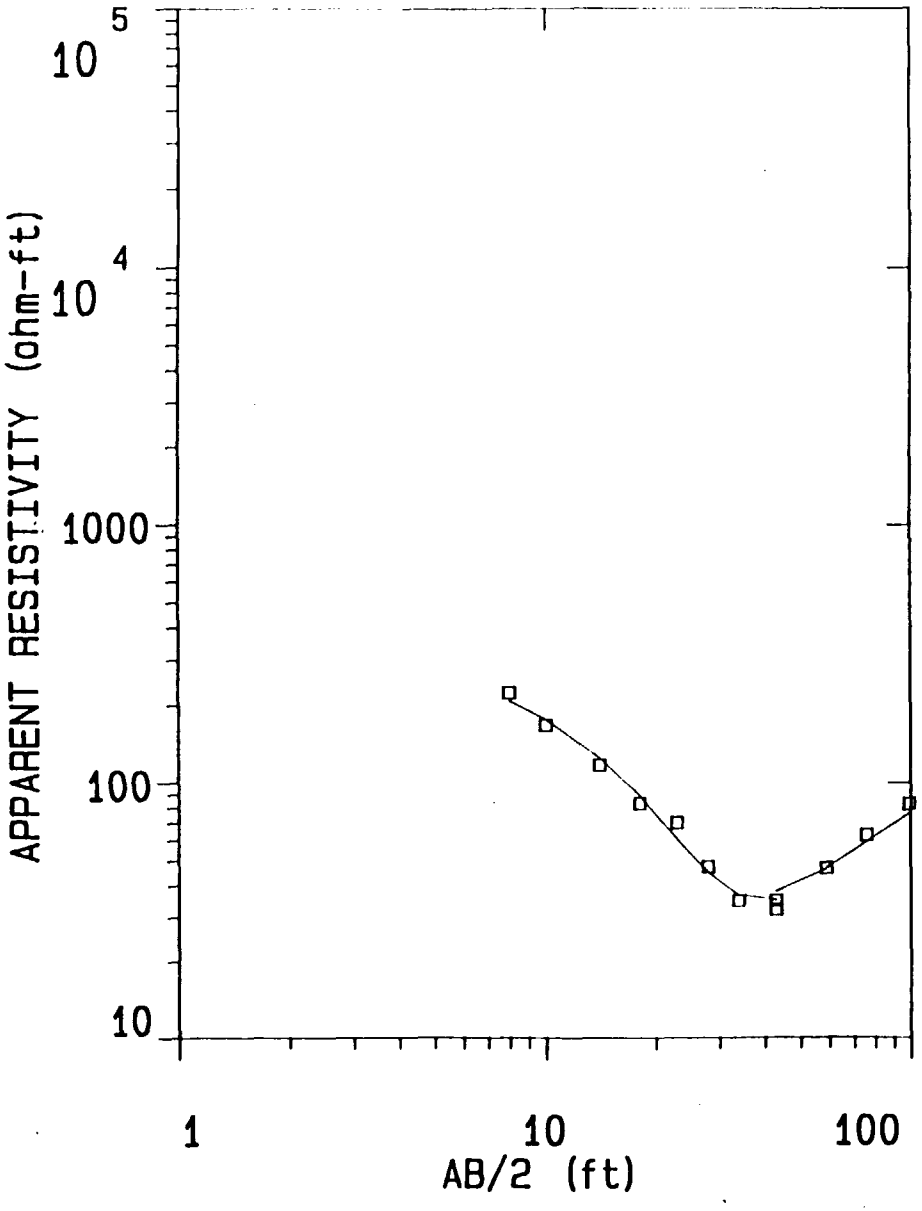

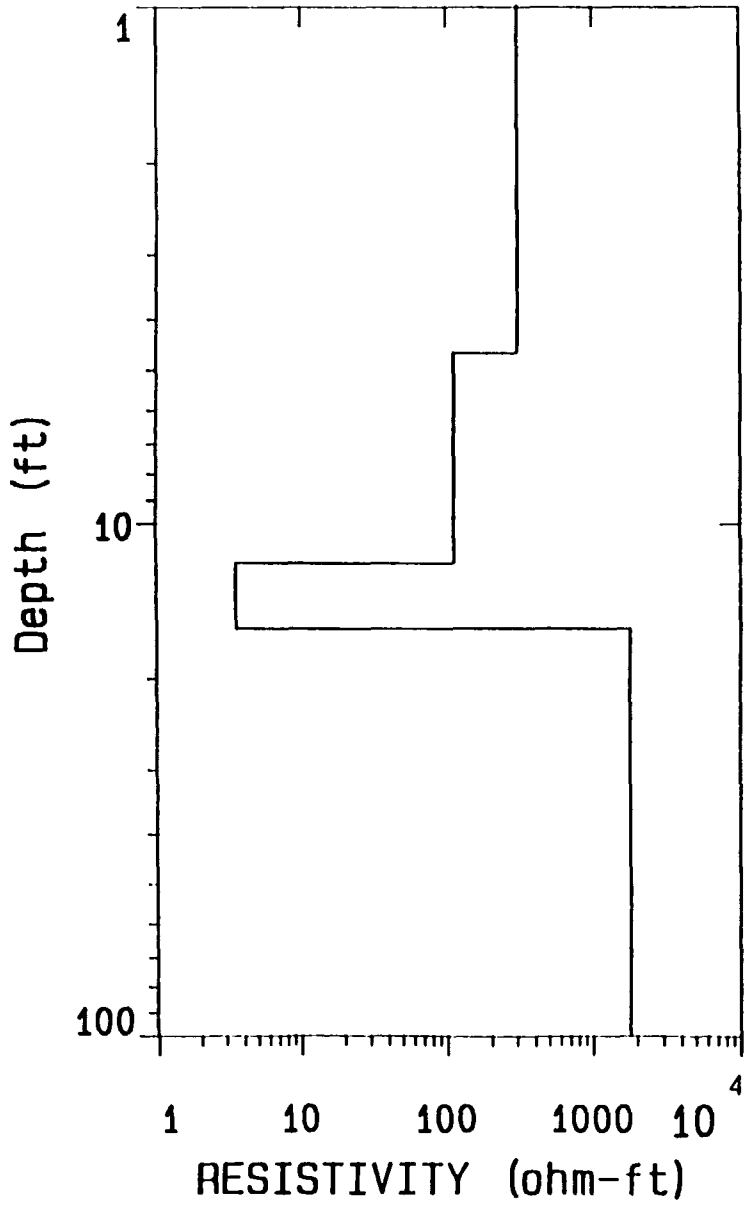

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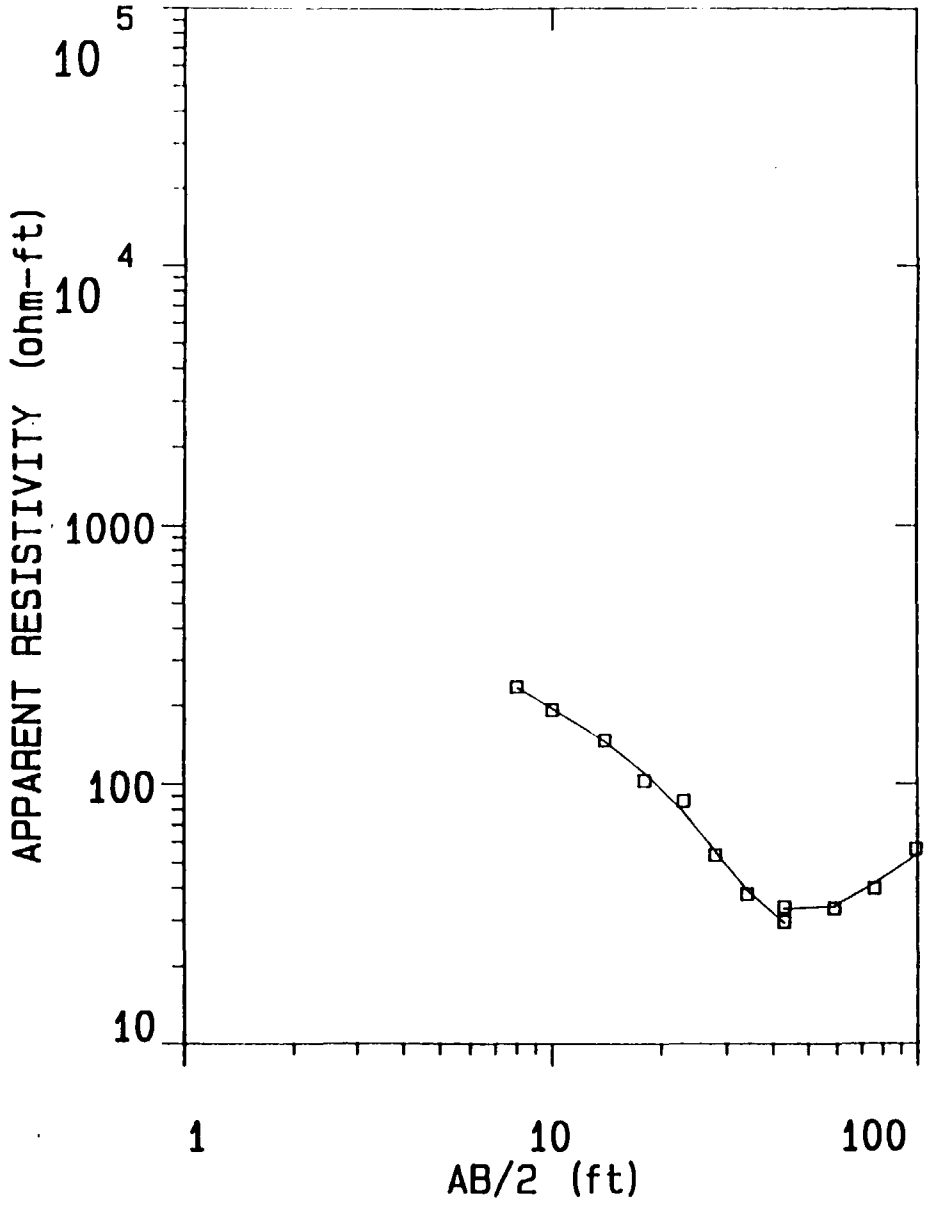
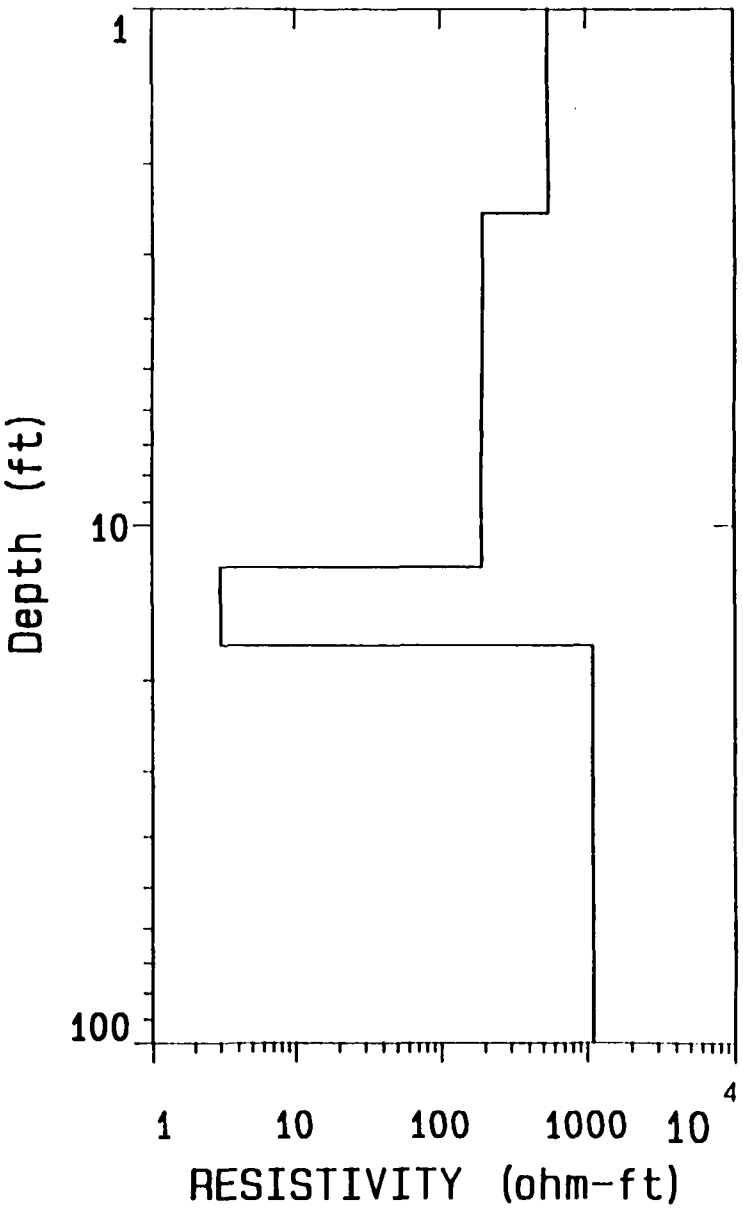
4 9 0490





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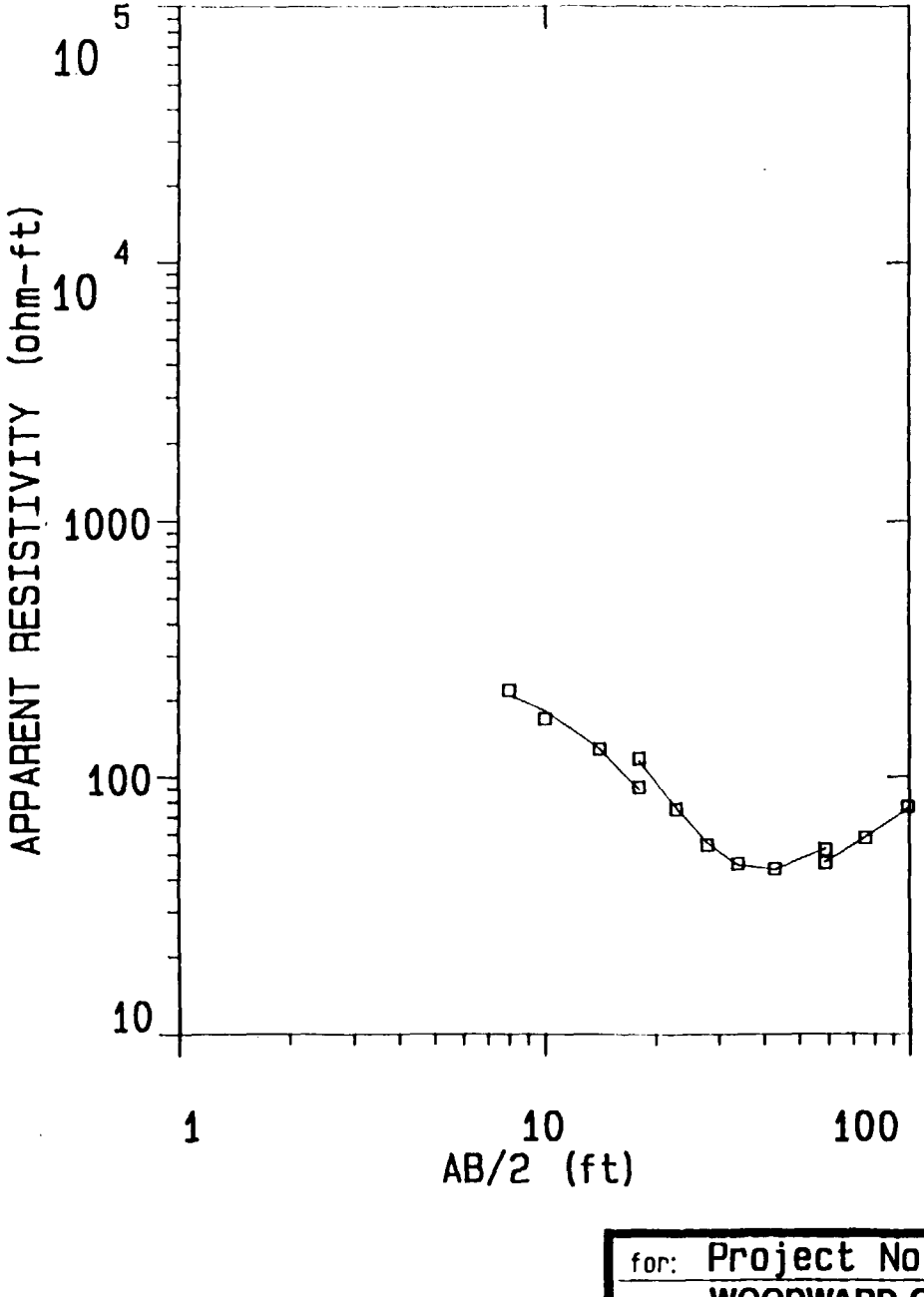

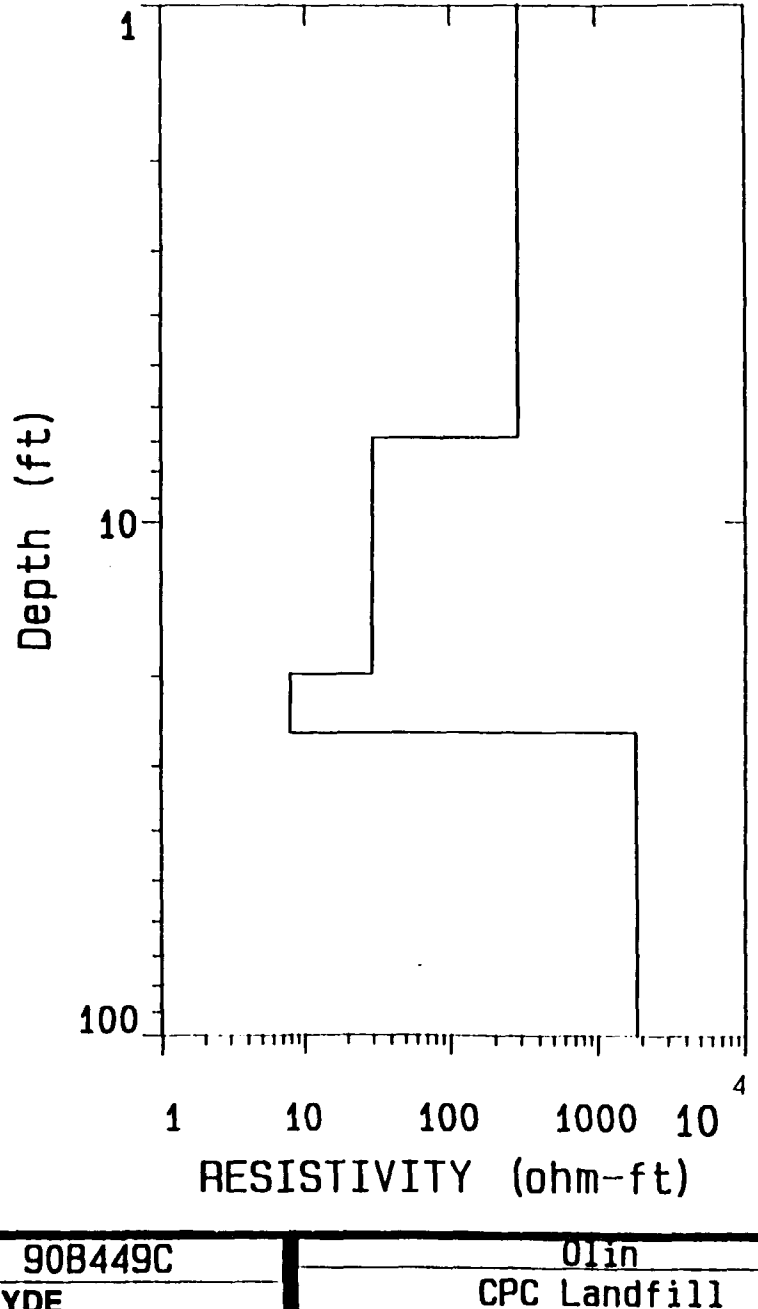

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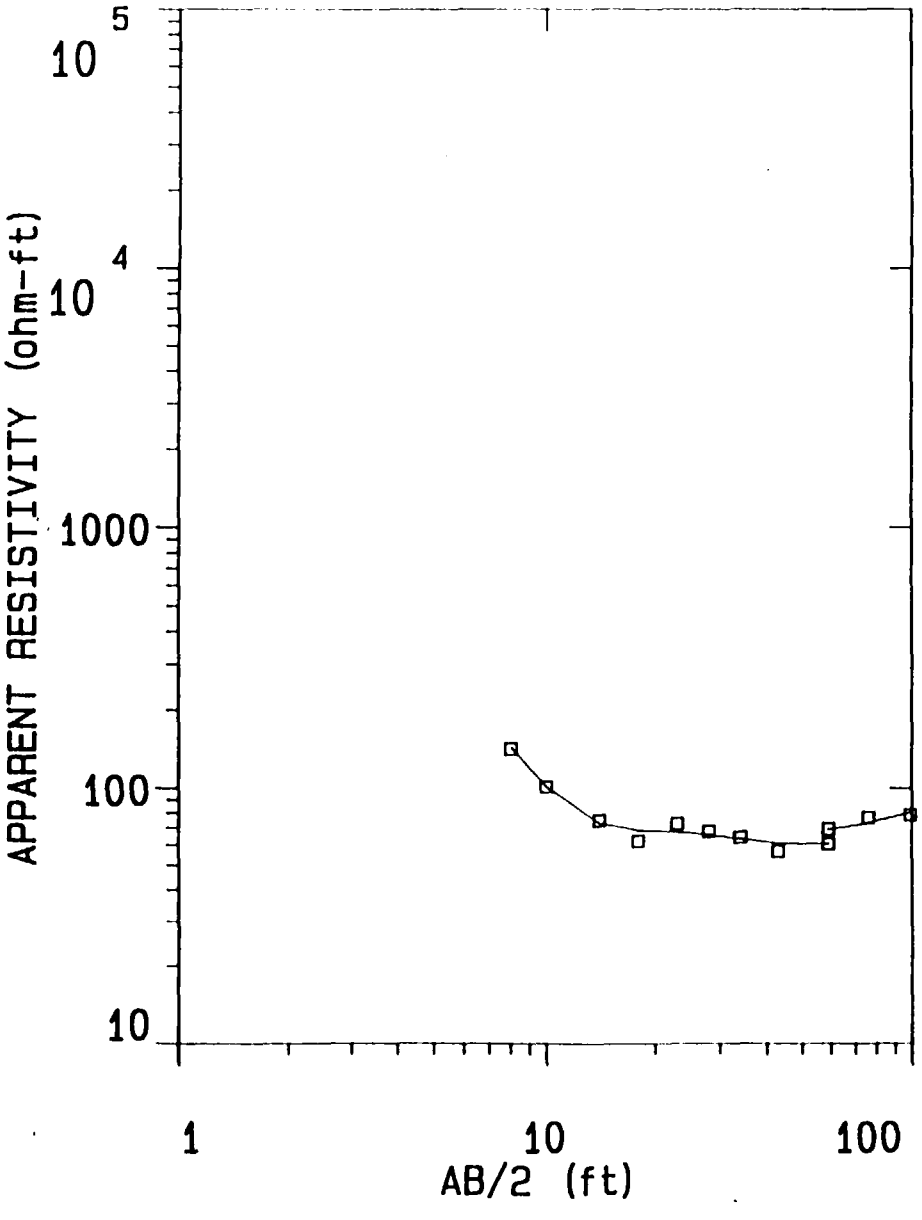
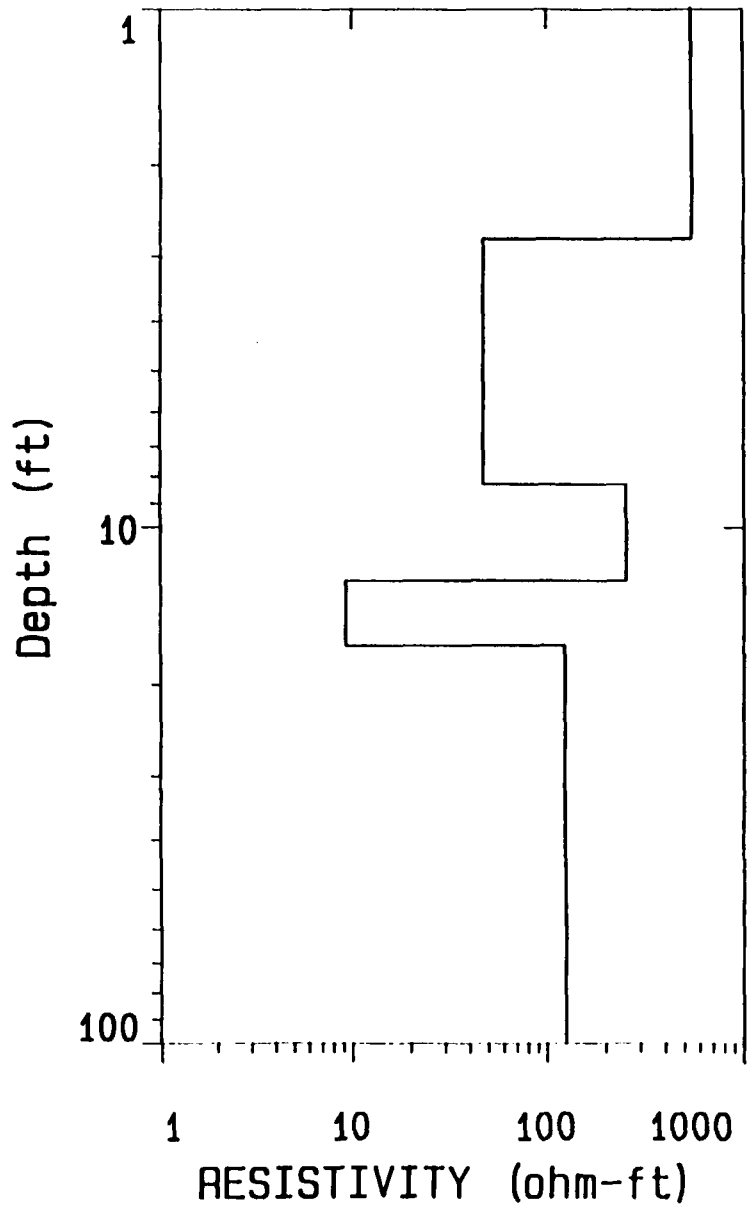
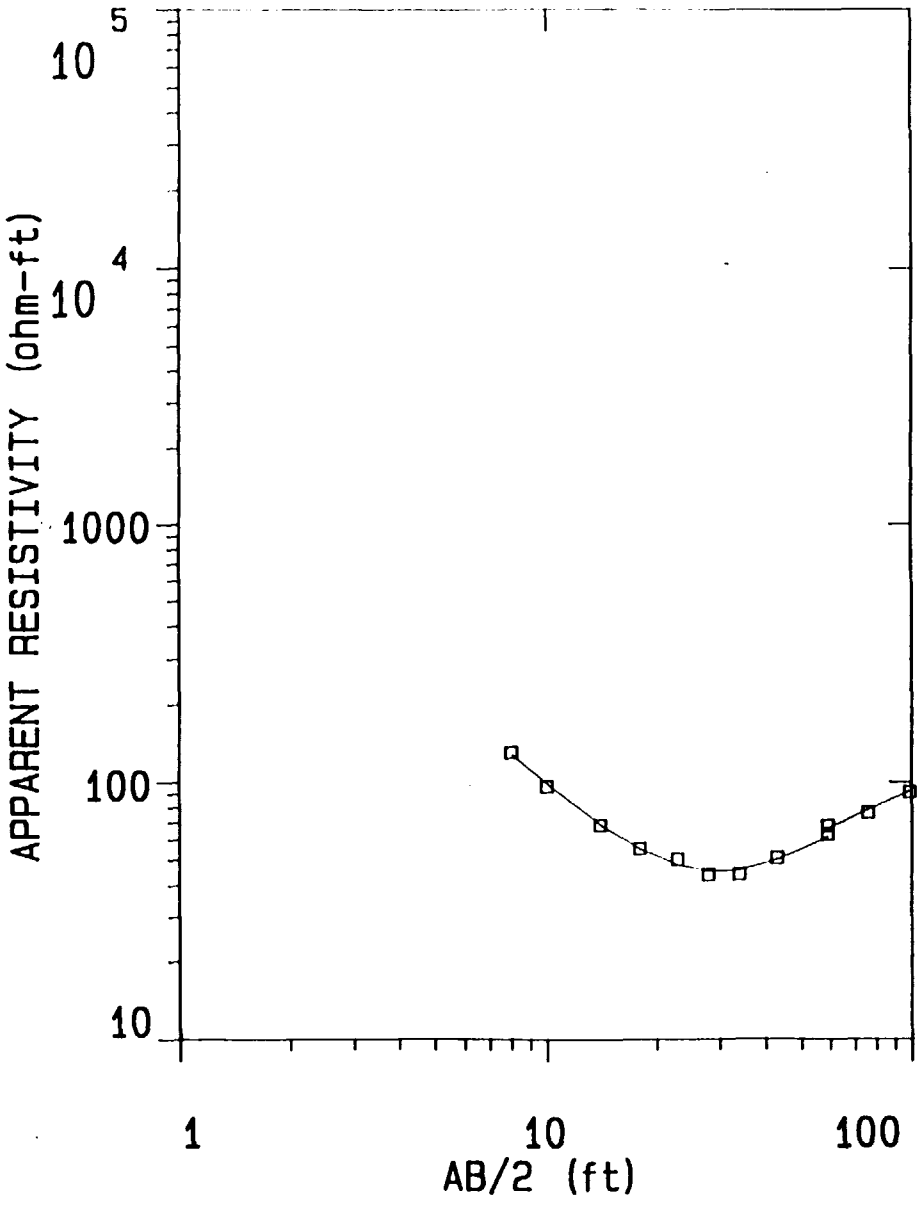
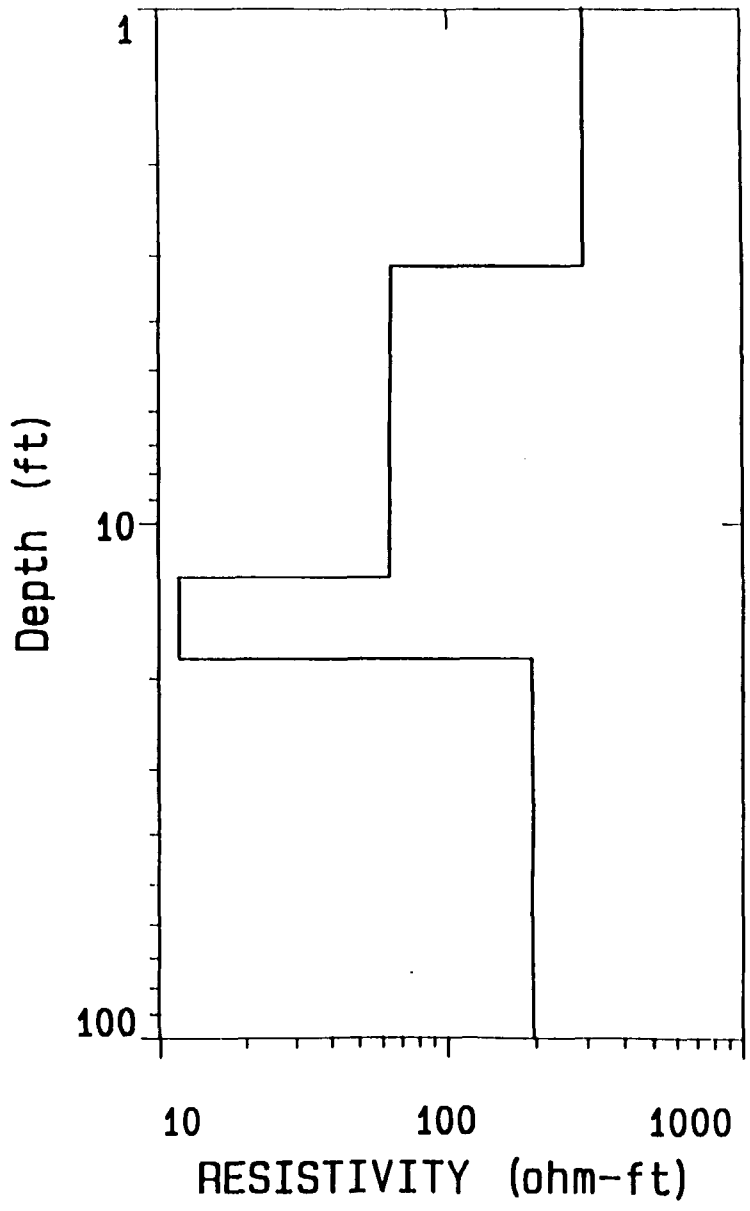
4 9 0491





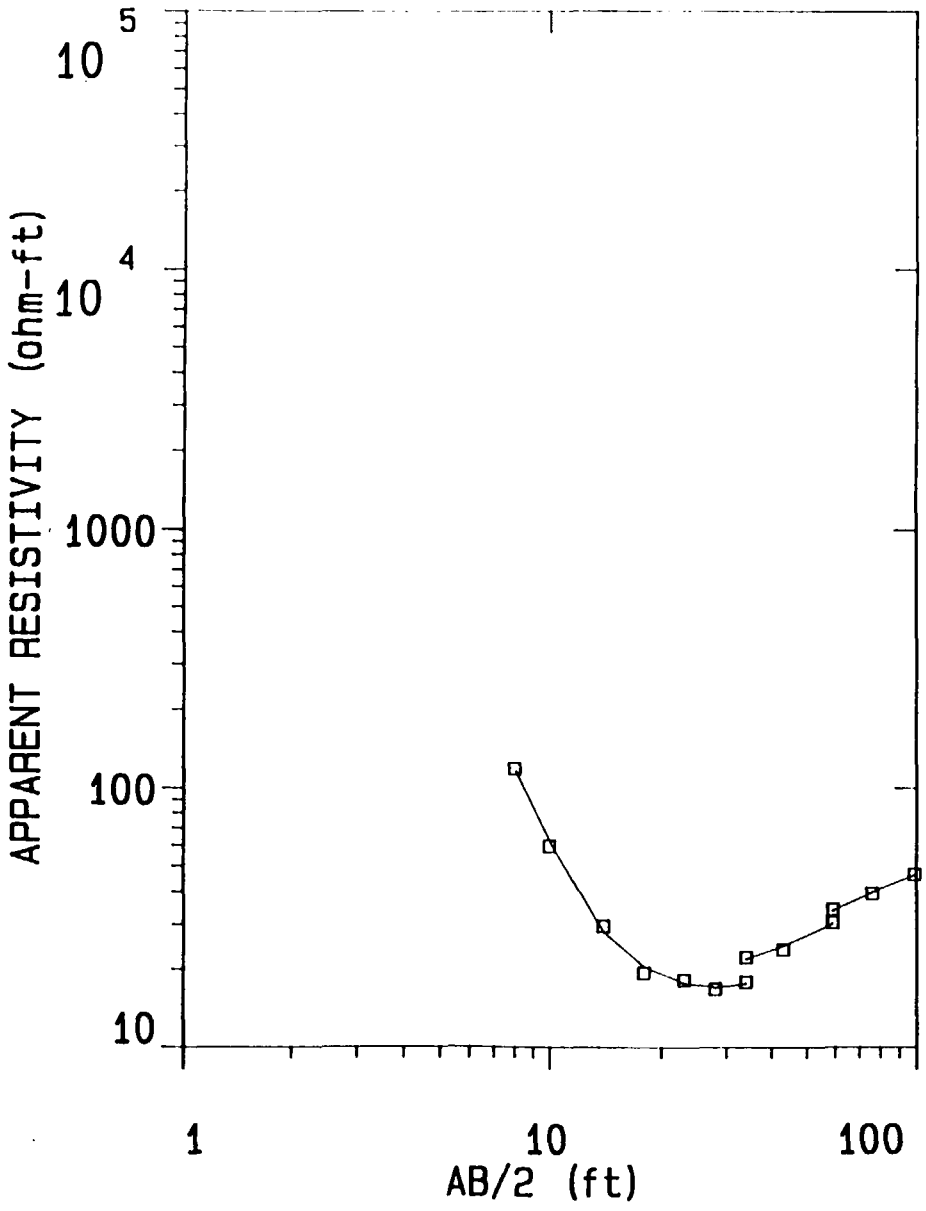
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP06 | Date: Feb., '93	Schlumberger Sounding
Equipment: Abem Sounding: GP06	Azimuth: n/a

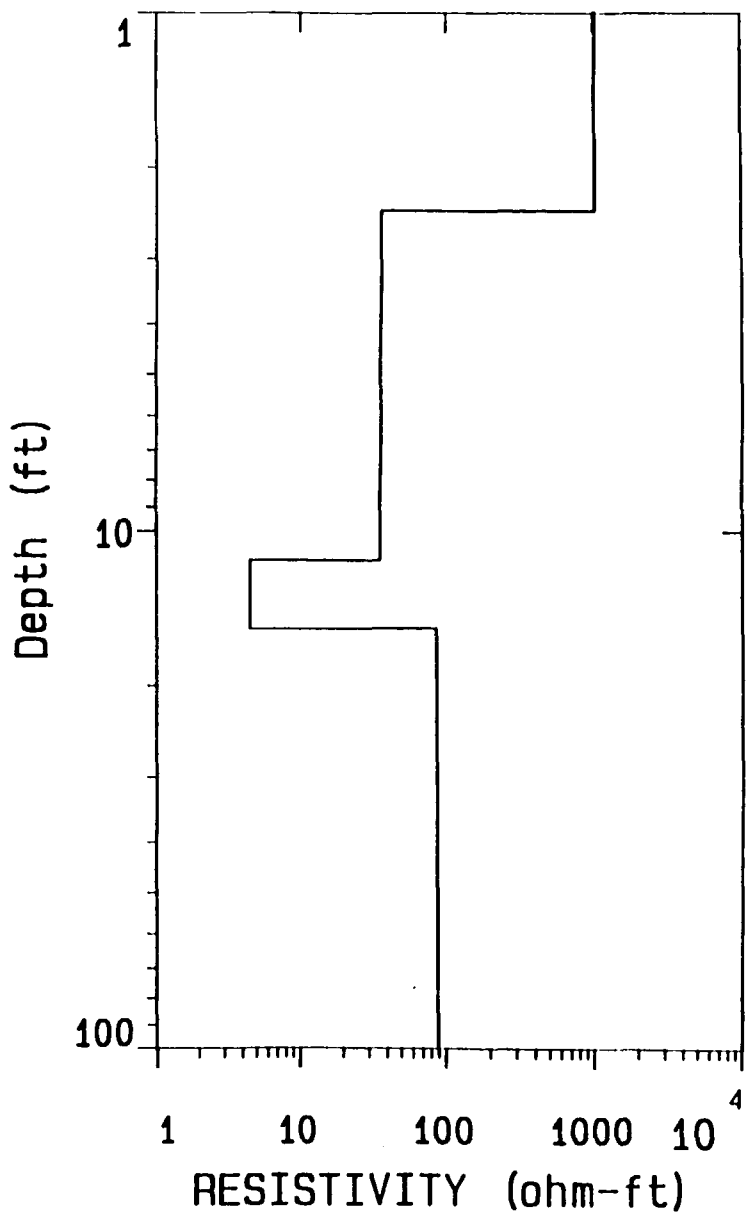




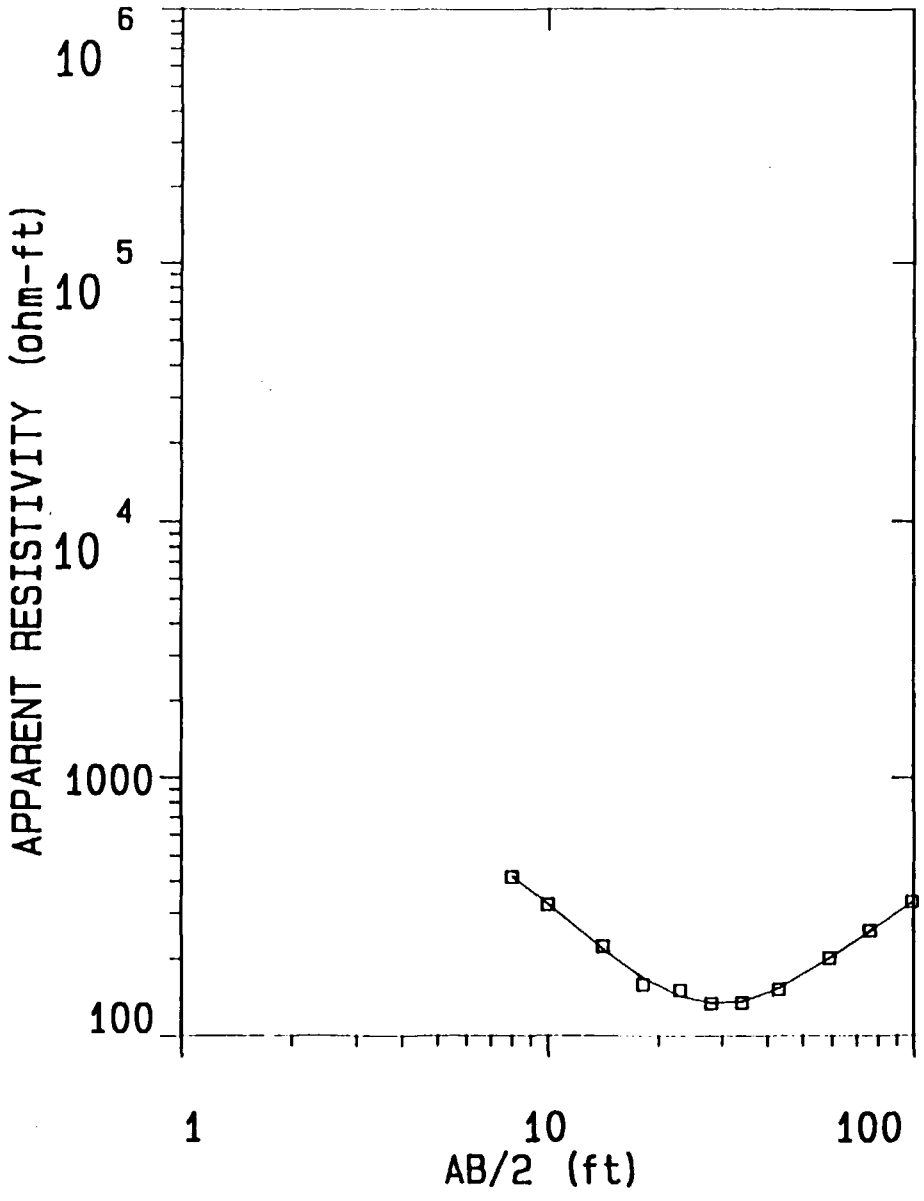
for: Project No. 90B449C		Olin
by: WOODWARD-CLYDE		CPC Landfill
Data Set: GP07	Date: Feb., '93	Schlumberger Sounding
Equipment: Abem	Sounding: GP07	Azimuth: n/a

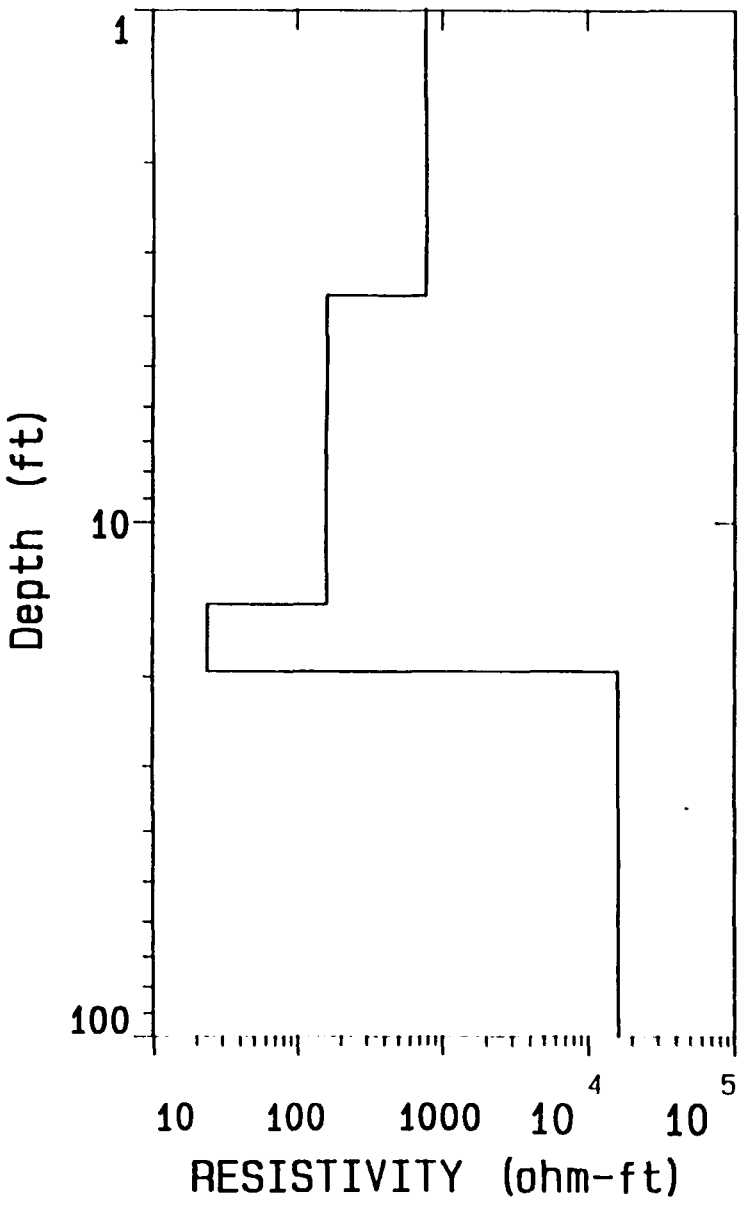
4 9 0492





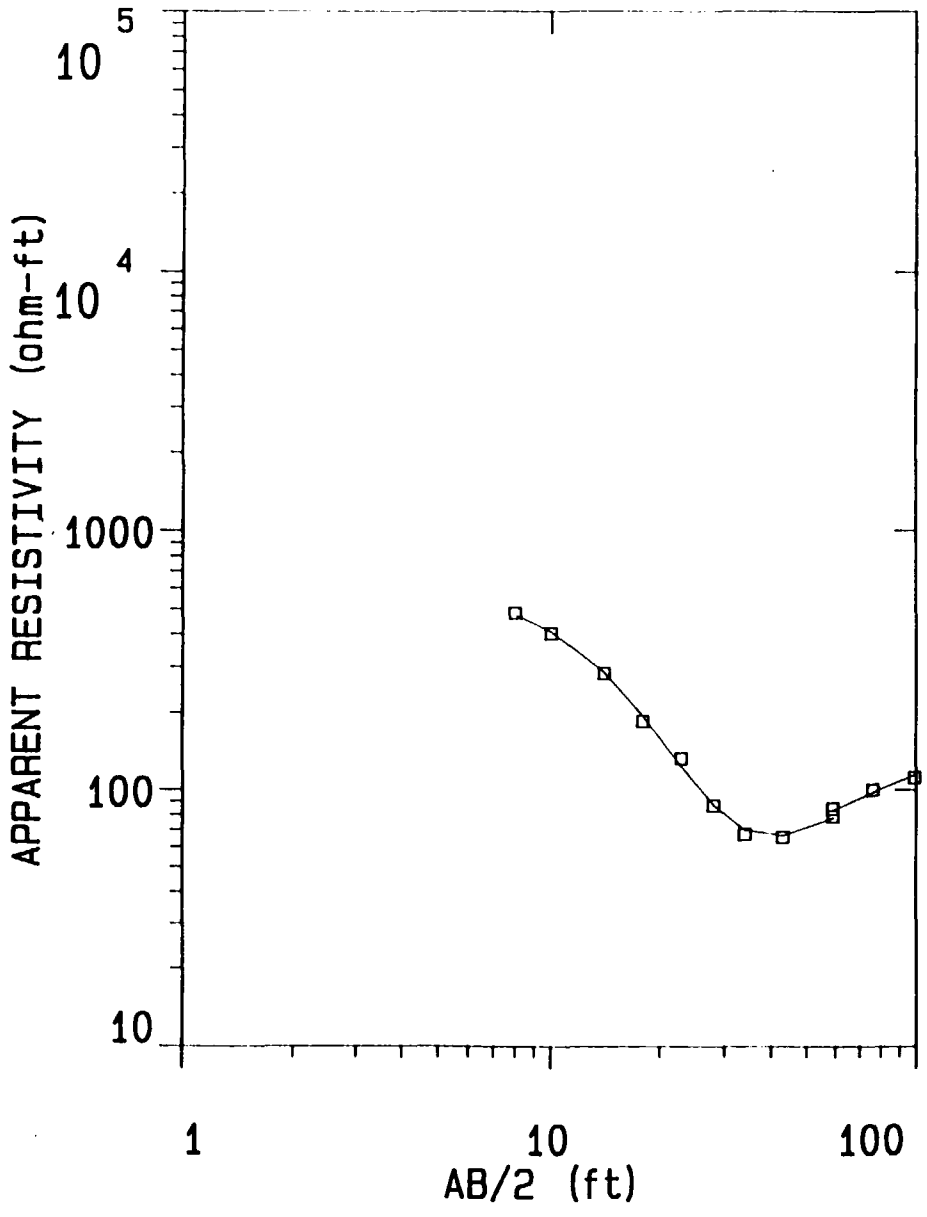
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP08 | Date: Feb., '93	Schlumberger Sounding
Equipment: Abem | Sounding: GP08	Azimuth: n/a

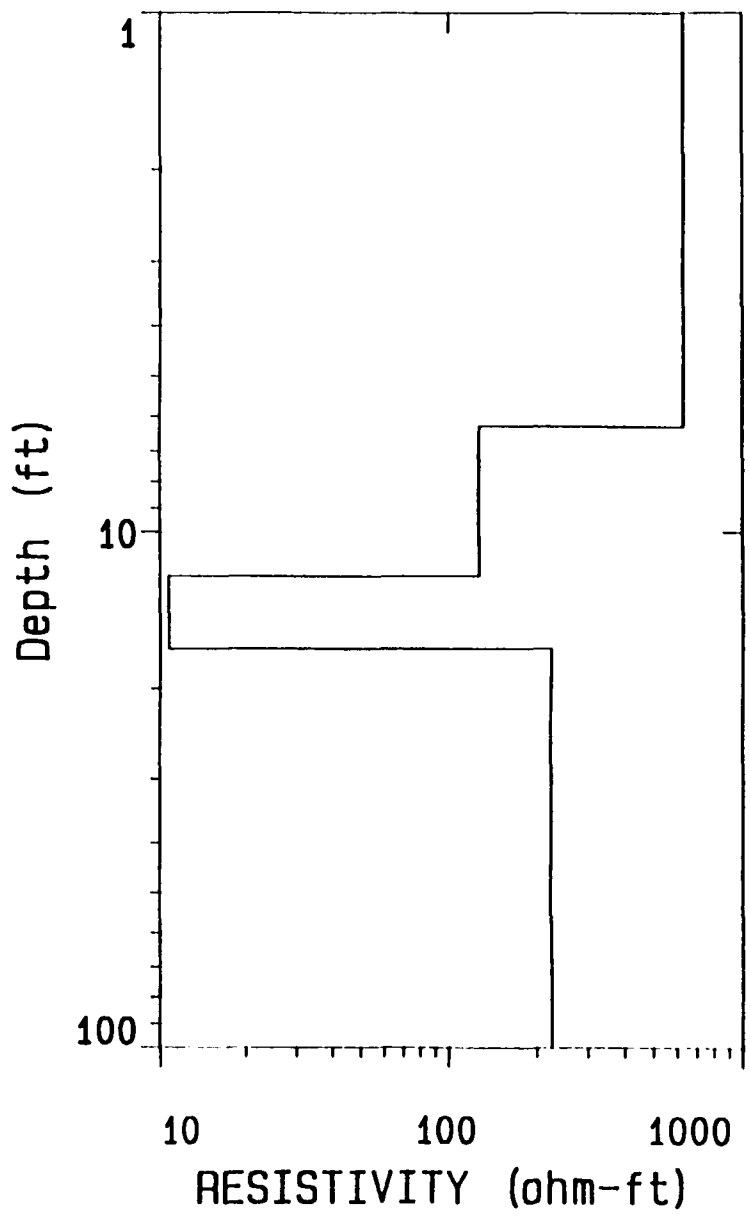




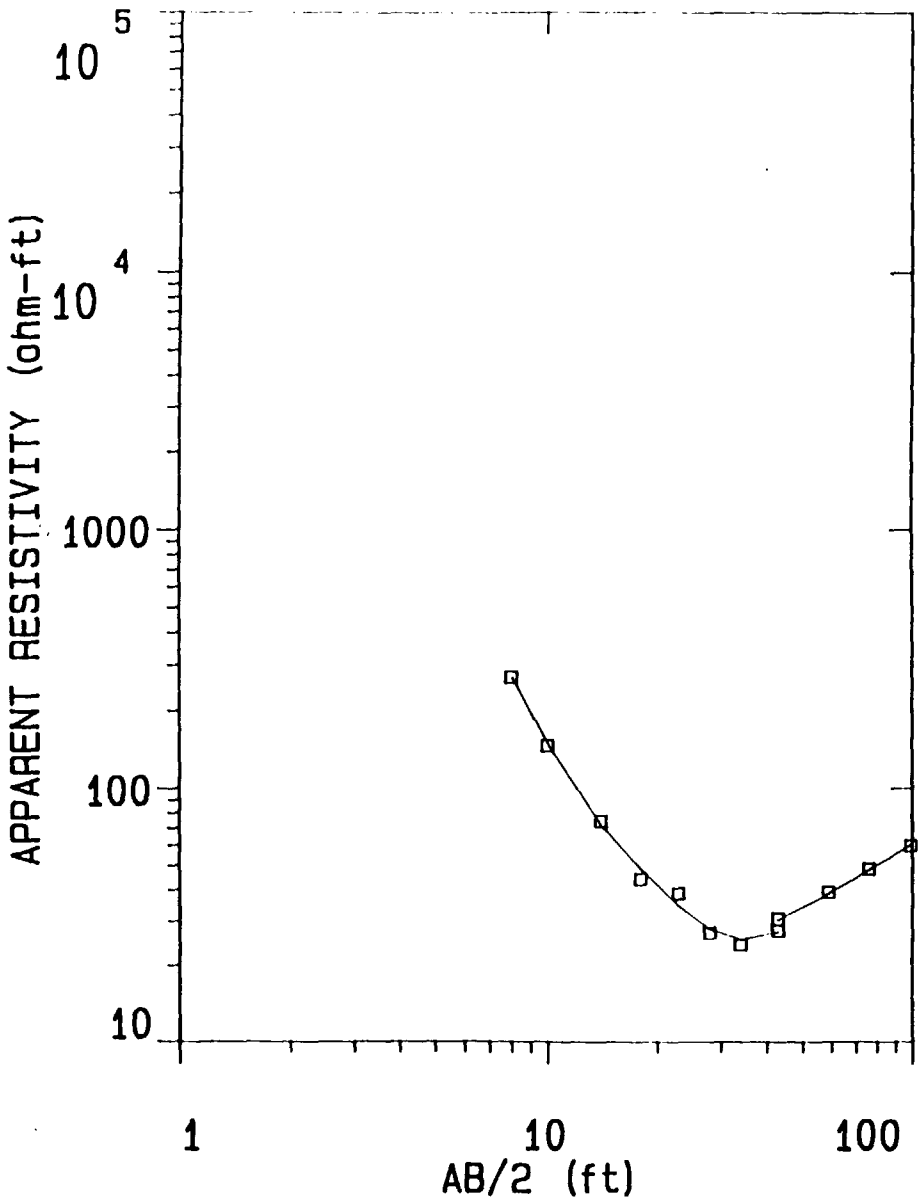
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill Schlumberger Sounding
Data Set: GP09 / Date: Feb., '93	
Equipment: Abem / Sounding: GP09	Azimuth: n/a

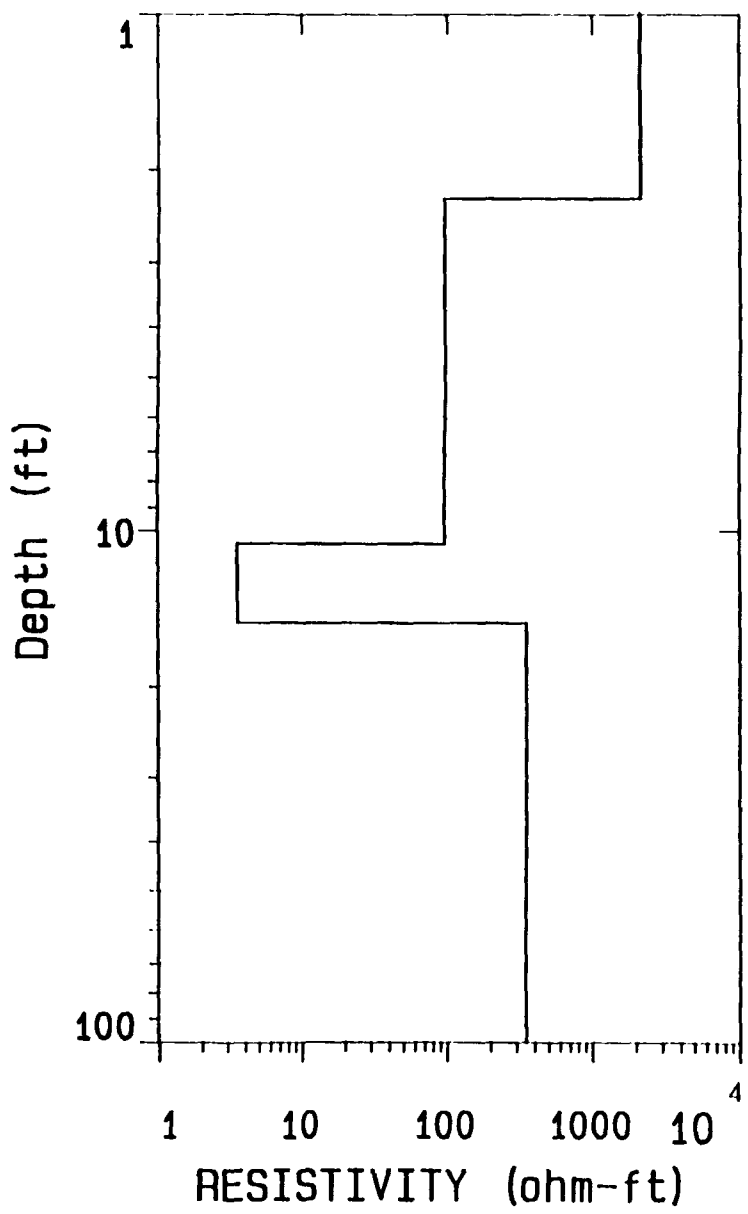
4 9 0493



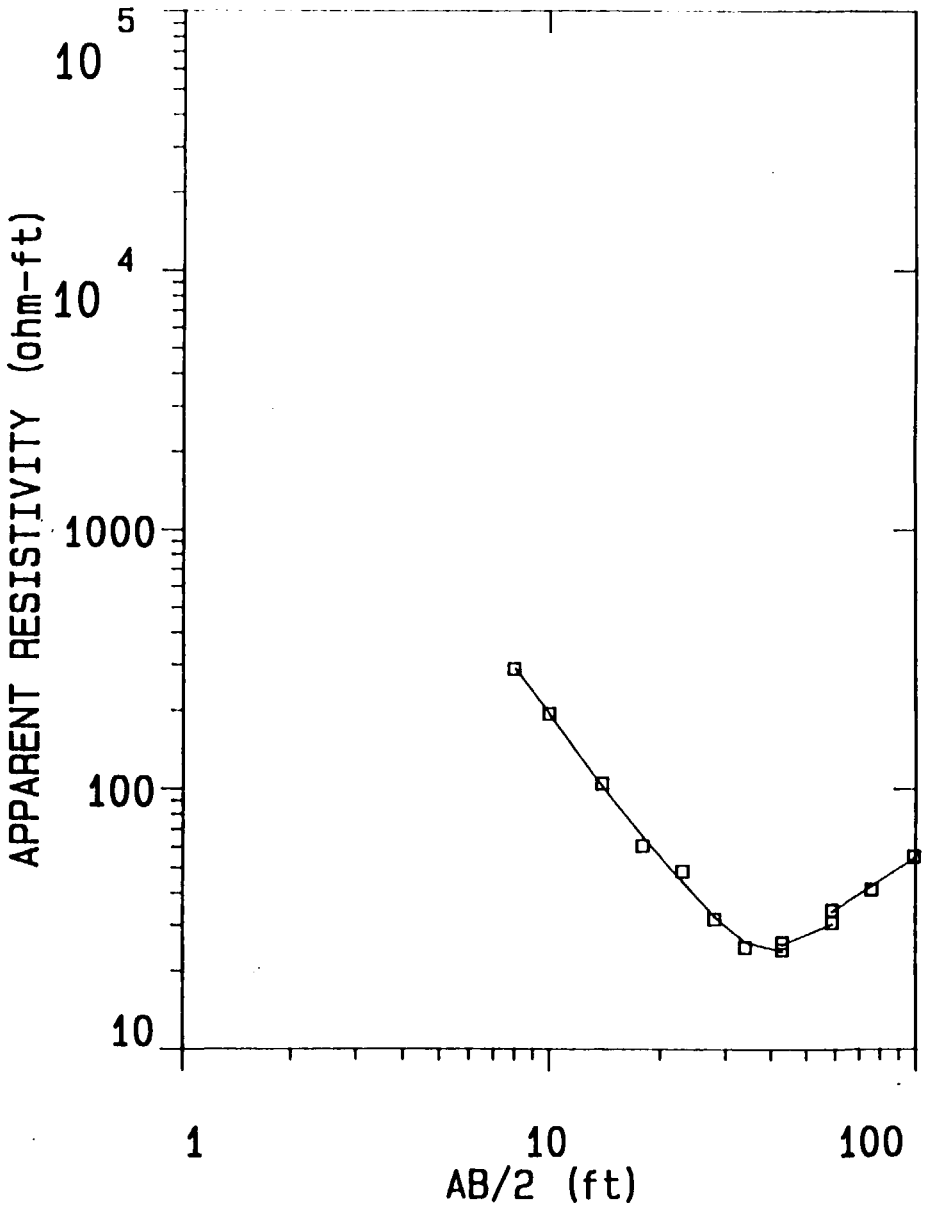


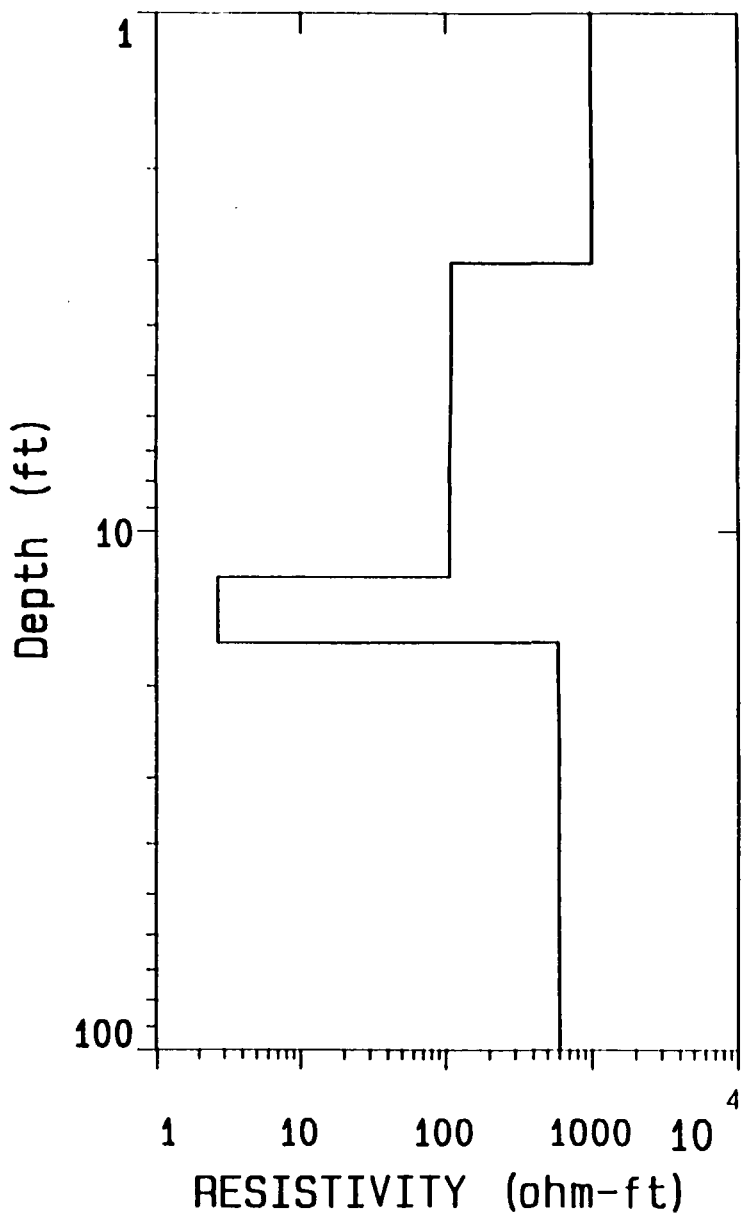
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP10 | Date: Feb., '93	Schlumberger Sounding
Equipment: Abem | Sounding: GP10	Azimuth: n/a



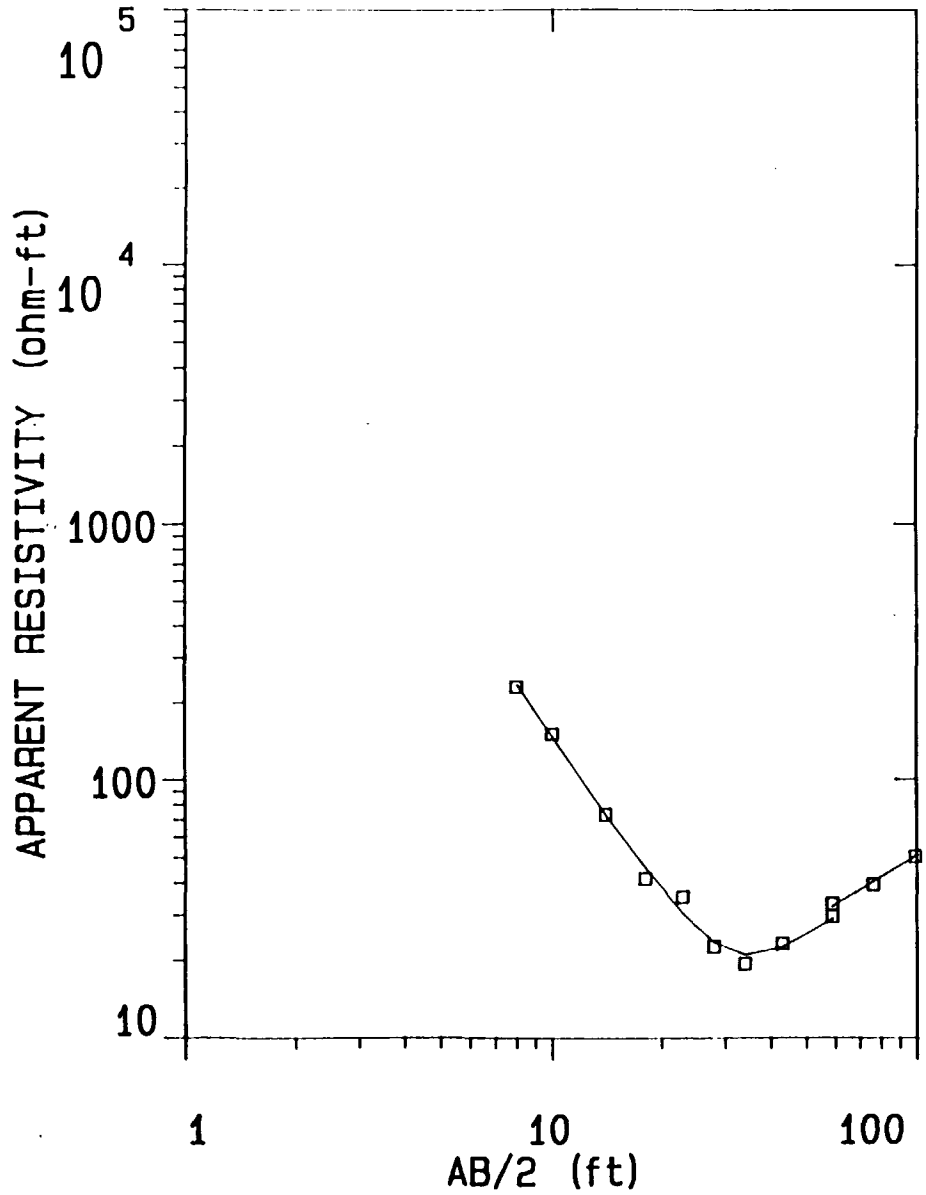


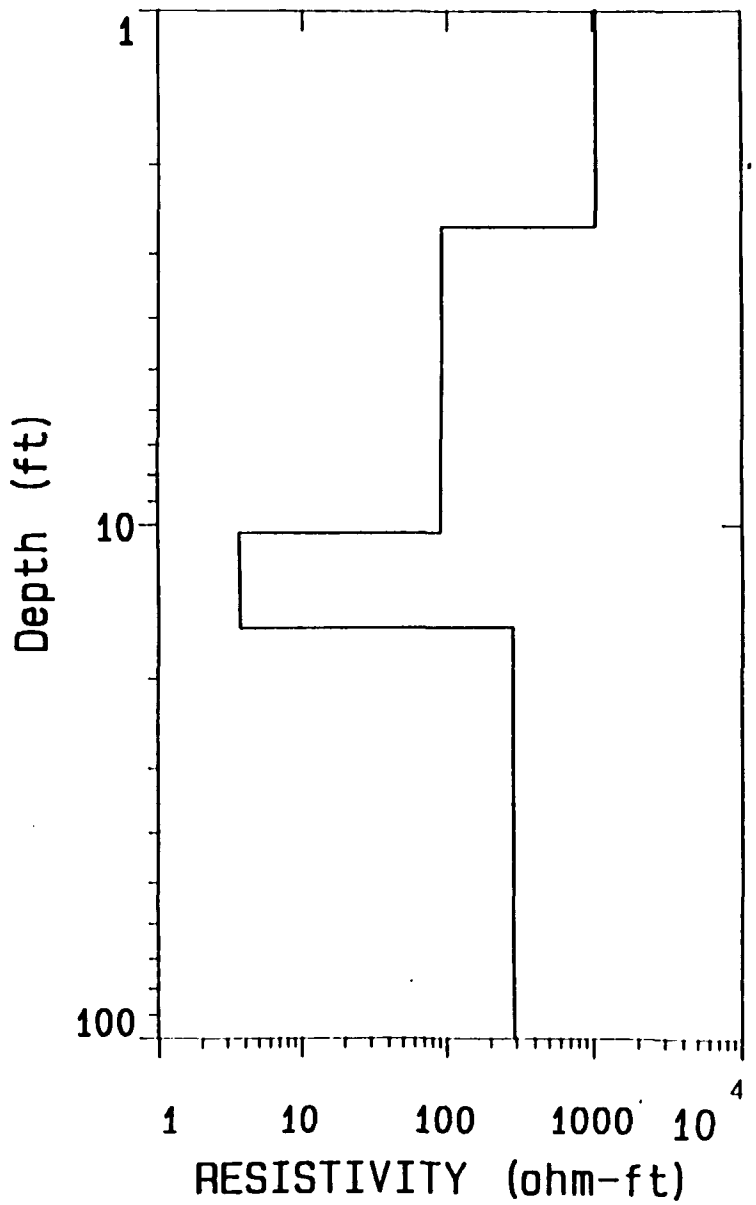
for: Project No. 90B449C		Olin
by: WOODWARD-CLYDE		CPC Landfill
Data Set: GP11	Date: Feb., '93	Schlumberger Sounding
Equipment: Abem	Sounding: GP11	Azimuth: n/a





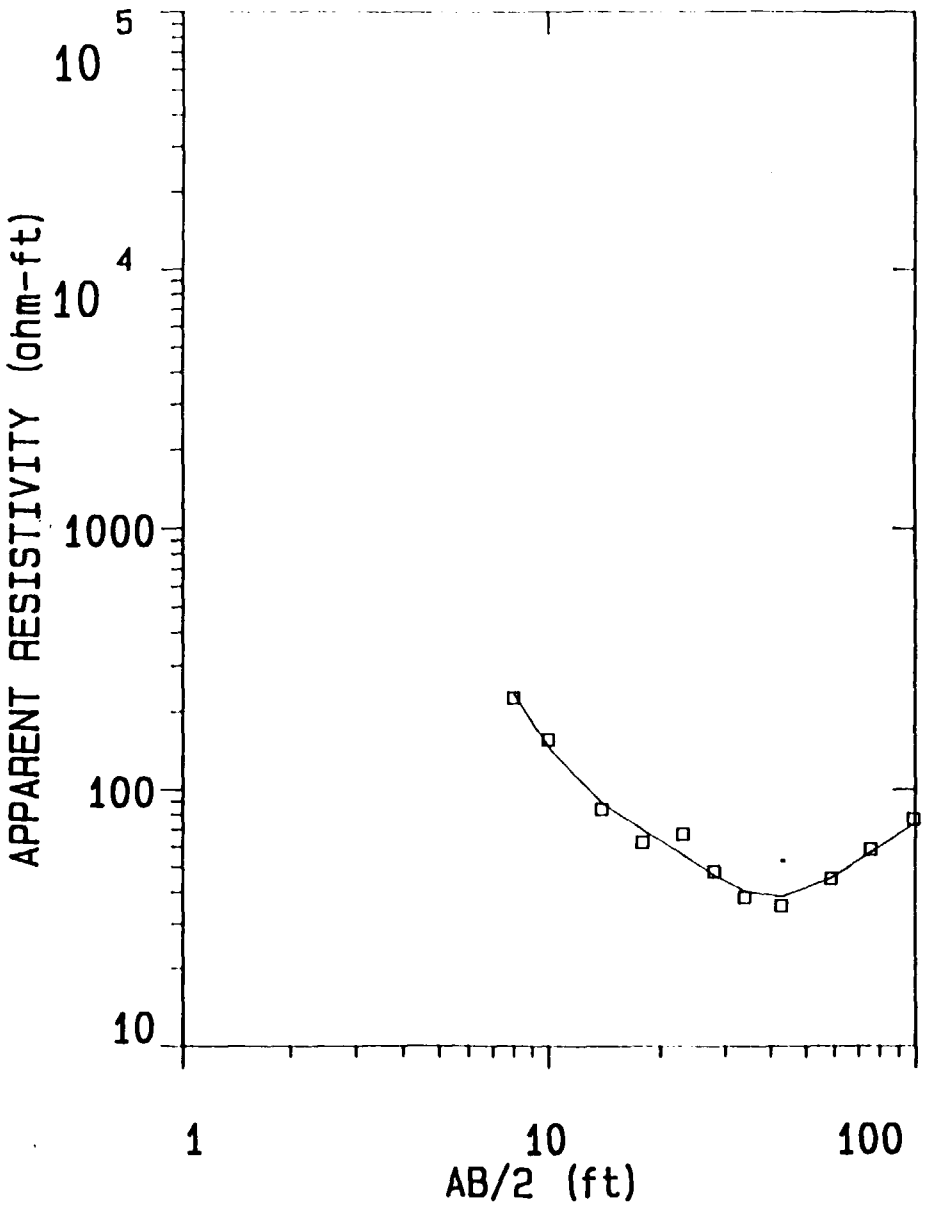
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill Schlumberger Sounding
Data Set: GP12 | Date: Feb., '93	
Equipment: Abem | Sounding: GP12	Azimuth: n/a

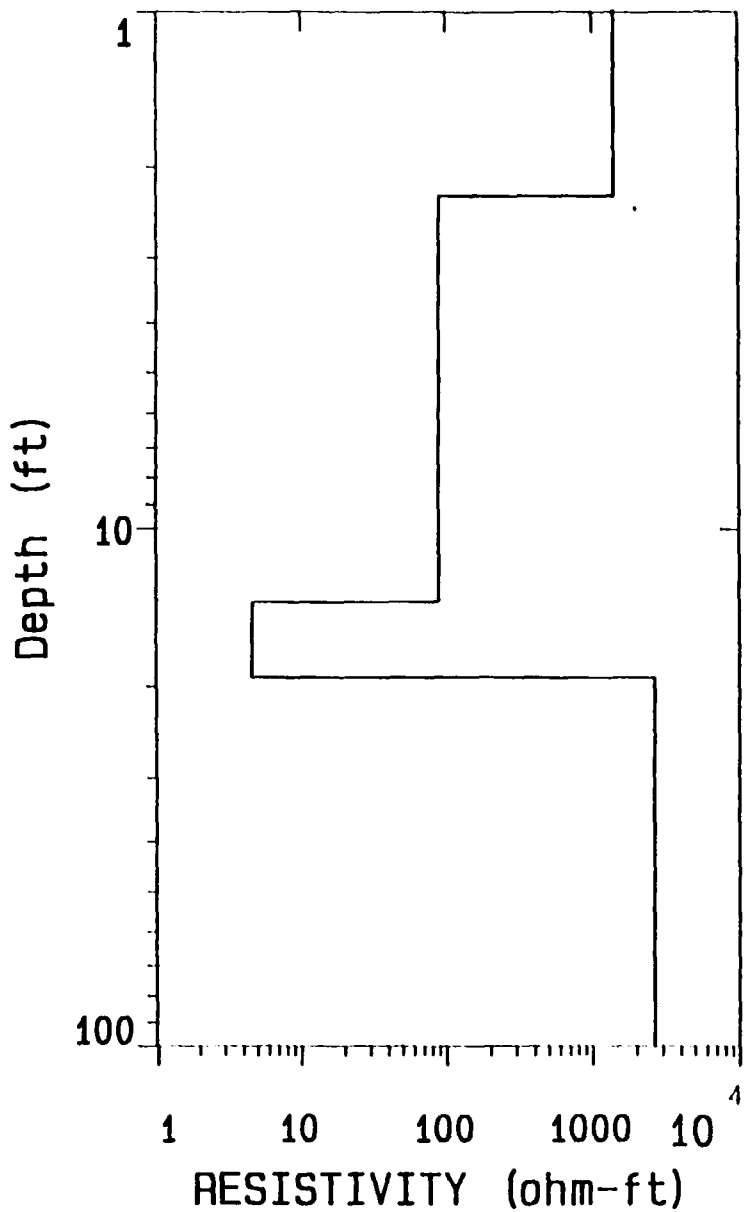




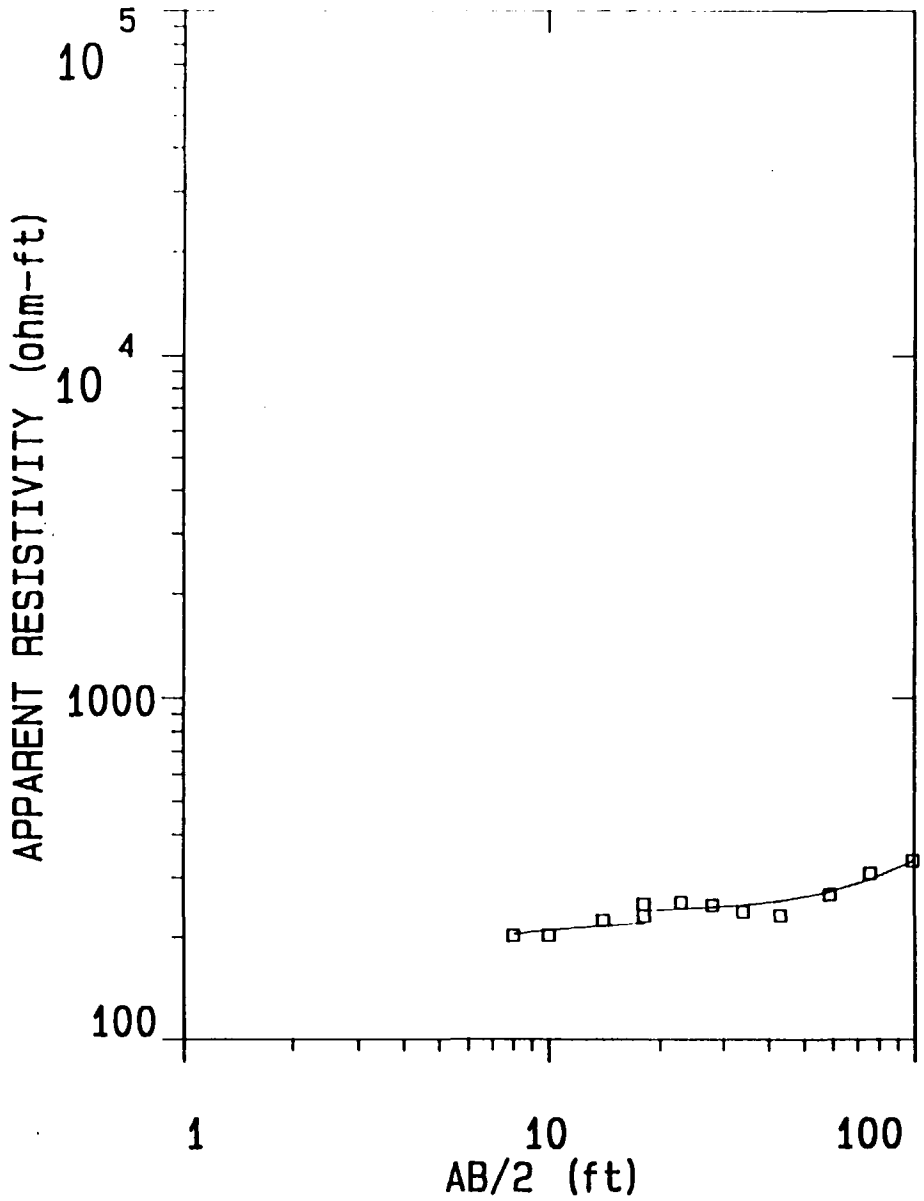
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP13 / Date: Feb., '93	Schlumberger Sounding
Equipment: Abem / Sounding: GP13	Azimuth: n/a

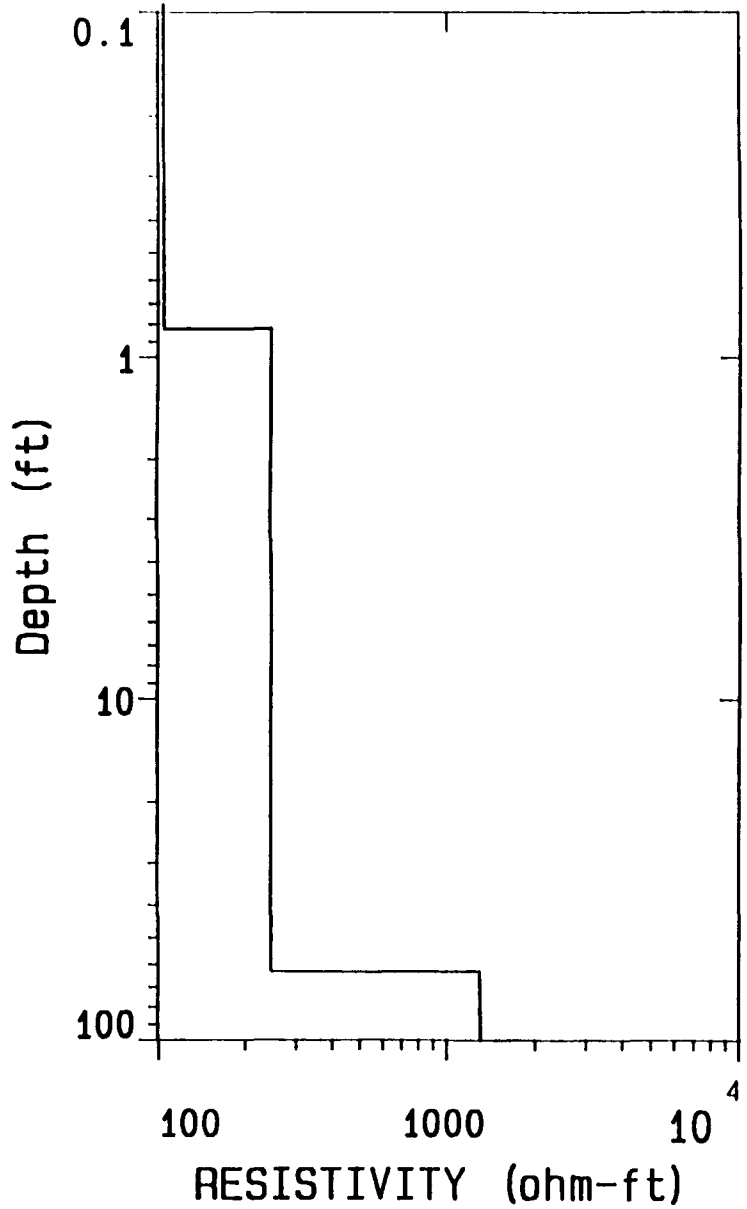
4 9 0495



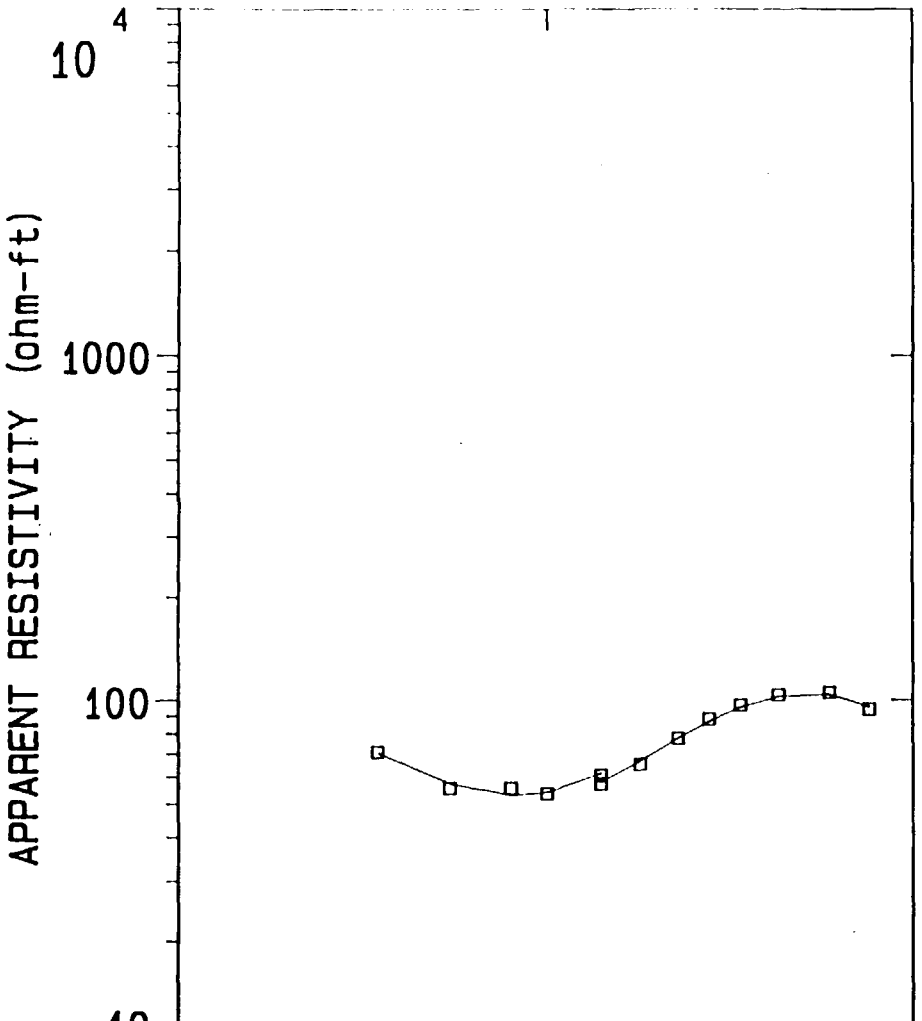


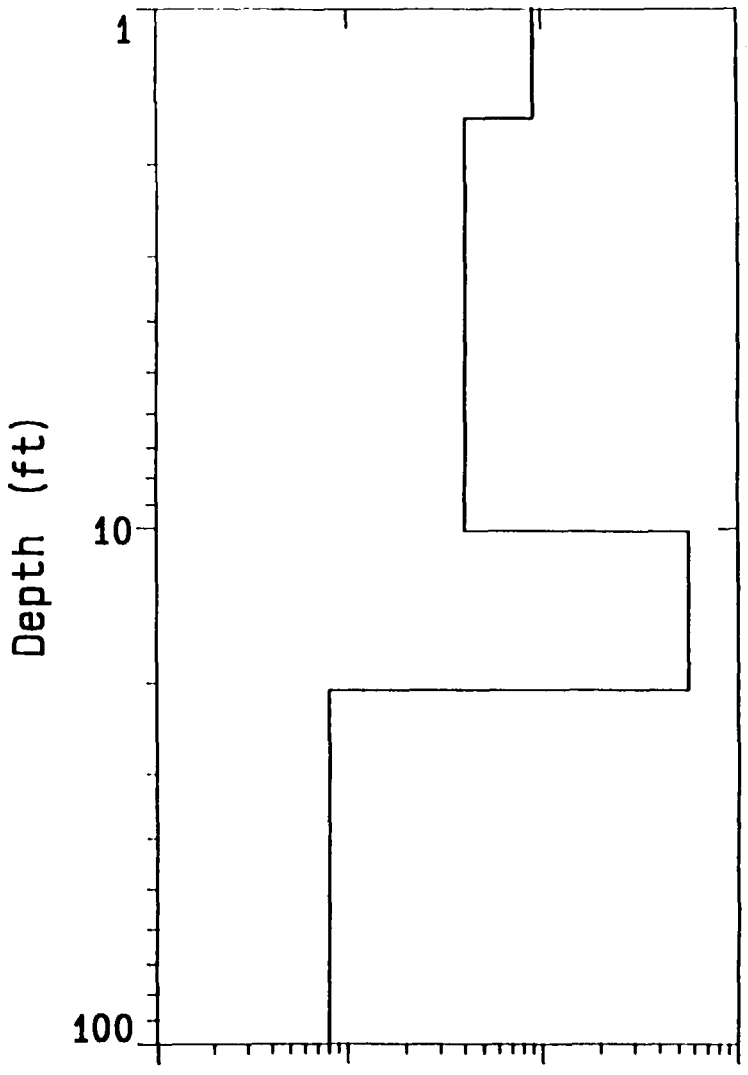
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill Schlumberger Sounding
Data Set: GP14 | Date: Feb., '93	
Equipment: Abem | Sounding: GP14	Azimuth: n/a



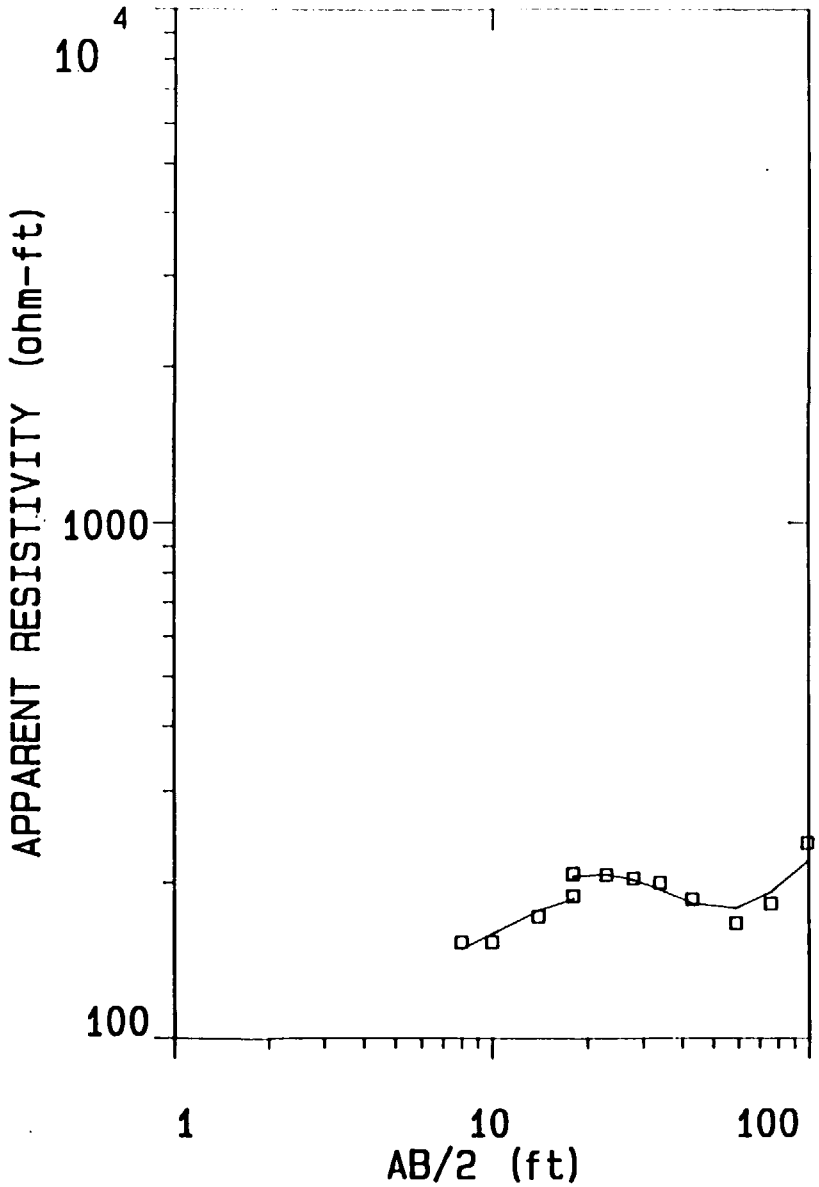


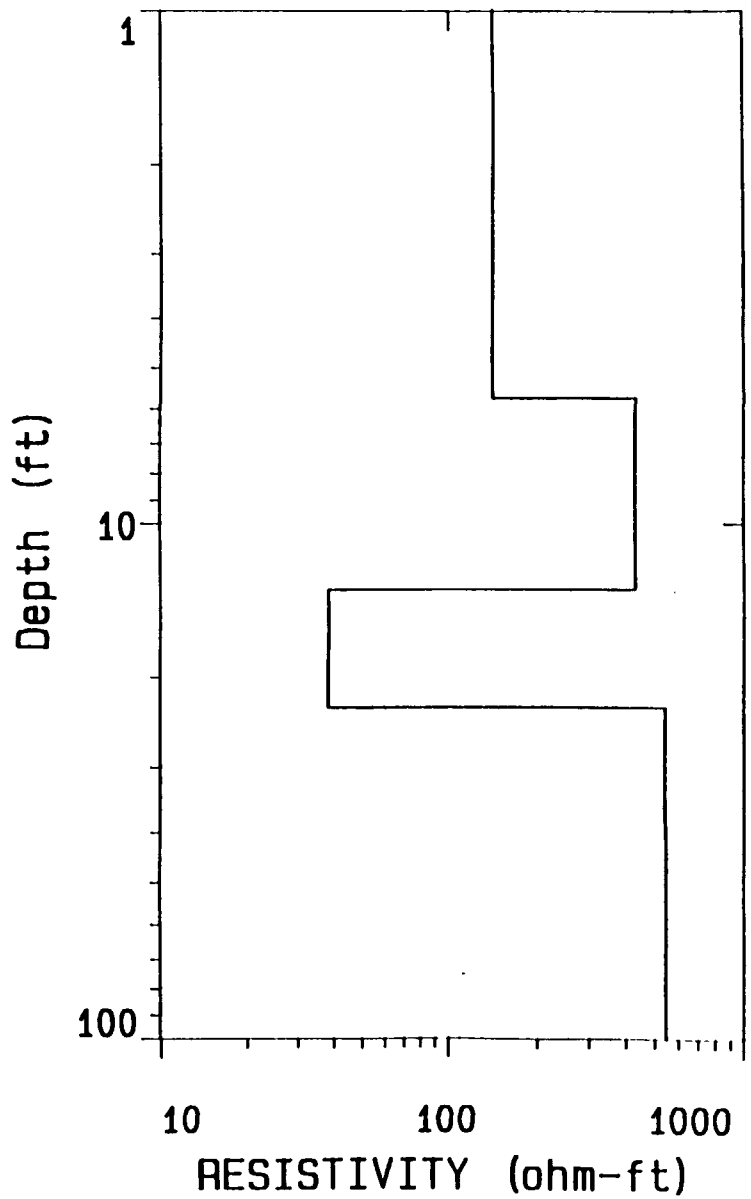
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP15 / Date: Feb., '93	Schlumberger Sounding
Equipment: Abem / Sounding: GP15	Azimuth: n/a





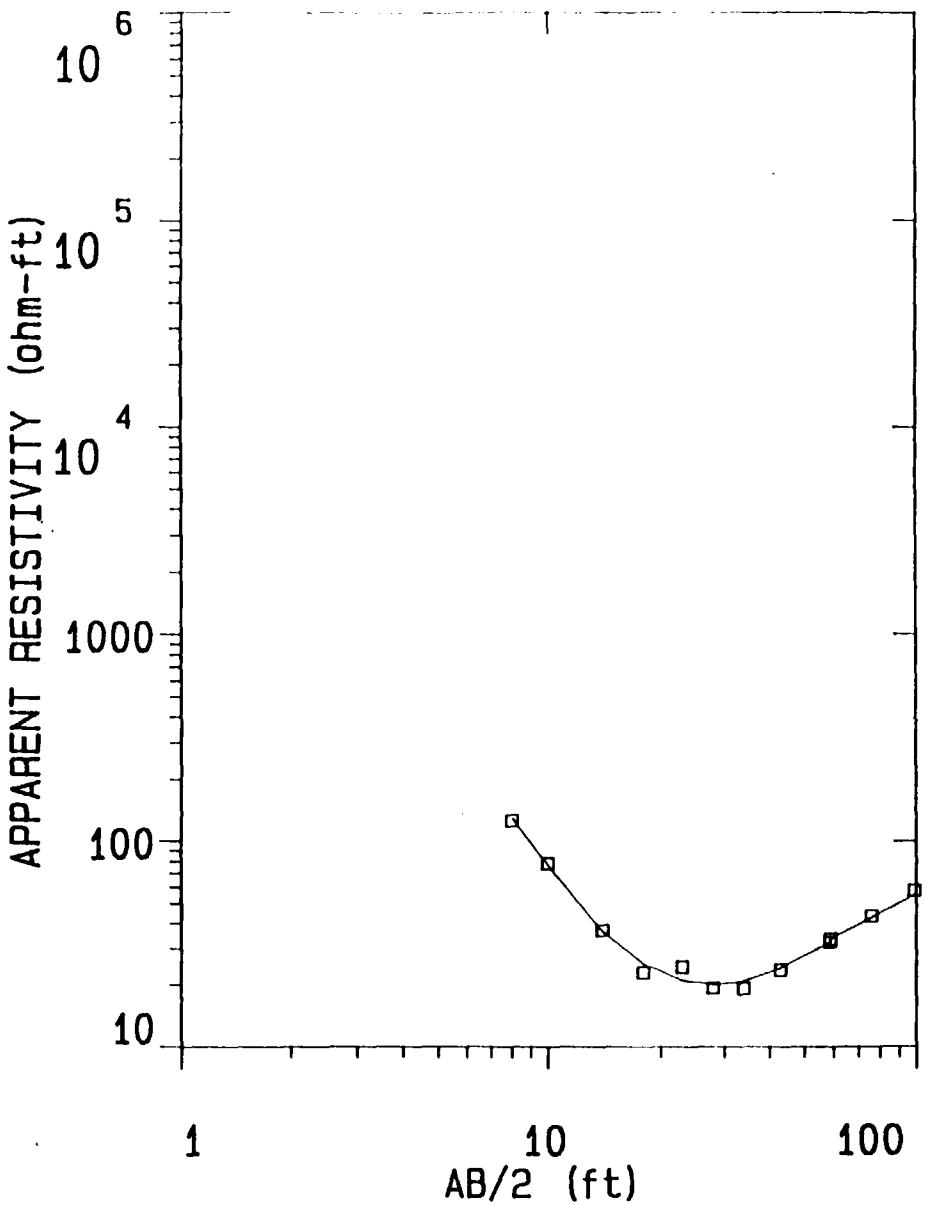
for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP16 | Date: Feb., '93	Schlumberger Sounding
Equipment: Abem | Sounding: GP16	Azimuth: n/a

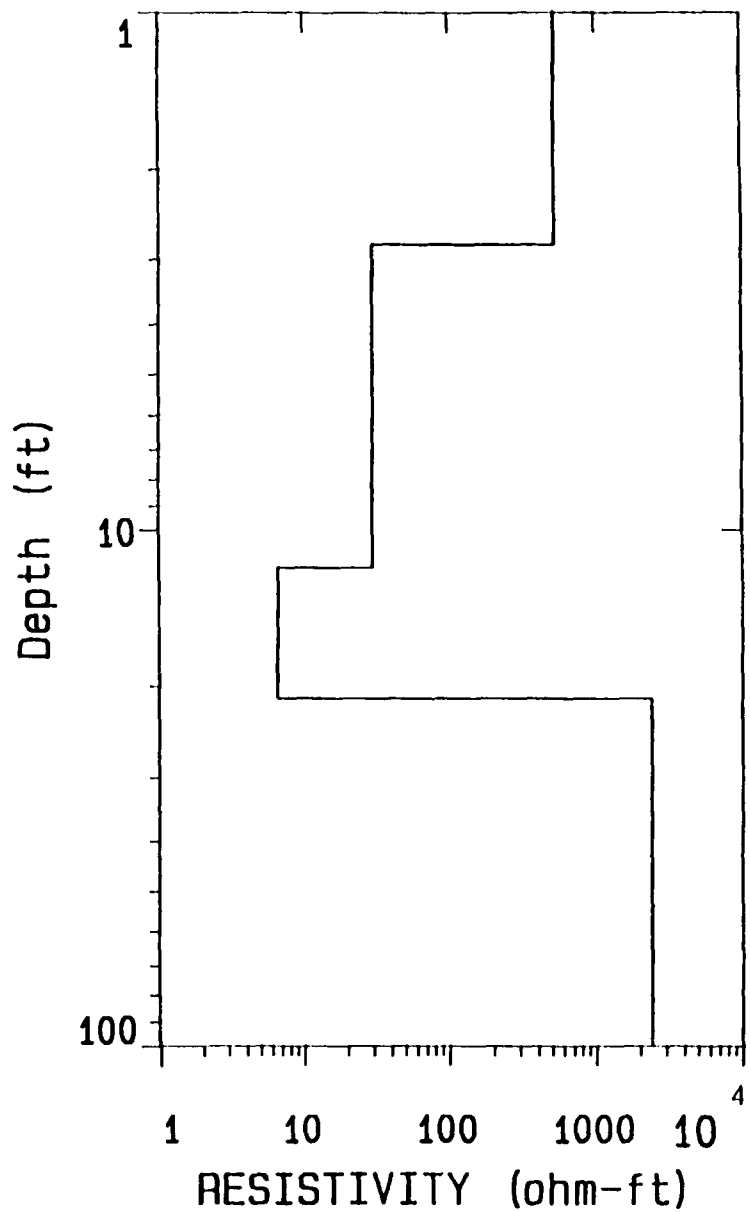




for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill
Data Set: GP17 / Date: Feb., '93	Schlumberger Sounding
Equipment: Abem / Sounding: GP17	Azimuth: n/a

4 9 0497





for: Project No. 90B449C	Olin
by: WOODWARD-CLYDE	CPC Landfill Schlumberger Sounding
Data Set: GP18 | Date: Feb., '93	
Equipment: Abem | Sounding: GP18	Azimuth: n/a

ATTACHMENT C-2

DATA SHEETS

4 9 0499

DATA SET: OLBO1T1

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 52.20
SOUNDING COORDINATES: X: 1596.0000 Y: 1042.5000

DATE: Feb.,'93
SOUNDING: B1T1
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 1.853 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			52.20		
1	101.9	1.43	50.76	0.0140	13.59
2	88.71	15.54	35.22	0.175	128.1
3	2.71	6.92	28.29	2.55	1.74
4	181.5				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	99.78	98.23	1.55
2	5.50	91.74	94.56	-3.07
3	8.00	92.17	91.58	0.645
4	10.00	88.89	89.37	-0.539
5	14.00	83.69	84.08	-0.468
6	14.00	81.29	81.67	-0.468
7	18.00	76.20	75.11	1.42
8	23.00	68.29	65.69	3.80
9	28.00	54.65	56.16	-2.76
10	34.00	44.94	46.01	-2.37
11	43.00	35.84	34.98	2.40
12	59.00	26.26	26.59	-1.25
13	76.00	26.46	26.46	0.0212
14	99.00	31.12	30.96	0.522
15	118.0	35.50	35.53	-0.0880

DATA SET: OLB01T2

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 51.80
SOUNDING COORDINATES: X: 1839.7000 Y: 1085.3000

DATE: Feb.,'93
SOUNDING: B1T2
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 2.690 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			51.80		
1	90.02	3.61	48.18	0.0401	30.24
2	141.0	8.45	39.73	0.0599	110.7
3	2.39	8.54	31.19	3.56	1.90
4	675.5				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	85.85	86.02	-0.200
2	5.50	90.71	90.00	0.782
3	8.00	94.72	93.97	0.784
4	10.00	92.96	94.90	-2.08
5	14.00	90.33	90.63	-0.333
6	14.00	97.47	97.80	-0.333
7	18.00	89.02	87.26	1.97
8	23.00	69.70	71.12	-2.03
9	28.00	55.97	55.81	0.287
10	34.00	43.69	41.21	5.67
11	43.00	25.98	27.65	-6.41
12	59.00	20.27	19.84	2.13
13	76.00	20.81	20.92	-0.553

4 9 0530

DATA SET: OLB02T1

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 49.50
SOUNDING COORDINATES: X: 1824.2000 Y: 1040.7000

DATE: Feb.,'93
SOUNDING: B2T1
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 4.214 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			49.50		
1	107.5	3.86	45.63	0.0359	38.58
2	54.21	17.48	28.15	0.322	88.04
3	2.11	5.26	22.89	2.49	1.03
4	2172.4				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	90.84	93.82	-3.27
2	5.50	90.30	86.22	4.51
3	8.00	76.06	75.63	0.555
4	10.00	66.72	68.39	-2.50
5	14.00	58.66	58.10	0.942
6	14.00	64.25	63.65	0.942
7	18.00	55.88	56.30	-0.764
8	23.00	46.73	49.52	-5.96
9	28.00	43.70	43.92	-0.501
10	34.00	39.97	38.25	4.31
11	43.00	34.26	32.02	6.53
12	59.00	25.85	27.42	-6.07
13	76.00	26.69	28.63	-7.29
14	99.00	35.35	34.49	2.41
15	118.0	42.60	40.49	4.93

DATA SET: OLB02T2

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 49.10
SOUNDING COORDINATES: X: 1839.7000 Y: 1085.3000

DATE: Feb.,'93
SOUNDING: B2T2
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 1.169 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			49.10		
1	100.1	4.42	44.67	0.0442	41.16
2	8.73	11.51	33.15	1.31	9.34
3	7.40	5.93	27.22	0.801	4.08
4	118.5				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	78.21	79.91	-2.18
2	5.50	68.24	67.82	0.612
3	8.00	51.36	49.85	2.93
4	10.00	37.32	37.39	-0.190
5	14.00	21.21	21.40	-0.896
6	14.00	24.59	24.82	-0.896
7	18.00	16.71	16.72	-0.0305
8	23.00	13.65	13.64	0.133
9	28.00	13.72	13.59	0.914
10	34.00	14.95	14.87	0.508
11	43.00	17.42	17.58	-0.927
12	59.00	22.72	22.70	0.104
13	76.00	27.82	27.84	-0.0698

4 9 050

DATA SET: OLB03T1

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 49.80
SOUNDING COORDINATES: X: 1826.7000 Y: 963.4000

DATE: Feb.,'93
SOUNDING: B3T1
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 1.276 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			49.80		
1	96.72	5.42	44.37	0.0561	48.76
2	17.10	4.89	39.47	0.286	7.78
3	6.05	2.24	37.23	0.370	1.26
4	437.8				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	91.94	92.94	-1.08
2	5.50	86.59	85.43	1.33
3	8.00	72.29	72.29	-0.00472
4	10.00	61.15	61.57	-0.701
5	14.00	45.54	45.33	0.465
6	14.00	45.66	45.45	0.465
7	18.00	37.25	37.43	-0.490
8	23.00	35.05	35.53	-1.36
9	28.00	38.90	38.24	1.69
10	34.00	44.14	43.87	0.609
11	43.00	54.06	53.52	0.985
12	59.00	69.26	70.44	-1.70
13	76.00	85.27	87.19	-2.24
14	99.00	110.2	107.9	2.09

DATA SET: OLBO3T2

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 49.60
SOUNDING COORDINATES: X: 1840.5000 Y: 914.6000

DATE: Feb.,'93
SOUNDING: B3T2
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 1.405 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			49.60		
1	84.35	3.34	46.25	0.0396	26.19
2	45.35	11.03	35.22	0.243	46.50
3	14.98	1.41	33.80	0.0943	1.96
4	7837.5				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	75.61	75.50	0.149
2	5.50	68.03	68.83	-1.17
3	8.00	63.24	61.26	3.12
4	10.00	55.87	57.34	-2.62
5	14.00	54.74	54.75	-0.0181
6	14.00	57.75	57.76	-0.0181
7	18.00	60.11	60.03	0.134
8	23.00	67.89	66.98	1.33
9	28.00	76.30	76.62	-0.415
10	34.00	89.22	90.11	-0.999
11	43.00	112.6	112.1	0.488

4 9 0502

DATA SET: GP01

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.90
SOUNDING COORDINATES: X: 1767.3000 Y: 1042.0000

DATE: Feb.,'93
SOUNDING: GP01
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 8.302 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.90		
1	156.5	2.81	48.08	0.0180	40.96
2	299.4	5.10	42.97	0.0170	142.1
3	69.98	61.24	-18.27	0.875	398.1
4	16.54				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	178.6	195.7	-9.57
2	10.00	210.3	196.4	6.61
3	14.00	183.9	183.4	0.272
4	18.00	164.1	162.6	0.898
5	23.00	157.1	137.2	12.68
6	28.00	111.5	117.0	-4.84
7	34.00	87.74	99.96	-13.91
8	43.00	81.19	84.68	-4.29
9	59.00	80.82	71.58	11.43
10	76.00	65.14	63.58	2.39
11	99.00	52.26	54.71	-4.70

DATA SET: GP02

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 51.00
SOUNDING COORDINATES: X: 1765.9000 Y: 963.5000

DATE: Feb.,'93
SOUNDING: GP02
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 8.264 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			51.00		
1	1445.1	1.91	49.08	0.00132	256.9
2	51.94	2.03	47.04	0.0392	9.83
3	1159.0	5.13	41.91	0.00443	552.4
4	9.26	14.22	27.69	1.53	12.24
5	1239.1				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	212.0	208.2	1.79
2	10.00	185.4	191.4	-3.21
3	14.00	194.3	210.5	-8.32
4	18.00	215.3	227.2	-5.49
5	18.00	237.7	250.8	-5.49
6	23.00	258.0	256.2	0.723
7	28.00	275.0	247.5	10.00
8	34.00	271.7	226.8	16.51
9	43.00	196.5	188.6	4.01
10	59.00	117.8	129.5	-9.94
11	76.00	87.99	93.54	-6.31
12	76.00	84.56	89.90	-6.31
13	99.00	81.06	74.75	7.78

4 9 0503

DATA SET: GP03

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 52.40
SOUNDING COORDINATES: X: 1709.5000 Y: 963.5000

DATE: Feb.,'93
SOUNDING: GP03
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 7.805 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			52.40		
1	304.1	4.63	47.76	0.0152	130.8
2	111.3	7.28	40.48	0.0653	75.32
3	3.49	4.03	36.45	1.15	1.30
4	1802.0				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	223.8	207.3	7.37
2	10.00	168.1	176.4	-4.94
3	14.00	117.4	125.1	-6.50
4	18.00	83.19	89.13	-7.14
5	23.00	70.10	60.75	13.34
6	28.00	47.38	45.01	4.99
7	34.00	34.78	36.54	-5.06
8	43.00	32.03	34.92	-9.02
9	43.00	34.76	37.90	-9.02
10	59.00	46.76	46.74	0.0472
11	76.00	62.92	59.27	5.80
12	99.00	82.97	76.43	7.88

DATA SET: GP04

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 52.20
SOUNDING COORDINATES: X: 1708.4000 Y: 1042.0000

DATE: Feb.,'93
SOUNDING: GP04
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 4.540 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			52.20		
1	543.9	2.49	49.70	0.00459	126.2
2	191.7	9.56	40.13	0.0498	170.3
3	2.95	5.03	35.10	1.70	1.38
4	1094.7				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	235.1	233.3	0.777
2	10.00	192.2	194.4	-1.11
3	14.00	146.7	145.1	1.10
4	18.00	102.7	110.5	-7.52
5	23.00	86.22	77.86	9.69
6	28.00	53.50	55.26	-3.29
7	34.00	37.74	39.06	-3.50
8	43.00	29.58	29.22	1.22
9	43.00	33.68	33.27	1.22
10	59.00	33.34	33.87	-1.58
11	76.00	39.81	41.63	-4.56
12	99.00	56.40	53.44	5.24

4 9 0504

DATA SET: GP05

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 52.80
SOUNDING COORDINATES: X: 1653.8000 Y: 1043.9000

DATE: Feb.,'93
SOUNDING: GP05
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 2.783 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			52.80		
1	293.2	6.87	45.92	0.0234	187.1
2	29.05	12.91	33.00	0.444	34.87
3	7.68	6.06	26.94	0.788	4.32
4	1834.2				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	219.1	208.3	4.93
2	10.00	168.8	181.5	-7.48
3	14.00	129.0	129.1	-0.0615
4	18.00	90.98	89.07	2.09
5	18.00	118.0	115.5	2.09
6	23.00	74.54	75.59	-1.41
7	28.00	54.19	55.24	-1.93
8	34.00	45.79	45.21	1.28
9	43.00	43.69	43.37	0.723
10	59.00	52.11	52.46	-0.669
11	59.00	46.16	46.47	-0.669
12	76.00	57.98	58.42	-0.762
13	99.00	76.28	75.22	1.38

DATA SET: GP06

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 53.30
SOUNDING COORDINATES: X: 1653.1000 Y: 963.8000

DATE: Feb.,'93
SOUNDING: GP06
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 4.653 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			53.30		
1	546.5	2.77	50.52	0.00508	141.0
2	47.03	5.49	45.02	0.116	24.00
3	253.8	4.35	40.67	0.0171	102.6
4	9.10	4.20	36.47	0.461	3.55
5	124.4				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	8.00	142.3	143.4	-0.763
2	10.00	101.4	101.0	0.471
3	14.00	74.64	72.77	2.50
4	18.00	62.07	68.49	-10.32
5	23.00	72.72	67.45	7.25
6	28.00	67.86	65.87	2.92
7	34.00	64.46	63.51	1.47
8	43.00	56.72	60.84	-7.27
9	59.00	60.68	60.52	0.274
10	59.00	69.37	69.18	0.274
11	76.00	76.71	73.21	4.55
12	99.00	78.57	80.42	-2.35

DATA SET: GP07 4 9 0505

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 52.30
SOUNDING COORDINATES: X: 1596.0000 Y: 964.5000

DATE: Feb.,'93
SOUNDING: GP07
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 2.665 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			52.30		
1	293.2	3.12	49.17	0.0106	85.14
2	63.07	9.59	39.57	0.152	56.24
3	11.64	5.57	33.99	0.479	6.03
4	196.1				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	130.5	127.8	2.07
2	10.00	96.28	98.75	-2.55
3	14.00	68.01	68.27	-0.381
4	18.00	55.29	55.14	0.277
5	23.00	50.16	47.81	4.68
6	28.00	43.82	45.29	-3.35
7	34.00	44.14	45.83	-3.82
8	43.00	51.03	50.32	1.39
9	59.00	63.00	61.37	2.58
10	59.00	67.96	66.20	2.58
11	76.00	76.26	78.36	-2.75
12	99.00	91.58	92.44	-0.943

DATA SET: GP08

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 48.30
SOUNDING COORDINATES: X: 1520.2000 Y: 964.6000

DATE: Feb.,'93
SOUNDING: GP08
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 2.828 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			48.30		
1	1029.3	2.42	45.87	0.00235	231.6
2	35.52	8.95	36.92	0.252	29.55
3	4.45	4.11	32.80	0.924	1.70
4	88.30				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	118.7	116.4	1.92
2	10.00	59.71	62.09	-3.97
3	14.00	29.48	28.01	4.98
4	18.00	19.45	20.53	-5.53
5	23.00	18.21	17.69	2.84
6	28.00	16.79	17.04	-1.47
7	34.00	17.90	17.66	1.37
8	34.00	22.32	22.01	1.37
9	43.00	23.93	24.69	-3.15
10	59.00	30.52	30.23	0.945
11	59.00	34.22	33.90	0.945
12	76.00	39.39	39.81	-1.04
13	99.00	46.57	46.43	0.304

4 9 0506

DATA SET: GP09

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 48.20
SOUNDING COORDINATES: X: 1875.9000 Y: 962.9000

DATE: Feb.,'93
SOUNDING: GP09
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 2.665 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			48.20		
1	759.0	3.64	44.55	0.00480	257.1
2	156.0	10.78	33.76	0.0691	156.4
3	23.31	5.10	28.66	0.218	11.05
4	16184.8				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	413.2	414.5	-0.315
2	10.00	322.7	323.3	-0.195
3	14.00	223.1	216.7	2.86
4	18.00	159.0	168.7	-6.06
5	23.00	150.8	142.9	5.25
6	28.00	133.9	134.3	-0.336
7	34.00	134.3	136.1	-1.39
8	43.00	151.1	152.7	-1.07
9	59.00	199.3	199.0	0.128
10	76.00	255.3	254.1	0.501
11	99.00	330.8	329.2	0.481

DATA SET: GP10

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 47.80
SOUNDING COORDINATES: X: 1881.0000 Y: 1039.7000

DATE: Feb.,'93
SOUNDING: GP10
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 3.106 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			47.80		
1	631.4	6.25	41.54	0.00991	367.1
2	127.2	5.87	35.66	0.0461	69.44
3	10.66	4.64	31.02	0.435	4.59
4	225.3				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	482.5	472.0	2.17
2	10.00	402.6	407.9	-1.32
3	14.00	284.2	286.0	-0.639
4	18.00	185.4	194.2	-4.69
5	23.00	132.7	123.4	6.98
6	28.00	87.16	87.41	-0.284
7	34.00	67.15	69.83	-3.99
8	43.00	65.50	66.46	-1.46
9	59.00	78.92	77.73	1.50
10	59.00	84.53	83.26	1.50
11	76.00	99.82	97.78	2.03
12	99.00	111.8	114.4	-2.33

4 9 0507

DATA SET: GP11

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.00
SOUNDING COORDINATES: X: 1770.0000 Y: 1144.9000

DATE: Feb.,'93
SOUNDING: GP11
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 4.932 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.00		
1	2120.0	2.26	47.73	0.00107	445.8
2	94.83	8.32	39.41	0.0877	73.30
3	3.49	4.48	34.92	1.28	1.45
4	349.5				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	269.5	268.4	0.394
2	10.00	147.1	148.7	-1.13
3	14.00	74.49	71.87	3.52
4	18.00	44.15	48.53	-9.90
5	23.00	38.64	34.40	10.95
6	28.00	26.75	27.69	-3.53
7	34.00	24.08	25.24	-4.82
8	43.00	27.28	26.98	1.07
9	43.00	30.45	30.13	1.07
10	59.00	39.04	38.52	1.33
11	76.00	48.45	48.12	0.679
12	99.00	59.84	60.44	-1.01

DATA SET: GP12

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.50
SOUNDING COORDINATES: X: 1707.6000 Y: 1145.0000

DATE: Feb.,'93
SOUNDING: GP12
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 3.949 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.50		
1	1000.0	3.02	47.47	0.00303	281.2
2	106.8	9.25	38.22	0.0865	91.83
3	2.65	4.15	34.06	1.56	1.02
4	600.3				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	288.8	290.3	-0.497
2	10.00	194.5	193.8	0.363
3	14.00	105.1	102.1	2.81
4	18.00	60.82	66.03	-8.57
5	23.00	48.55	44.13	9.09
6	28.00	31.75	32.49	-2.31
7	34.00	24.71	25.82	-4.51
8	43.00	24.18	23.78	1.66
9	43.00	25.76	25.33	1.66
10	59.00	30.72	30.31	1.33
11	59.00	34.32	33.86	1.33
12	76.00	41.16	42.47	-3.18
13	76.00	41.35	42.66	-3.18
14	99.00	55.25	54.45	1.45
15	99.00	55.28	54.48	1.45

DATA SET: GP13

4 9 0508

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.40
SOUNDING COORDINATES: X: 1653.4000 Y: 1146.8000

DATE: Feb.,'93
SOUNDING: GP13
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 6.177 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.40		
1	1047.6	2.64	47.75	0.00253	257.5
2	90.29	7.69	40.06	0.0851	64.52
3	3.59	5.56	34.49	1.54	1.85
4	290.6				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	230.9	235.1	-1.85
2	10.00	150.8	146.5	2.85
3	14.00	73.13	72.53	0.829
4	18.00	41.34	45.63	-10.37
5	23.00	34.99	30.23	13.60
6	28.00	22.55	23.42	-3.84
7	34.00	19.38	21.00	-8.35
8	43.00	23.16	22.44	3.10
9	59.00	29.52	28.81	2.38
10	59.00	33.08	32.29	2.38
11	76.00	39.29	40.35	-2.70
12	99.00	50.60	50.68	-0.151

DATA SET: GP14

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.40
SOUNDING COORDINATES: X: 1599.1000 Y: 1147.6000

DATE: Feb.,'93
SOUNDING: GP14
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 8.223 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.40		
1	1394.1	2.27	48.12	0.00163	294.4
2	89.09	11.54	36.58	0.129	95.55
3	4.55	5.35	31.22	1.17	2.26
4	2651.1				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	227.1	234.1	-3.09
2	10.00	156.0	146.1	6.34
3	14.00	83.69	88.61	-5.88
4	18.00	62.33	69.84	-12.05
5	23.00	66.88	55.80	16.56
6	28.00	48.04	46.47	3.27
7	34.00	38.00	40.28	-5.99
8	43.00	35.20	38.33	-8.89
9	59.00	44.95	45.21	-0.572
10	76.00	58.32	56.72	2.73
11	99.00	76.47	73.23	4.23

4 9 0509

DATA SET: GP15

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.20
SOUNDING COORDINATES: X: 1764.1000 Y: 875.4000

DATE: Feb.,'93
SOUNDING: GP15
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 4.517 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.20		
1	103.9	0.824	49.37	0.00793	7.96
2	245.6	62.22	-12.84	0.253	1419.8
3	1306.2				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	201.6	204.0	-1.16
2	10.00	202.0	210.2	-4.05
3	14.00	224.5	217.0	3.31
4	18.00	231.2	220.7	4.51
5	18.00	251.5	240.2	4.51
6	23.00	253.8	243.5	4.05
7	28.00	249.1	246.3	1.10
8	34.00	238.1	249.9	-4.92
9	43.00	231.7	256.3	-10.59
10	59.00	267.1	272.4	-2.00
11	76.00	308.0	295.9	3.93
12	99.00	335.8	335.1	0.221

DATA SET: GP16

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.40

DATE: Feb.,'93
SOUNDING: GP16
AZIMUTH: n/a
EQUIPMENT: Abem

SOUNDING COORDINATES: X: 1709.3000 Y: 874.5000

Schlumberger Configuration

FITTING ERROR: 1.987 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.40		
1	90.41	1.62	48.77	0.0179	13.63
2	40.10	8.49	40.28	0.211	31.65
3	560.0	10.52	29.76	0.0187	547.4
4	7.89				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	3.50	70.82	70.25	0.802
2	5.50	55.66	57.33	-2.99
3	8.00	55.60	53.06	4.56
4	10.00	53.76	54.25	-0.928
5	14.00	60.77	61.54	-1.26
6	14.00	57.25	57.98	-1.26
7	18.00	65.31	66.91	-2.44
8	23.00	77.76	77.82	-0.0735
9	28.00	88.36	87.03	1.50
10	34.00	96.70	95.35	1.38
11	43.00	103.6	102.6	0.975
12	59.00	105.1	103.9	1.13
13	76.00	94.10	95.67	-1.66

4 9 0 5 0

DATA SET: GP17

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 50.40
SOUNDING COORDINATES: X: 1653.5000 Y: 873.3000

DATE: Feb.,'93
SOUNDING: GP17
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 3.975 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			50.40		
1	140.3	5.70	44.69	0.0406	74.39
2	436.8	7.73	36.96	0.0177	313.9
3	38.07	9.50	27.45	0.249	33.63
4	546.1				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	8.00	153.6	149.3	2.78
2	10.00	153.8	159.9	-4.00
3	14.00	172.6	177.0	-2.56
4	18.00	188.2	185.9	1.19
5	18.00	207.9	205.4	1.19
6	23.00	206.6	207.1	-0.238
7	28.00	203.5	202.2	0.635
8	34.00	199.6	193.5	3.08
9	43.00	185.7	182.4	1.76
10	59.00	167.2	178.6	-6.81
11	76.00	182.0	191.5	-5.17
12	99.00	237.8	219.1	7.87

DATA SET: GP18

CLIENT: Project No. 90B449C
LOCATION: CPC Landfill
COUNTY: Schlumberger Sounding
PROJECT: Olin
ELEVATION: 48.40
SOUNDING COORDINATES: X: 1520.8000 Y: 1042.6000

DATE: Feb.,'93
SOUNDING: GP18
AZIMUTH: n/a
EQUIPMENT: Abem

Schlumberger Configuration

FITTING ERROR: 6.367 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	LONG. COND. (Siemens)	TRANS. RES. (Ohm-m^2)
			48.40		
1	523.8	2.80	45.59	0.00535	136.3
2	29.39	8.99	36.59	0.306	24.57
3	6.51	9.33	27.26	1.43	5.64
4	2407.5				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	SYNTHETIC	DIFFERENCE (percent)
1	8.00	125.8	128.1	-1.81
2	10.00	78.11	76.42	2.16
3	14.00	36.79	36.12	1.82
4	18.00	22.82	25.13	-10.12
5	23.00	24.33	20.89	14.14
6	28.00	19.18	19.91	-3.80
7	34.00	19.02	20.74	-9.02
8	43.00	23.51	24.06	-2.30
9	59.00	32.07	32.01	0.168
10	59.00	33.27	33.22	0.168
11	76.00	43.30	42.52	1.78
12	99.00	57.81	55.10	4.69

Appendix D

4 9 0512

APPENDIX D

LOCATIONS OF DOMESTIC WELLS SAMPLED FOR RI/FS

OVERSIZED

DOCUMENT

Appendix E

APPENDIX E

HYDRAULIC GRADIENT AND HELP MODEL CALCULATIONS

Woodward-Clyde Consultants

4 9 0516

Project Notes

Subject: HORIZONTAL GRADIENT (LIME PONDS/STRONG BRINE POND AND MERCURY CELL PLANT

Project Name: Olin McIntosh

Project No.: 90R4TL

Task No.: 9 File No.:

Sheet 1 of 4

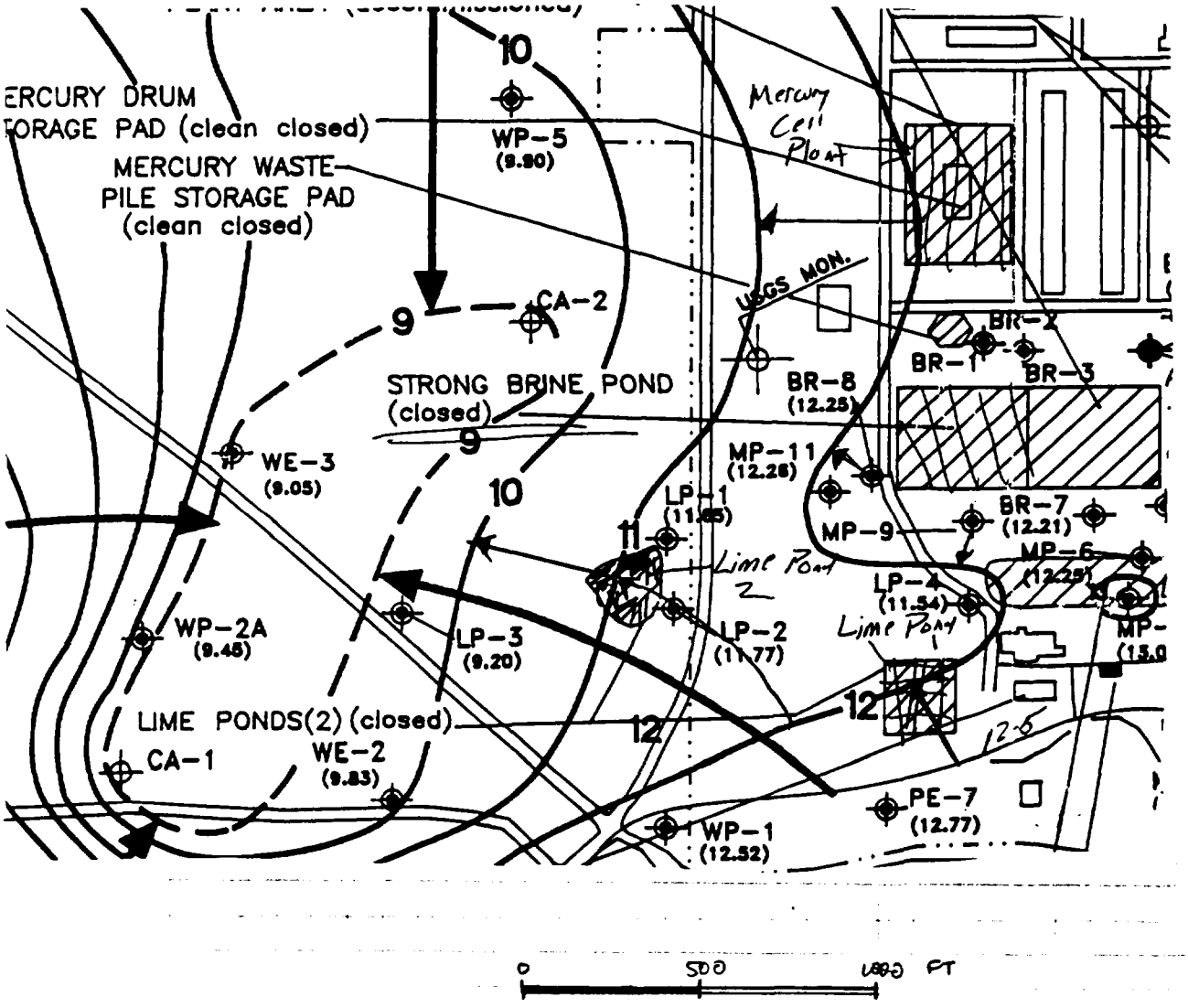
By: WAB Date: 7/14/93

Checked By: FGERRA Date: 7/26/93

PURPOSE - TO ESTIMATE THE HORIZONTAL GRADIENT IN THE VICINITY OF THE LIME PONDS, MERCURY CELL PLANT AND THE STRONG BRINE POND FOR THE ALUVIAL AQUIFER

PROCEDURE - GRADIENT MEASUREMENTS WERE TAKEN AT SEVERAL LOCATIONS FOR THESE AREAS FOR BOTH THE UPPER AND LOWER ZONES OF THE AQUIFER

UPPER ZONE - SEPTEMBER 1991 POTENTIOMETRIC MAP



Woodward-Clyde Consultants

4 9 0517

Project Notes

Subject: HORIZONTAL GRADIENTS
By: LWAB Date: 7/10/93
Checked By: FSIERRA Date: 7/26/93

Project Name: GOB4/9C
Project No.: 50449C
Task No.: File No.:
Sheet 2 of 4

LIME POND 1 (EAST)

$$\frac{12.5\text{ ft} - 12.0\text{ ft}}{250\text{ ft}} = 0.002 \quad NW$$

LIME POND 2 (WEST)

$$\frac{11\text{ ft} - 16\text{ ft}}{420\text{ ft}} = 0.0024 \quad N - NW$$

$$\frac{12\text{ ft} - 11\text{ ft}}{660\text{ ft}} = 0.0015 \quad NW$$

AVG – UPPER ZONE = 0.002 NW

STRONG BRINE POND

BR8 → 12 contour

$$\frac{12.25 - 12}{140} = 0.0019 \quad NW$$

BR7 → 12 CONTOUR

$$\frac{12.21 - 12}{140} = 0.0015 \quad SW$$

AVG – UPPER ZONE 0.0017

MERCURY CELL PLANT

$$\frac{12\text{ ft} - 11\text{ ft}}{450\text{ ft}} = 0.0022 \quad W$$

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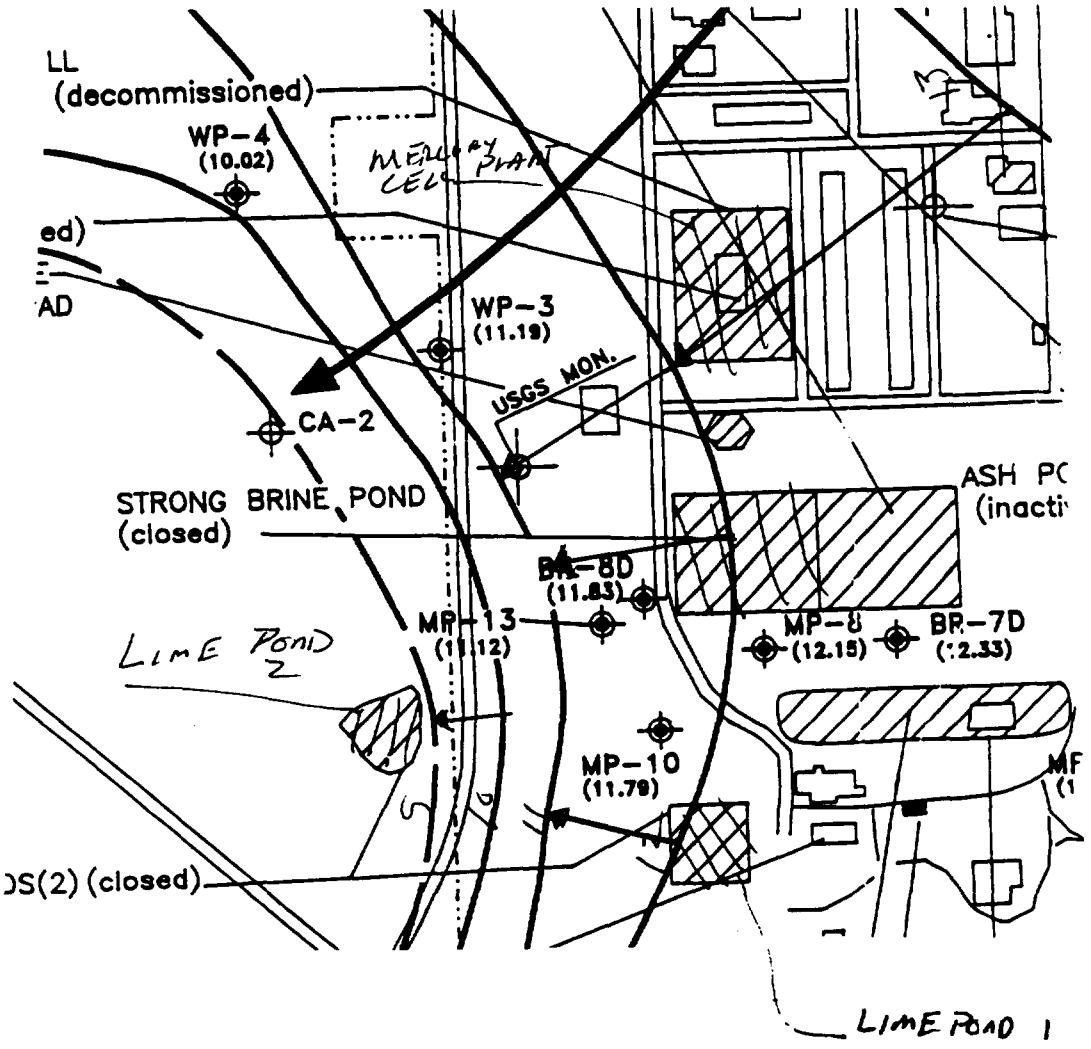
4 9 0518

Project Notes

Subject: HORIZONTAL GRADIENTS
By: LJAR Date: 7/10/93
Checked By: FSHELKA Date: 7/26/93

Project Name: Olin McIntosh
Project No.: 90 B4 4L
Task No. File No.
Sheet 3 of 4

LOWER ZONE SEPTEMBER 1991 POTENTIOMETRIC MAP



LIME POND 1

$$\frac{12\text{ ft} - 11\text{ ft}}{350\text{ ft}} = 0.0029\text{ ft W.} \quad \checkmark$$

LIME POND 2

$$\frac{10\text{ ft} - 9\text{ ft}}{180\text{ ft}} = 0.0056\text{ ft W} \quad \checkmark$$

Woodward-Clyde Consultants

4 9 0519

Project Notes

Subject: HORIZONTAL GRADIENTS
By: JAB Date: 7/10/93
Checked By: F. SKELLA Date: 7/26/93

Project Name: OLIN McINTOSH
Project No.: 90B4451
Task No.: File No.:
Sheet 4 of 4

STRONG BRINE POND

$$\frac{12\text{ ft} - 11\text{ ft}}{500\text{ ft}} = 0.0020 \text{ WEST}$$

MERCURY CELL PLANT

$$\frac{13\text{ ft} - 12\text{ ft}}{\cancel{900}\text{ ft}\ 1100\text{ ft}} = \cancel{0.0011}\ 0.0009 \text{ F.S. SW}$$

$$\frac{12\text{ ft} - 11\text{ ft}}{430\text{ ft}\ 540} = \cancel{0.0023}\ 0.0019 \text{ F.S. SW}$$

AVG - lower zone = $\cancel{0.0017}$ F.S. 0.0014

SUMMARY

	UPPER ZONE	LOWER ZONE	BOTH ZONES (AVG)
LIME POND 1	0.002	0.0029	0.0024
LIME POND 2	0.002	0.0056	0.0038
STRONG BRINE POND	0.0017	0.0020	0.0018
MERCURY CELL PLANT	0.0022	$\cancel{0.0017}$ F.S. 0.0014	$\cancel{0.0019}$ F.S. 0.0018

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4 9 0520

Project Notes

Subject: HYDRAULIC GRADIENTS SANIT. LANDFILLS

F SIERRA Date: 10/12/93

Checked By: UAB Date: 10/15/93

Project Name: OUN MCINT

Project No.: 98B449C

Task No.: 9 File No.:

Sheet 1 of 2

→ OBJECTIVE

CALCULATION OF HYDRAULIC GRADIENT IN SANITARY LANDFILL AREA

→ PROCEDURE

USE POTENTIOMETRIC MAPS OF ALLUVIAL AQUIFER (USE UPPER ZONE ONLY, MAP OF LOWER ZONE DO NOT HAVE POTENTIOMETRIC LINES IN THE AREA) (COPY OF MAP ATTACHED)

$$i = \frac{\Delta h}{\Delta l}$$

4 measurements were taken:

9.26×10^{-4}

9.52×10^{-4}

1.53×10^{-4}

2.78×10^{-4}

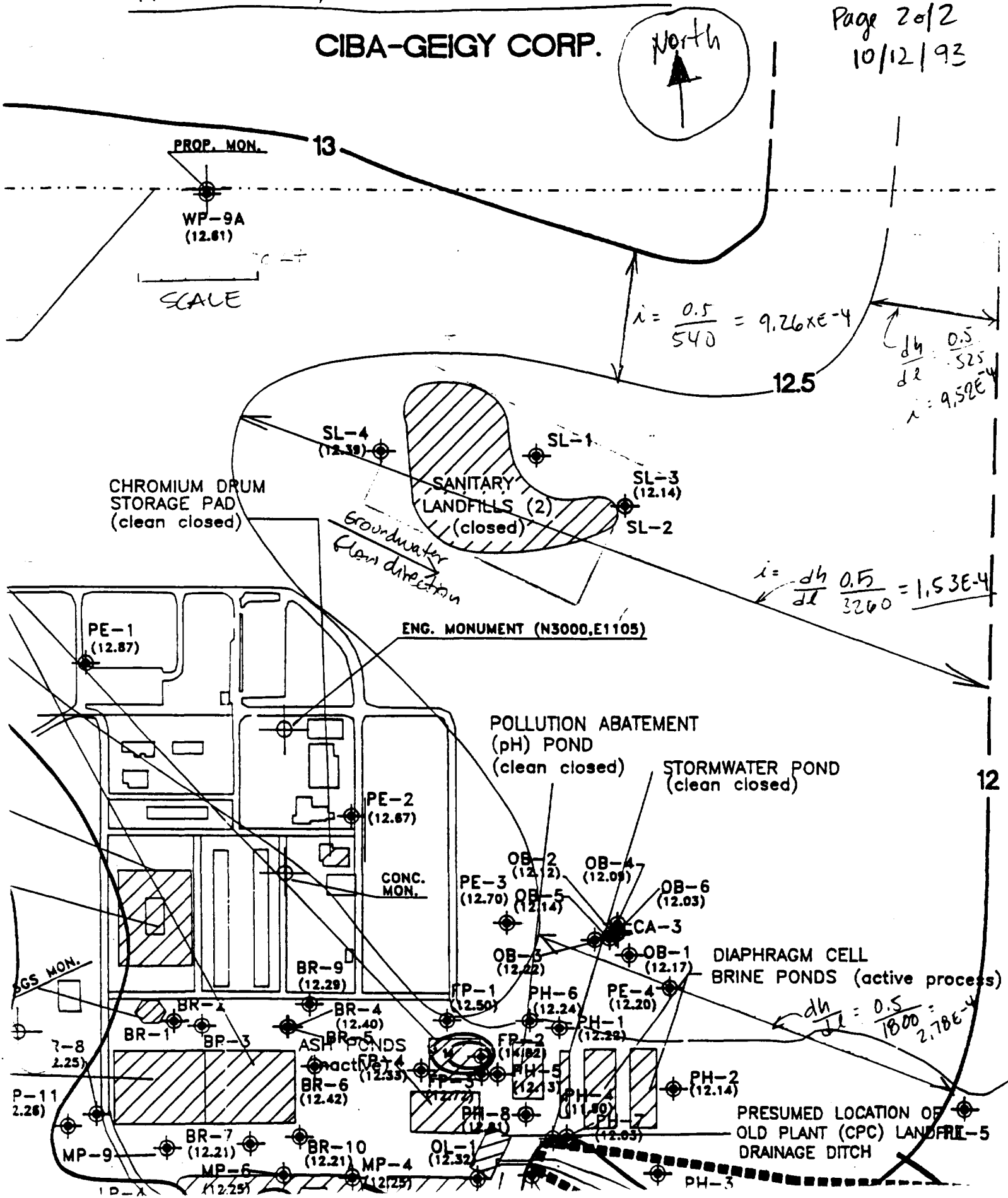
→ $\boxed{\text{Average } i} = 5.77 \times 10^{-4}$

4 9 0521

UPPER ZONE, SEPT 91 POTENT. MAP

908449C-9
Ohm Mac
Page 2 of 2
10/12/93

CIBA-GEIGY CORP.



Woodward-Clyde Consultants

4 9 0522 **Project Notes**

Subject: OLIN/MCINTOSH

Project Name: OLIN

Project No.:

Task No.: 90B449C6 File No.:

Sheet 1 of

AMS Date: 01/28/93

Checked By: JAB Date: 02/14/93

OBJECTIVE: To Compute an estimated infiltration rate from precipitation to specified depths at Lime Pond, Strong Brine Pond and CPC Plant areas at Olin's McIntosh facility

REFERENCES: ① HELP Model Version 2.0 Program and Draft Guidance (EPA/530/SW/84/009 and 010)

② Boring Logs (Attached)

ASSUMPTIONS: 1. The Lime Ponds 1 & 2 are 2 scenarios of the same soil type but 2 depths - 6' and 12'

2. The Strong Brine Pond will follow same scenario as Lime Pond 1 with depth of 6'

3. CPC Plant Area has depth of 11'

4. The CPC Landfill has 2 layers of 6" and 2'

PROGRAM INPUT - 1 Model for each scenario
- 5th. Latitude = 31°26' corrected
- Bare Ground
- Fair Grass for CPC Landfill

① Lime Pond 1 and Strong Brine Pond

Thickness = 72 inches Area = 113,750
Soil Type = 12

② Lime Pond 2 Area = 40,000
Thickness = 6 inches
Soil Type = 12

③ CPC Plant Area Area = 105,000 SEE NOTE 2 ON PAGE 2
Thickness = 132 inches
Soil Type = 12

④ CPC Landfill Area = 110,000 * SEE NOTE 1, PAGE 2
Layer 1 - 6" Soil Type 10 } Both Layers Compacted
Layer 2 - 24" Soil Type 14 } with Fair Grass

Woodward-Clyde Consultants

Project Notes

Subject: OLIN MCINTOSH

AMS Date: 01/28/93

Checked By: WAB Date: 2/14/93

Project Name: OLIN

Project No.:

Task No.: 90B0496-6 File No.:

Sheet 2 of

CONCLUSIONS: 5 YEAR VALUES AND AVERAGE FOR EACH SCENARIO FROM OUTPUT AS FOLLOWS

	SCENARIO ①	SCENARIO ②	SCENARIO ③	CPC LANDFILL SCENARIO ④
1.	3.8037	4.6896	2.2869	2.0654
2.	3.9725	4.4464	2.4375	0.9224
3.	2.6830	8.4855	4.1031	4.2523
4.	2.5187	4.4561	3.6950	2.1405
5.	4.2343	4.3755	3.5700	2.0338
AVERAGE*	3.3147	5.2906	3.2185	2.2329

SEE NOTE

* AVERAGES COMPUTED FROM PROGRAM OUTPUT

SEE ATTACHED OUTPUT : SCEN1.OUT
SCEN2.OUT
SCEN3.OUT
CPC LAND.

NOTE 1: ON 2/2/93, THE CPC LANDFILL CALCULATION WAS MODIFIED USING THE AREA OF 120,000 FT², THE AVERAGE 5 YEAR VALUE IS 2.2704 IN/YR. OUTPUT FILE IS ATTACHED. F. SIERRA

NOTE 2: ON 9/28/93, THE CPC PLANT CALCULATIONS WERE MODIFIED USING A CORRECTED AREA (15,000 SQ.FT.) THE AVERAGE PERCOLATION BECAME 3.19 IN/YR. OUTPUT FILE ATTACHED. F SIERRA

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

4 9 0523

BORING: BL1
FILE: 90B449C-3F
DATE: 8/12/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: **Full Depth**

Free water was encountered at a depth of 10' during hollow-stem augering. The water level rose to a depth of approximately 6' after an observation period of 5 minutes.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		1.5			17	Stiff reddish brown and gray (10YR 4/8) Silty CLAYS (FILL)
						—with ash and gravel at 1'
		1.5			23	Stiff reddish brown and gray (10YR 4/8) Sandy CLAYS (FILL)
		1.25				
		1.0			24	—with gravel, 2'- 4'
5						—red (2.5R 4/8), 4'- 6.25'
		1.0			24	Very loose black (2.5YR 2.5/0) Ash FILL and Sandy GRAVEL (FILL)
		<0.25			24	—wet at 8'
10		<0.25			24	
		<0.25			24	
		<0.25			10	
15		<0.25			10	Soft white (5Y 8/1) LIME waste material, damp (FILL)
		0.5			24	
20						Red and gray (2.5YR 5/8) CLAYS (CH)
						Bottom of boring at 20'.
						Drilled to 18' and pushed a split spoon from 18'- 20'
						Borehole grouted to full depth.

Soil sample retained for lab analysis from 16'- 18'.

Unified Soil Classifications based on visual observations.

FEB 15 93 ENVSOH 0B449 474UND

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BL2
FILE: 90B449C-3F
DATE: 8/16/92
TECHNICIAN: J. Davis
APPROVED: VP
PAGE: 1 of 1

Hollow-stem Augered: Full Depth

Free water was encountered at a depth of 8' during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					24	Stiff brown (7.5YR 5/4) Sandy CLAYS, dry (FILL)
					21	Black Ash material, dry (FILL)
						—with coal, wood and gravel to 2'
					20	
5						—with a clay lense at 5'
					10	—damp at 5.8'
						—wet at 6'
					11	
10					18	—with black and white lime waste at 10'
						Soft brown (7.5YR 5/4) CLAYS, wet (FILL)
					20	White Lime, black ash and fiberous geotextile fabric (5Y 8/1) (FILL)
					16	—damp at 12'
15						Stiff yellowish red (5YR 5/8) CLAYS, damp to dry (CH)

Bottom of boring at 16'.
Drilled to 14' and pushed a split spoon from 14'- 16'
Borehole grouted to full depth.

Soil sample retained for lab analysis from 12'- 14'.

Unified Soil Classifications based on visual observations.

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LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

4 9 0524

BORING: BSB1
FILE: 90B449C-3F
DATE: 8/13/92
TECHNICIAN: J. Davis
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: Full Depth

No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		1.5			24	Medium yellowish red (5YR 4/6) Silty CLAYS, dry (FILL)
		1.5			20	—with wood and rocks, 0.5'- 2'
5		1.5			10	
		1.5			14	Medium to stiff dark red (10R 3/6) CLAYS (CL)
		2.0			21	—with gypsum-like nodules, 6'- 8'
10						Bottom of boring at 10'. Borehole grouted full depth.

Soil sample retained for lab analysis from 8'- 10'.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT:	RI/FS Phase III	BORING:	BSB2
LOCATION:	Olin Chemicals McIntosh, Alabama	FILE:	90B449C-3F
		DATE:	8/13/92
		TECHNICIAN:	J. Davis
CLIENT:	Olin Chemical Corporation Charleston, Tennessee	APPROVED:	VP.
		PAGE:	1 of 1

Hollow-stem Augered: **Full Depth**

No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0					16	Stiff yellowish red (5YR 4/6) Silty CLAYS, damp (FILL)
					10	—with rocks, shells and wood, 0.5'- 2' —dry below 2'
					24	
5					20	
					17	Very stiff dark red (10R 3/6) CLAYS, dry (CL)
10						Bottom of boring at 10'. Borehole grouted full depth.

Soil sample retained for lab analysis from 8'- 10'.

Unified Soil Classifications based on visual observations.

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4 9 0525

Project Notes

Subject: OLIN MCINTOSH

AMW Date: 9/28/93

Checked By: VAB Date: 9/28/93

Project Name: OLIN

Project No.: 90B4K/SC

Task No.: 6 File No.: —

Sheet 1 of 4

OBJECTIVE: To compute the estimated infiltration rate from precipitation to specified depth at an area adjacent to the CPC Plant Area

References: 1. HELP Model

2. Calculations for CPC Plant (HELP Model Output)

Parameters: 1. Vertical Percolation Layer

2. Bare Ground

3. Depth is 11' = 132 in. Not Compacted

4. Soil Type 12

Output: The percolation from the layer is 3.19 in/yr (average) which is comparable to the CPC Plant area percolation of 3.218 in/yr (From 1/93 Calculations)

****
****

CPC PLANT EXTENSION
OLIN MCINTOSH
9-28-93

****
****

BARE GROUND

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	132.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3418 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3418 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000042000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	95.00
TOTAL AREA OF COVER	=	14500. SQ FT
EVAPORATIVE ZONE DEPTH	=	10.00 INCHES
UPPER LIMIT VEG. STORAGE	=	4.7100 INCHES
INITIAL VEG. STORAGE	=	2.3442 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	45.1176 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND

3/4

SOLAR RADIATION FOR MOBILE ALABAMA

4 9 0526

MAXIMUM LEAF AREA INDEX = 0.00
START OF GROWING SEASON (JULIAN DATE) = 49
END OF GROWING SEASON (JULIAN DATE) = 359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

****

AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.055	1.235	1.080	4.311	1.764	1.889
	3.518	3.617	5.114	0.490	0.632	2.950
STD. DEVIATIONS	1.607	1.030	1.555	3.600	1.075	1.648
	2.403	1.416	3.739	0.839	0.306	1.296
EVAPOTRANSPIRATION						
TOTALS	2.231	2.351	2.072	2.956	3.201	3.401
	4.801	4.649	3.902	1.350	1.017	2.445
STD. DEVIATIONS	0.580	0.763	1.144	1.516	0.801	1.271
	1.643	1.501	1.465	1.000	0.563	0.413
PERCOLATION FROM LAYER 1						
TOTALS	0.2889	0.2630	0.3249	0.2994	0.2965	0.2546
	0.2468	0.2401	0.2579	0.2561	0.2251	0.2446
STD. DEVIATIONS	0.1074	0.0837	0.0987	0.0947	0.0980	0.0756
	0.0602	0.0647	0.0836	0.0976	0.0746	0.0688

****

****

AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	78907.	100.00
RUNOFF	27.655	(5.283)	33417.	42.35
EVAPOTRANSPIRATION	34.376	(4.115)	41538.	52.64
PERCOLATION FROM LAYER 1	3.1980	(0.8041)	3864.	4.90
CHANGE IN WATER STORAGE	0.072	(1.577)	88.	0.11

****

****

PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	7262.1
RUNOFF	4.957	5990.2
PERCOLATION FROM LAYER 1	0.0152	18.3
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4298

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2083

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	45.21	0.3425
SNOW WATER	0.00	

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OLIN MCINTOSH
LIME POND 1 AND STRONG BRINE POND
JANUARY 28,1993

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BARE GROUND

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	72.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3418 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3418 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000042000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	95.00
TOTAL AREA OF COVER	=	113750. SQ FT
EVAPORATIVE ZONE DEPTH	=	10.00 INCHES
UPPER LIMIT VEG. STORAGE	=	4.7100 INCHES
INITIAL VEG. STORAGE	=	3.9041 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	24.6096 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	49
END OF GROWING SEASON (JULIAN DATE)	=	359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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MONTHLY TOTALS FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	9.77	3.67	5.60	6.37	3.40	4.77
	3.97	9.94	4.48	2.52	0.84	6.71
RUNOFF (INCHES)	5.157	1.094	2.056	4.185	1.243	1.685
	1.405	4.479	1.393	0.565	0.046	2.064
EVAPOTRANSPIRATION	2.944	3.022	3.534	2.687	1.920	2.748
(INCHES)	3.018	4.874	3.483	1.127	1.693	1.730
PERCOLATION FROM	0.4181	0.8033	0.5987	0.4190	0.3332	0.2536
LAYER 1 (INCHES)	0.2155	0.1823	0.1533	0.1396	0.1207	0.1664

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ANNUAL TOTALS FOR YEAR 1

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	62.04	588087.	100.00
RUNOFF	25.371	240497.	40.89
EVAPOTRANSPIRATION	32.781	310741.	52.84
PERCOLATION FROM LAYER 1	3.8037	36056.	6.13
CHANGE IN WATER STORAGE	0.084	793.	0.13
SOIL WATER AT START OF YEAR	25.85	245049.	
SOIL WATER AT END OF YEAR	25.93	245841.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
NNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.38	8.49	11.86	3.56	3.93	4.49
	6.82	4.79	4.47	4.55	6.26	5.10
RUNOFF (INCHES)	0.039	3.973	6.892	2.170	1.007	1.194
	1.714	1.165	1.898	2.181	2.457	1.381
EVAPOTRANSPIRATION	2.652	2.506	4.763	1.301	2.848	3.125
(INCHES)	5.048	2.922	3.425	2.155	2.626	3.047
PERCOLATION FROM	0.3766	0.2815	0.6969	0.6829	0.4539	0.3219
LAYER 1 (INCHES)	0.2618	0.2149	0.1778	0.1646	0.1607	0.1790

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ANNUAL TOTALS FOR YEAR 2

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	65.70	622781.	100.00
RUNOFF	26.072	247144.	39.68
EVAPOTRANSPIRATION	36.417	345203.	55.43
PERCOLATION FROM LAYER 1	3.9725	37656.	6.05
CHANGE IN WATER STORAGE	-0.762	-7222.	-1.16
SOIL WATER AT START OF YEAR	25.93	245841.	
SOIL WATER AT END OF YEAR	25.17	238619.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 3

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION (INCHES)	4.86	6.18	2.67	3.20	2.42	8.28
	10.14	6.23	8.61	3.13	2.02	5.88
RUNOFF (INCHES)	2.434	2.792	0.934	0.802	0.702	3.092
	4.012	2.253	3.801	1.779	0.440	2.573
EVAPOTRANSPIRATION	3.019	1.194	3.341	1.967	2.133	4.955
(INCHES)	5.905	3.928	4.819	1.351	1.480	1.627
PERCOLATION FROM	0.3096	0.2863	0.3784	0.2876	0.2390	0.1930
LAYER 1 (INCHES)	0.1919	0.1887	0.1745	0.1651	0.1401	0.1288

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ANNUAL TOTALS FOR YEAR 3

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	63.62	603064.	100.00
RUNOFF	25.614	242801.	40.26
EVAPOTRANSPIRATION	35.718	338574.	56.14
PERCOLATION FROM LAYER 1	2.6830	25432.	4.22
CHANGE IN WATER STORAGE	-0.395	-3743.	-0.62
SOIL WATER AT START OF YEAR	25.17	238619.	
SOIL WATER AT END OF YEAR	24.78	234877.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	6.24	5.22	6.61	6.70	1.18	4.96
	5.34	5.10	3.23	2.94	3.33	6.12
RUNOFF (INCHES)	3.336	0.773	2.265	3.890	0.030	1.315
	1.474	1.224	1.383	0.935	0.489	2.254
EVAPOTRANSPIRATION	2.904	3.189	4.189	3.824	0.912	3.561

(INCHES)	4.103	3.153	2.457	1.779	2.475	2.170
PERCOLATION FROM	0.2490	0.2919	0.3167	0.2954	0.2469	0.2020
LAYER 1 (INCHES)	0.1941	0.1665	0.1412	0.1298	0.1130	0.1723

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ANNUAL TOTALS FOR YEAR 4

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	56.97	540028.	100.00
RUNOFF	19.369	183600.	34.00
EVAPOTRANSPIRATION	34.716	329076.	60.94
PERCOLATION FROM LAYER 1	2.5187	23875.	4.42
CHANGE IN WATER STORAGE	0.367	3476.	0.64
SOIL WATER AT START OF YEAR	24.78	234877.	
SOIL WATER AT END OF YEAR	25.14	238353.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	5.39	2.26	12.97	6.67	4.22	2.39
	4.24	4.68	6.85	3.16	5.11	10.13
RUNOFF (INCHES)	2.742	0.497	6.610	4.510	1.145	0.232
	1.776	1.265	3.889	0.560	1.026	6.288
EVAPOTRANSPIRATION	2.760	1.352	3.959	3.228	2.749	2.046
(INCHES)	1.732	3.453	3.496	2.684	2.686	2.583
PERCOLATION FROM	0.3757	0.3766	0.5316	0.6580	0.4437	0.3165
AYER 1 (INCHES)	0.2583	0.2164	0.1921	0.1762	0.1712	0.5182

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ANNUAL TOTALS FOR YEAR 5

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	68.07	645247.	100.00
RUNOFF	30.541	289500.	44.87
EVAPOTRANSPIRATION	32.729	310246.	48.08
PERCOLATION FROM LAYER 1	4.2343	40138.	6.22
CHANGE IN WATER STORAGE	0.566	5362.	0.83
SOIL WATER AT START OF YEAR	25.14	238353.	
SOIL WATER AT END OF YEAR	25.71	243715.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	5.53	5.16	7.94	5.30	3.03	4.98
	6.10	6.15	5.53	3.26	3.51	6.79
STD. DEVIATIONS	3.01	2.39	4.35	1.76	1.24	2.11
	2.52	2.21	2.16	0.77	2.21	1.96
RUNOFF						
TOTALS	2.742	1.826	3.751	3.11	0.825	1.504
	2.076	2.077	2.473	1.204	0.892	2.912
STD. DEVIATIONS	1.843	1.496	2.787	1.576	0.489	1.037
	1.094	1.416	1.270	0.739	0.942	1.937
EVAPOTRANSPIRATION						
TOTALS	2.856	2.253	3.957	2.602	2.112	3.287
	3.961	3.666	3.536	1.819	2.192	2.231
STD. DEVIATIONS	0.148	0.931	0.562	0.999	0.779	1.085
	1.646	0.773	0.841	0.624	0.563	0.594
PERCOLATION FROM LAYER 1						

TOTALS	0.3430	0.3039	0.4103	0.3383	0.3149	0.2381
	0.2229	0.2178	0.2658	0.2493	0.2006	0.2398
STD. DEVIATIONS	0.1327	0.0902	0.1675	0.1268	0.1456	0.0854
	0.0580	0.0752	0.1268	0.1331	0.0839	0.0842

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	272092.	100.00
RUNOFF	27.677	(5.291)	115321.	42.38
EVAPOTRANSPIRATION	34.317	(4.062)	142988.	52.55
PERCOLATION FROM LAYER 1	3.3447	(0.9297)	13936.	5.12
CHANGE IN WATER STORAGE	-0.037	(1.245)	-154.	-0.06

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	25041.7
RUNOFF	4.957	20656.0
PERCOLATION FROM LAYER 1	0.0230	95.6
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4299

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2083

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	24.20	0.3361
SNOW WATER	0.00	

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OLIN MCINTOSH
LIME POND 2
JANUARY 28,1993

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BARE GROUND

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3418 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3418 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000042000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	95.00
TOTAL AREA OF COVER	=	40000. SQ FT
EVAPORATIVE ZONE DEPTH	=	10.00 INCHES
UPPER LIMIT VEG. STORAGE	=	2.8260 INCHES
INITIAL VEG. STORAGE	=	1.2579 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	2.0508 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	49
END OF GROWING SEASON (JULIAN DATE)	=	359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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MONTHLY TOTALS FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.75	5.62	2.32	1.64	2.67	9.63
	7.42	7.93	7.18	1.00	2.80	7.26
RUNOFF (INCHES)	0.151	1.707	0.719	0.279	0.530	4.937
	2.476	3.028	4.049	0.240	0.939	4.000
EVAPOTRANSPIRATION (INCHES)	1.111	2.429	1.868	0.675	2.520	4.460
	4.559	4.802	3.071	0.679	0.743	2.557
PERCOLATION FROM LAYER 1 (INCHES)	0.0004	1.1745	0.2360	0.0057	0.2447	0.5842
	0.2067	0.2639	0.0206	0.0000	0.3402	1.6127

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ANNUAL TOTALS FOR YEAR 1

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	57.22	190733.	100.00
RUNOFF	23.057	76856.	40.29
EVAPOTRANSPIRATION	29.474	98245.	51.51
PERCOLATION FROM LAYER 1	4.6896	15632.	8.20
CHANGE IN WATER STORAGE	0.000	0.	0.00
SOIL WATER AT START OF YEAR	1.26	4197.	
SOIL WATER AT END OF YEAR	1.26	4197.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.79	1.18	1.79	10.04	5.93	6.31
	5.16	9.72	7.49	4.06	2.15	8.12
RUNOFF (INCHES)	0.426	0.067	0.104	5.952	3.213	2.645
	1.891	4.087	3.836	2.021	0.541	4.736
EVAPOTRANSPIRATION (INCHES)	2.133	1.354	0.634	3.616	3.551	2.131
	4.073	3.843	2.561	2.105	1.382	2.770
PERCOLATION FROM LAYER 1 (INCHES)	0.0010	0.0000	0.0000	0.3176	0.3630	0.4315
	0.3215	1.7722	0.2712	0.7600	0.0000	0.2083

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ANNUAL TOTALS FOR YEAR 2

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	64.74	215800.	100.00
RUNOFF	29.519	98398.	45.60
EVAPOTRANSPIRATION	30.153	100511.	46.58
PERCOLATION FROM LAYER 1	4.4464	14821.	6.87
CHANGE IN WATER STORAGE	0.621	2070.	0.96
SOIL WATER AT START OF YEAR	1.26	4197.	
SOIL WATER AT END OF YEAR	1.88	6267.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 3

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION (INCHES)	3.67	6.98	2.51	14.76	2.82	5.06
	14.26	7.37	15.26	0.09	1.71	5.92
RUNOFF (INCHES)	0.795	2.196	0.626	8.784	1.127	1.164
	7.608	3.062	8.796	0.000	0.254	2.456
EVAPOTRANSPIRATION (INCHES)	2.658	2.648	2.241	3.753	1.734	4.509
	5.283	4.177	5.416	0.077	0.330	2.235
PERCOLATION FROM LAYER 1 (INCHES)	0.2487	1.8847	0.4946	1.1643	0.1420	0.2292
	0.8411	0.1350	1.6076	0.0000	0.2653	1.4730

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ANNUAL TOTALS FOR YEAR 3

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	80.41	268033.	100.00
RUNOFF	36.868	122893.	45.85
EVAPOTRANSPIRATION	35.061	116872.	43.60
PERCOLATION FROM LAYER 1	8.4855	28285.	10.55
CHANGE IN WATER STORAGE	-0.005	-16.	-0.01
SOIL WATER AT START OF YEAR	1.88	6267.	
SOIL WATER AT END OF YEAR	1.88	6250.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.80	1.94	7.77	3.33	4.99	2.66
	4.05	6.43	13.32	0.55	2.39	7.23
RUNOFF (INCHES)	0.114	0.256	4.027	1.061	1.955	0.728
	1.978	2.689	9.528	0.004	1.127	2.774
EVAPOTRANSPIRATION	2.187	1.730	2.623	1.408	3.640	2.029

(INCHES)	1.707	2.466	3.852	0.542	1.191	2.032
PERCOLATION FROM	0.0798	0.0002	1.1097	0.0000	0.0006	0.0000
LAYER 1 (INCHES)	0.3711	0.2967	1.0758	0.0000	0.0083	1.5138

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ANNUAL TOTALS FOR YEAR 4

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	56.46	188200.	100.00
RUNOFF	26.240	87466.	46.48
EVAPOTRANSPIRATION	25.407	84689.	45.00
PERCOLATION FROM LAYER 1	4.4561	14854.	7.89
CHANGE IN WATER STORAGE	0.357	1191.	0.63
SOIL WATER AT START OF YEAR	1.88	6250.	
SOIL WATER AT END OF YEAR	2.23	7442.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	5.98	6.14	1.10	10.39	5.51	4.51
	10.00	13.34	2.28	2.07	2.99	3.37
RUNOFF (INCHES)	3.970	1.973	0.358	6.559	2.704	0.816
	4.633	6.104	0.484	0.298	0.685	1.393
EVAPOTRANSPIRATION	1.659	2.960	0.618	3.879	2.712	2.853
(INCHES)	5.451	6.760	1.614	1.748	1.545	1.701
PERCOLATION FROM	0.7842	1.3559	0.0000	0.4775	0.0936	0.0161
LAYER 1 (INCHES)	0.7261	0.3498	0.0004	0.0000	0.1479	0.4240

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ANNUAL TOTALS FOR YEAR 5

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	67.68	225600.	100.00
RUNOFF	29.977	99924.	44.29
EVAPOTRANSPIRATION	33.501	111670.	49.50
PERCOLATION FROM LAYER 1	4.3755	14585.	6.47
CHANGE IN WATER STORAGE	-0.174	-579.	-0.26
SOIL WATER AT START OF YEAR	2.23	7442.	
SOIL WATER AT END OF YEAR	2.06	6862.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.091	1.240	1.167	4.527	1.906	2.058
	3.717	3.794	5.339	0.512	0.709	3.072
STD. DEVIATIONS	1.632	1.002	1.617	3.686	1.101	1.785
	2.443	1.393	3.774	0.854	0.341	1.315
EVAPOTRANSPIRATION						
TOTALS	1.950	2.224	1.597	2.666	2.831	3.197
	4.214	4.410	3.303	1.030	1.038	2.259
STD. DEVIATIONS	0.587	0.664	0.926	1.509	0.788	1.218
	1.508	1.568	1.434	0.858	0.497	0.422
PERCOLATION FROM LAYER 1						

TOTALS	0.2228	0.8831	0.3681	0.3930	0.1688	0.2522
	0.4933	0.5635	0.5951	0.1520	0.1524	1.0464
STD. DEVIATIONS	0.3298	0.8472	0.4622	0.4775	0.1398	0.2561
	0.2747	0.6803	0.7150	0.3399	0.1517	0.6729

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	217673.	100.00
RUNOFF	29.132	(5.147)	97107.	44.61
EVAPOTRANSPIRATION	30.719	(3.765)	102397.	47.04
PERCOLATION FROM LAYER 1	5.2906	(1.7899)	17635.	8.10
CHANGE IN WATER STORAGE	0.160	(0.322)	533.	0.24

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	20033.3
RUNOFF	5.024	16745.5
PERCOLATION FROM LAYER 1	0.3890	1296.7
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4379

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2039

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	2.06	0.3431
SNOW WATER	0.00	

FILE: SCEN3.OUT

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OLIN MCINTOSH
CPC PLANT AREA
JANUARY 28, 1993

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BARE GROUND

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	132.00 INCHES
POROSITY	=	0.4710 VOL/VOL
FIELD CAPACITY	=	0.3418 VOL/VOL
WILTING POINT	=	0.2099 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.3418 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000042000000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	95.00
TOTAL AREA OF COVER	=	105000. SQ FT
EVAPORATIVE ZONE DEPTH	=	10.00 INCHES
UPPER LIMIT VEG. STORAGE	=	4.7100 INCHES
INITIAL VEG. STORAGE	=	2.3631 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	45.1176 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX	=	0.00
START OF GROWING SEASON (JULIAN DATE)	=	49
END OF GROWING SEASON (JULIAN DATE)	=	359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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MONTHLY TOTALS FOR YEAR 1

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.75	5.62	2.32	1.64	2.67	9.63
	7.42	7.93	7.18	1.00	2.80	7.26
RUNOFF (INCHES)	0.128	1.730	0.612	0.225	0.438	4.561
	2.348	2.650	3.784	0.216	0.786	3.961
EVAPOTRANSPIRATION (INCHES)	1.363	2.426	2.470	1.174	2.571	4.633
	5.399	4.974	3.588	1.074	0.629	2.800
PERCOLATION FROM LAYER 1 (INCHES)	0.2142	0.1798	0.2370	0.2106	0.1993	0.1796
	0.1983	0.1835	0.1646	0.1586	0.1436	0.2177

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ANNUAL TOTALS FOR YEAR 1

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	57.22	500675.	100.00
RUNOFF	21.439	187588.	37.47
EVAPOTRANSPIRATION	33.102	289639.	57.85
PERCOLATION FROM LAYER 1	2.2869	20010.	4.00
CHANGE IN WATER STORAGE	0.393	3437.	0.69
SOIL WATER AT START OF YEAR	44.88	392671.	
SOIL WATER AT END OF YEAR	45.27	396108.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 2

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	2.79 5.16	1.18 9.72	1.79 7.49	10.04 4.06	5.93 2.15	6.31 8.12
RUNOFF (INCHES)	0.412 1.709	0.062 4.145	0.064 3.487	5.604 1.976	3.073 0.521	2.383 4.522
EVAPOTRANSPIRATION (INCHES)	2.411 4.726	1.317 3.913	0.642 3.635	3.864 2.287	4.318 1.792	2.495 2.921
PERCOLATION FROM LAYER 1 (INCHES)	0.2527 0.1732	0.2078 0.1824	0.2104 0.2317	0.1871 0.2185	0.1913 0.2098	0.1730 0.1996

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ANNUAL TOTALS FOR YEAR 2

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	64.74	566475.	100.00
RUNOFF	27.958	244637.	43.19
EVAPOTRANSPIRATION	34.321	300311.	53.01
PERCOLATION FROM LAYER 1	2.4375	21328.	3.77
CHANGE IN WATER STORAGE	0.023	199.	0.04
SOIL WATER AT START OF YEAR	45.27	396108.	
SOIL WATER AT END OF YEAR	45.29	396307.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 3

JAN/JUL FEB/AUG MAR/SEP APR/OCT MAY/NOV JUN/DEC

PRECIPITATION (INCHES)	3.67	6.98	2.51	14.76	2.82	5.06
	14.26	7.37	15.26	0.09	1.71	5.92
RUNOFF (INCHES)	0.722	2.299	0.592	8.617	0.959	1.117
	7.466	2.971	8.463	0.000	0.213	2.370
EVAPOTRANSPIRATION (INCHES)	2.655	2.647	2.920	3.762	2.378	4.909
	5.174	4.942	5.828	0.340	0.333	2.250
PERCOLATION FROM LAYER 1 (INCHES)	0.1915	0.2279	0.3876	0.3636	0.4148	0.3448
	0.3173	0.3390	0.3932	0.4184	0.3462	0.3588

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ANNUAL TOTALS FOR YEAR 3

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	80.41	703588.	100.00
RUNOFF	35.789	313150.	44.51
EVAPOTRANSPIRATION	38.139	333713.	47.43
PERCOLATION FROM LAYER 1	4.1031	35902.	5.10
CHANGE IN WATER STORAGE	2.380	20821.	2.96
SOIL WATER AT START OF YEAR	45.29	396307.	
SOIL WATER AT END OF YEAR	47.67	417128.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 4

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	1.80	1.94	7.77	3.33	4.99	2.66
	4.05	6.43	13.32	0.55	2.39	7.23
RUNOFF (INCHES)	0.104	0.201	3.832	0.929	1.893	0.618
	1.941	2.457	9.404	0.001	1.035	2.628
EVAPOTRANSPIRATION	2.601	1.916	3.234	1.494	3.674	2.199

(INCHES)	2.128	2.672	4.589	0.547	1.113	2.023
PERCOLATION FROM LAYER 1 (INCHES)	0.4553 0.2611	0.3661 0.2351	0.3696 0.2635	0.3725 0.2639	0.3328 0.2300	0.2833 0.2618

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ANNUAL TOTALS FOR YEAR 4

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	56.46	494025.	100.00
RUNOFF	25.041	219106.	44.35
EVAPOTRANSPIRATION	28.190	246659.	49.93
PERCOLATION FROM LAYER 1	3.6950	32332.	6.54
CHANGE IN WATER STORAGE	-0.465	-4072.	-0.82
SOIL WATER AT START OF YEAR	47.67	417128.	
SOIL WATER AT END OF YEAR	47.21	413056.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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MONTHLY TOTALS FOR YEAR 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION (INCHES)	5.98 10.00	6.14 13.34	1.10 2.28	10.39 2.07	5.51 2.99	4.51 3.37
RUNOFF (INCHES)	3.896 4.135	1.902 5.863	0.300 0.428	6.181 0.276	2.452 0.608	0.798 1.319
EVAPOTRANSPIRATION (INCHES)	2.246 6.574	3.300 6.739	1.095 2.205	4.528 1.793	3.061 1.545	2.682 2.066
PERCOLATION FROM LAYER 1 (INCHES)	0.3393 0.2938	0.3425 0.2696	0.4347 0.2438	0.3753 0.2280	0.3524 0.2013	0.2980 0.1912

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ANNUAL TOTALS FOR YEAR 5

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	67.68	592200.	100.00
RUNOFF	28.159	246391.	41.61
EVAPOTRANSPIRATION	37.834	331047.	55.90
PERCOLATION FROM LAYER 1	3.5700	31237.	5.27
CHANGE IN WATER STORAGE	-1.883	-16476.	-2.78
SOIL WATER AT START OF YEAR	47.21	413056.	
SOIL WATER AT END OF YEAR	45.32	396580.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.052	1.239	1.080	4.311	1.763	1.896
	3.520	3.617	5.113	0.494	0.632	2.960
STD. DEVIATIONS	1.609	1.033	1.555	3.600	1.074	1.642
	2.403	1.416	3.741	0.838	0.306	1.284
EVAPOTRANSPIRATION						
TOTALS	2.255	2.321	2.072	2.964	3.201	3.384
	4.800	4.648	3.969	1.208	1.082	2.412
STD. DEVIATIONS	0.524	0.750	1.143	1.521	0.801	1.282
	1.642	1.501	1.342	0.824	0.610	0.420
PERCOLATION FROM LAYER 1						

TOTALS	0.2906	0.2648	0.3279	0.3018	0.2981	0.2558
	0.2488	0.2419	0.2594	0.2575	0.2262	0.2458
STD. DEVIATIONS	0.1079	0.0839	0.0985	0.0945	0.0987	0.0760
	0.0615	0.0656	0.0835	0.0976	0.0744	0.0688

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	571392.	100.00
RUNOFF	27.677	(5.291)	242175.	42.38
EVAPOTRANSPIRATION	34.317	(4.062)	300274.	52.55
PERCOLATION FROM LAYER 1	3.2185	(0.8079)	28162.	4.93
CHANGE IN WATER STORAGE	0.089	(1.544)	782.	0.14

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	52587.5
RUNOFF	4.957	43377.6
PERCOLATION FROM LAYER 1	0.0153	133.5
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4299

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.2083

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	45.32	0.3434
SNOW WATER	0.00	

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OLIN MCINTOSH
CPC LANDFILL
2/2/93

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.3325 VOL/VOL
FIELD CAPACITY	=	0.2173 VOL/VOL
WILTING POINT	=	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2173 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000017999999 CM/SEC

LAYER 2

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4219 VOL/VOL
FIELD CAPACITY	=	0.3412 VOL/VOL
WILTING POINT	=	0.2505 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4219 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000001250000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	85.56
TOTAL AREA OF COVER	=	120000. SQ FT
EVAPORATIVE ZONE DEPTH	=	22.00 INCHES
UPPER LIMIT VEG. STORAGE	=	1.9950 INCHES
INITIAL VEG. STORAGE	=	0.8158 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	11.4294 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 49
END OF GROWING SEASON (JULIAN DATE) = 359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.247	1.658	1.413	5.078	2.295	2.106
	4.062	4.215	6.084	0.604	0.873	3.823
STD. DEVIATIONS	1.757	1.382	1.884	4.061	1.242	1.959
	2.523	1.644	4.253	0.998	0.444	1.573
EVAPOTRANSPIRATION						
TOTALS	1.763	2.225	1.660	2.621	2.310	3.298
	4.178	4.387	2.949	1.145	1.047	1.862
STD. DEVIATIONS	0.464	0.651	0.721	1.204	0.549	1.156
	1.445	1.341	1.319	0.992	0.320	0.208
PERCOLATION FROM LAYER 2						
TOTALS	0.2087	0.4673	0.2328	0.1622	0.0015	0.0726
	0.1478	0.1761	0.1714	0.0043	0.0645	0.5613
STD. DEVIATIONS	0.1700	0.5283	0.2410	0.2434	0.0033	0.1085
	0.1753	0.2176	0.2061	0.0096	0.0760	0.4785

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)	PERCENT

PRECIPITATION	65.30	(9.718)	653020.	100.00
RUNOFF	33.458	(5.797)	334579.	51.24
VAPOTRANSPIRATION	29.446	(3.835)	294456.	45.09
PERCOLATION FROM LAYER 2	2.2704	(1.2094)	22704.	3.48
CHANGE IN WATER STORAGE	0.128	(0.302)	1281.	0.20

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	60100.0
RUNOFF	5.505	55045.2
PERCOLATION FROM LAYER 2	0.0527	527.3
HEAD ON LAYER 2	6.0	
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3325

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1312

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.46	0.2429
2	10.13	0.4219
SNOW WATER	0.00	

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Woodward-Clyde Consultants

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Project Notes

Subject: OLIN McINTOSH

AMS Date: 01/28/93

Checked By: WAB Date: 5/5/93

Project Name: OLIN

Project No.: 90B449C

Task No.: 6 File No.:

Sheet 1 of 2

OBJECTIVE: TO COMPUTE AN ESTIMATED INFILTRATION RATE FROM PRECIPITATION AT THE CPC LANDFILL

REFERENCES: HELP MODEL VERSION 20
BORING LOGS

ASSUMPTIONS/PARAMETERS: 1. CPC LANDFILL HAS 2 LAYERS

LAYER 1 6" SOIL TYPE 10
LAYER 2 24" SOIL TYPE 14

2. FAIR GRASS

3. AREA = 110,000

4 COMPACTED

OUTPUT: 5 YEARLY VALUES AND AVERAGE

YEAR	INFILT. in/yr
1	2.0654
2	0.9224
3	4.2523
4	2.1405
5	2.0338
AV.	2.2829

Woodward-Clyde Consultants

Project Notes

Subject: OLIN-McINTOSH OU-1 Soils

Project Name: OLIN

Project No.: 90B449C

Task No.: 6 File No.:

Sheet 2 of 2

AMS Date:

Checked By: WAB Date: 5/15/93

OBJECTIVE: To Evaluate the efficiency of the proposed cover system for OU-1 Soils (CPC Landfill) using the HELP MODEL

References: 1. Draft F.S. Report, specifically section 4.0, Figures 4-8 & 4-7
2. HELP MODEL

Assumptions: 1. Synthetic Climate data for Mobile Ala.
2. Area = 120,000

Parameters:

1. Multimedia System is As follows

Layer
1 (1' Topsoil (Soil Type 8, Loam) ~ Percol
2 (1' Soil (Soil Type 10, SiCl) ~ Percol
3 Drainage Layer (1/4" thick) Type 1 ~ Drainage
4 Impermeable Liner
2' Clay (Soil Type 16, Liner Soil) ~ Barrier
Waste 30' (Soil Type 10, Sandy Clay)

2. Clay Cover System As follows.

1' Topsoil (8) ~ Percol
2' Clay (16) ~ Barrier

3. Slope length 250'
% Slope Drainage = 25%

Results

Multimedia Cap - 0.0356 in/yr from base of Clay

Clay Cap - 0.0433 in/yr from base of Clay

FILE CPC LAN10

4 9 0540

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OLIN MCINTOSH
CPC LANDFILL
2/2/93

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FAIR GRASS

LAYER 1 - 10 COMPACTED

VERTICAL PERCOLATION LAYER

THICKNESS	=	6.00 INCHES
POROSITY	=	0.3325 VOL/VOL
FIELD CAPACITY	=	0.2173 VOL/VOL
WILTING POINT	=	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2173 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000017999999 CM/SEC

LAYER 2 - 14 COMPACTED

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4219 VOL/VOL
FIELD CAPACITY	=	0.3412 VOL/VOL
WILTING POINT	=	0.2505 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4219 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000001250000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	85.56
TOTAL AREA OF COVER	=	110000. SQ FT
EVAPORATIVE ZONE DEPTH	=	22.00 INCHES
UPPER LIMIT VEG. STORAGE	=	1.9950 INCHES
INITIAL VEG. STORAGE	=	0.8159 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	11.4294 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

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SOLAR RADIATION FOR MOBILE ALABAMA

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END OF GROWING SEASON (JULIAN DATE) = 359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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ANNUAL TOTALS FOR YEAR 1

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	57.22	524517.	100.00
RUNOFF	26.663	244414.	46.60
EVAPOTRANSPIRATION	28.491	261170.	49.79
PERCOLATION FROM LAYER 2	2.0654	18933.	3.61
CHANGE IN WATER STORAGE	0.000	0.	0.00
SOIL WATER AT START OF YEAR	10.94	100303.	
SOIL WATER AT END OF YEAR	10.94	100303.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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ANNUAL TOTALS FOR YEAR 2

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	64.74	593450.	100.00
RUNOFF	33.664	308585.	52.00
EVAPOTRANSPIRATION	29.704	272288.	45.88
PERCOLATION FROM LAYER 2	0.9224	8456.	1.42
CHANGE IN WATER STORAGE	0.450	4121.	0.69
SOIL WATER AT START OF YEAR	10.94	100303.	
SOIL WATER AT END OF YEAR	11.39	104425.	

SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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ANNUAL TOTALS FOR YEAR 3

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	80.41	737092.	100.00
RUNOFF	42.362	388319.	52.68
EVAPOTRANSPIRATION	33.546	307505.	41.72
PERCOLATION FROM LAYER 2	4.2523	38979.	5.29
CHANGE IN WATER STORAGE	0.250	2288.	0.31
SOIL WATER AT START OF YEAR	11.39	104425.	
SOIL WATER AT END OF YEAR	11.64	106713.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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ANNUAL TOTALS FOR YEAR 4

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	56.46	517550.	100.00
RUNOFF	30.508	279660.	54.04
EVAPOTRANSPIRATION	23.536	215742.	41.69
PERCOLATION FROM LAYER 2	2.1405	19621.	3.79
CHANGE IN WATER STORAGE	0.276	2526.	0.49
SOIL WATER AT START OF YEAR	11.64	106713.	
SOIL WATER AT END OF YEAR	11.92	109240.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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ANNUAL TOTALS FOR YEAR 5

	(INCHES)	(CU. FT.)	PERCENT
PRECIPITATION	67.68	620400.	100.00
RUNOFF	34.152	313063.	50.46
EVAPOTRANSPIRATION	31.828	291760.	47.03
PERCOLATION FROM LAYER 2	2.0338	18643.	3.00
CHANGE IN WATER STORAGE	-0.335	-3067.	-0.49
SOIL WATER AT START OF YEAR	11.92	109240.	
SOIL WATER AT END OF YEAR	11.58	106173.	
SNOW WATER AT START OF YEAR	0.00	0.	
SNOW WATER AT END OF YEAR	0.00	0.	
ANNUAL WATER BUDGET BALANCE	0.00	0.	0.00

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.252	1.660	1.413	5.078	2.295	2.106
	4.062	4.215	6.084	0.604	0.874	3.826
STD. DEVIATIONS	1.769	1.384	1.884	4.061	1.241	1.959
	2.523	1.644	4.253	0.998	0.444	1.572
EVAPOTRANSPIRATION						
TOTALS	1.747	2.225	1.660	2.621	2.310	3.298
	4.178	4.387	2.948	1.145	1.045	1.858
STD. DEVIATIONS	0.468	0.648	0.721	1.203	0.549	1.156
	1.445	1.341	1.319	0.992	0.321	0.208
PERCOLATION FROM LAYER 2						

TOTALS	0.2128	0.4724	0.2331	0.1624	0.0015	0.0726
	0.1478	0.1761	0.1715	0.0046	0.0647	0.5635
STD. DEVIATIONS	0.1729	0.5314	0.2414	0.2434	0.0033	0.1085
	0.1753	0.2176	0.2061	0.0102	0.0760	0.4799

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	598602.	100.00
RUNOFF	33.470	(5.802)	306808.	51.25
EVAPOTRANSPIRATION	29.421	(3.821)	269693.	45.05
PERCOLATION FROM LAYER 2	2.2829	(1.2103)	20926.	3.50
CHANGE IN WATER STORAGE	0.128	(0.304)	1174.	0.20

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	55091.7
RUNOFF	5.505	50458.1
PERCOLATION FROM LAYER 2	0.0527	483.4
HEAD ON LAYER 2	6.0	
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.3325

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1312

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	1.46	0.2428
2	10.13	0.4219
SNOW WATER	0.00	

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OLIN MCINTOSH
OU-1 SOILS (CPC LANDFILL)
MULTIMEDIA CAP

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1157 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001109999954 CM/SEC

LAYER 2

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.3325 VOL/VOL
FIELD CAPACITY	=	0.2173 VOL/VOL
WILTING POINT	=	0.1361 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2173 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000006000000 CM/SEC

LAYER 3

LATERAL DRAINAGE LAYER

THICKNESS	=	0.25 INCHES
POROSITY	=	0.4170 VOL/VOL
FIELD CAPACITY	=	0.0454 VOL/VOL
WILTING POINT	=	0.0200 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.0454 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.009999999776 CM/SEC
SLOPE	=	25.00 PERCENT
DRAINAGE LENGTH	=	250.0 FEET

LAYER 4

BARRIER SOIL LINER WITH FLEXIBLE MEMBRANE LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC
LINER LEAKAGE FRACTION	=	0.02000000

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	79.01
TOTAL AREA OF COVER	=	120000. SQ FT
EVAPORATIVE ZONE DEPTH	=	12.00 INCHES
UPPER LIMIT VEG. STORAGE	=	5.5560 INCHES
INITIAL VEG. STORAGE	=	4.2617 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	15.7229 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX = 2.00
START OF GROWING SEASON (JULIAN DATE) = 49
END OF GROWING SEASON (JULIAN DATE) = 359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	0.649	0.920	0.504	2.433	0.283	0.145
	0.828	1.191	2.695	0.010	0.008	1.095
STD. DEVIATIONS	1.174	1.226	0.909	2.767	0.346	0.218
	1.358	1.700	3.329	0.021	0.017	1.320
VAPOTRANSPIRATION						
TOTALS	2.262	2.764	2.603	4.087	5.400	4.467
	6.263	6.386	5.603	2.793	1.402	1.832

STD. DEVIATIONS	0.205	0.327	1.007	0.820	1.584	1.260
	1.632	1.934	0.621	1.191	0.716	0.203

LATERAL DRAINAGE FROM LAYER 3

TOTALS	1.0534	0.9465	0.7821	0.8352	0.6240	0.4215
	0.6280	0.8280	0.8889	0.5159	0.4245	0.8836
STD. DEVIATIONS	0.2570	0.4864	0.2168	0.3645	0.2620	0.0168
	0.1508	0.3714	0.3180	0.1017	0.1701	0.4499

PERCOLATION FROM LAYER 4

TOTALS	0.0038	0.0034	0.0036	0.0035	0.0033	0.0028
	0.0032	0.0034	0.0035	0.0032	0.0027	0.0033
STD. DEVIATIONS	0.0002	0.0003	0.0002	0.0003	0.0003	0.0003
	0.0005	0.0006	0.0002	0.0003	0.0005	0.0007

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	653020.	100.00
RUNOFF	10.758	(6.062)	107581.	16.47
EVAPOTRANSPIRATION	45.862	(4.184)	458621.	70.23
LATERAL DRAINAGE FROM LAYER 3	8.8317	(1.3529)	88317.	13.52
PERCOLATION FROM LAYER 4	0.0396	(0.0014)	396.	0.06
CHANGE IN WATER STORAGE	-0.190	(1.196)	-1895.	-0.29

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	60100.0
RUNOFF	3.944	39442.7
LATERAL DRAINAGE FROM LAYER 3	0.0605	604.9
PERCOLATION FROM LAYER 4	0.0001	1.4
HEAD ON LAYER 4	24.5	
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4630

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1110

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	3.30	0.2748
2	3.99	0.3325
3	0.10	0.4170
4	10.32	0.4300
SNOW WATER	0.00	

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ALT. E (RERUN 10-20-93)

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OLIN MCINTOSH
OU-1 SOILS CPC LANDFILL
CLAY CAP

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1157 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001109999954 CM/SEC

LAYER 2

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	79.01
TOTAL AREA OF COVER	=	120000. SQ FT
EVAPORATIVE ZONE DEPTH	=	22.00 INCHES
UPPER LIMIT VEG. STORAGE	=	5.5560 INCHES
INITIAL VEG. STORAGE	=	4.9817 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.1040 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	49
END OF GROWING SEASON (JULIAN DATE)	=	359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.149	1.840	0.930	3.569	0.329	0.261
	1.034	1.813	3.340	0.014	0.011	2.321
STD. DEVIATIONS	1.513	1.917	1.727	3.618	0.438	0.465
	1.498	2.288	3.982	0.031	0.017	2.002
EVAPOTRANSPIRATION						
TOTALS	2.245	2.755	2.597	4.137	6.023	4.675
	6.512	6.390	5.884	3.198	1.378	1.793
STD. DEVIATIONS	0.205	0.316	1.002	0.797	1.220	1.195
	1.499	1.940	0.469	1.171	0.693	0.185
PERCOLATION FROM LAYER 2						
TOTALS	0.1476	0.1328	0.1383	0.1328	0.0905	0.0200
	0.0937	0.1017	0.1231	0.0759	0.0480	0.1256
STD. DEVIATIONS	0.0055	0.0070	0.0070	0.0083	0.0360	0.0199
	0.0472	0.0631	0.0295	0.0526	0.0630	0.0314

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	653020.	100.00
RUNOFF	16.610	(7.621)	166104.	25.44
EVAPOTRANSPIRATION	47.589	(3.802)	475887.	72.87
PERCOLATION FROM LAYER 2	1.2297	(0.1567)	12297.	1.88
CHANGE IN WATER STORAGE	-0.127	(0.660)	-1268.	-0.19

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	60100.0
RUNOFF	4.247	42468.6
PERCOLATION FROM LAYER 2	0.0051	51.3
HEAD ON LAYER 2	12.3	
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4630

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1150

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	4.34	0.3616
2	10.32	0.4300
SNOW WATER	0.00	

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SANITARY LANDFILLS

PESTAN INPUT AND OUTPUT PRINTOUTS

Woodward-Clyde Consultants

4 9 0548

Project Notes

Subject: OLIN McINTOSH

By: [illegible] Date: 10/20/93

Checked By: WAB Date: 10/21/93

Project Name:

Project No.: 90B4490-6

Task No.: File No.:

Sheet 1 of 4

OBJECTIVE: To compute an estimated infiltration rate through the base of a clay cap over the area west of the OPL Plant area.

Reference: HELP Model Version 2.0 Program

Assumptions/Parameters

1. The clay cap consists of the following configuration

Topsoil, Texture 8	1' Noncompacted
Clay, Texture 16	2' Compacted

2. Area is 15,000 S.F.

3. Fair Grass Cover

Output ~ The average annual percolation rate is 1.23 in/yr

Output is attached.

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 OLIN MCINTOSH
 CPC PLANT
 CLAY CAP

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FAIR GRASS

LAYER 1

VERTICAL PERCOLATION LAYER

THICKNESS	=	12.00 INCHES
POROSITY	=	0.4630 VOL/VOL
FIELD CAPACITY	=	0.2320 VOL/VOL
WILTING POINT	=	0.1157 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.2320 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.001109999954 CM/SEC

LAYER 2

BARRIER SOIL LINER

THICKNESS	=	24.00 INCHES
POROSITY	=	0.4300 VOL/VOL
FIELD CAPACITY	=	0.3663 VOL/VOL
WILTING POINT	=	0.2802 VOL/VOL
INITIAL SOIL WATER CONTENT	=	0.4300 VOL/VOL
SATURATED HYDRAULIC CONDUCTIVITY	=	0.000000100000 CM/SEC

GENERAL SIMULATION DATA

SCS RUNOFF CURVE NUMBER	=	79.01
TOTAL AREA OF COVER	=	15000. SQ FT
EVAPORATIVE ZONE DEPTH	=	22.00 INCHES
UPPER LIMIT VEG. STORAGE	=	5.5560 INCHES
INITIAL VEG. STORAGE	=	4.9817 INCHES
INITIAL SNOW WATER CONTENT	=	0.0000 INCHES
INITIAL TOTAL WATER STORAGE IN SOIL AND WASTE LAYERS	=	13.1040 INCHES

SOIL WATER CONTENT INITIALIZED BY PROGRAM.

CLIMATOLOGICAL DATA

SYNTHETIC RAINFALL WITH SYNTHETIC DAILY TEMPERATURES AND
SOLAR RADIATION FOR MOBILE ALABAMA

MAXIMUM LEAF AREA INDEX	=	2.00
START OF GROWING SEASON (JULIAN DATE)	=	49
END OF GROWING SEASON (JULIAN DATE)	=	359

NORMAL MEAN MONTHLY TEMPERATURES, DEGREES FAHRENHEIT

JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
50.80	53.60	60.10	68.00	74.90	80.50
82.20	81.80	78.20	68.50	58.60	53.10

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AVERAGE MONTHLY VALUES IN INCHES FOR YEARS 1 THROUGH 5

	JAN/JUL	FEB/AUG	MAR/SEP	APR/OCT	MAY/NOV	JUN/DEC
PRECIPITATION						
TOTALS	3.20	4.37	3.10	8.03	4.38	5.63
	8.18	8.96	9.11	1.55	2.41	6.38
STD. DEVIATIONS	1.74	2.63	2.67	5.43	1.53	2.59
	4.09	2.73	5.21	1.58	0.51	1.86
RUNOFF						
TOTALS	1.149	1.840	0.930	3.569	0.329	0.261
	1.034	1.813	3.340	0.014	0.011	2.321
STD. DEVIATIONS	1.513	1.917	1.727	3.618	0.438	0.465
	1.498	2.288	3.982	0.031	0.017	2.002
EVAPOTRANSPIRATION						
TOTALS	2.245	2.755	2.597	4.137	6.023	4.675
	6.512	6.390	5.884	3.198	1.378	1.793
STD. DEVIATIONS	0.205	0.316	1.002	0.797	1.220	1.195
	1.499	1.940	0.469	1.171	0.693	0.185
PERCOLATION FROM LAYER 2						
TOTALS	0.1476	0.1328	0.1383	0.1328	0.0905	0.0200
	0.0937	0.1017	0.1231	0.0759	0.0480	0.1256
STD. DEVIATIONS	0.0055	0.0070	0.0070	0.0083	0.0360	0.0199
	0.0472	0.0631	0.0295	0.0526	0.0630	0.0314

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AVERAGE ANNUAL TOTALS & (STD. DEVIATIONS) FOR YEARS 1 THROUGH 5

	(INCHES)		(CU. FT.)	PERCENT
PRECIPITATION	65.30	(9.718)	81627.	100.00
RUNOFF	16.610	(7.621)	20763.	25.44
EVAPOTRANSPIRATION	47.589	(3.802)	59486.	72.87
PERCOLATION FROM LAYER 2	1.2297	(0.1567)	1537.	1.88
CHANGE IN WATER STORAGE	-0.127	(0.660)	-159.	-0.19

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PEAK DAILY VALUES FOR YEARS 1 THROUGH 5

	(INCHES)	(CU. FT.)
PRECIPITATION	6.01	7512.5
RUNOFF	4.247	5308.6
PERCOLATION FROM LAYER 2	0.0051	6.4
HEAD ON LAYER 2	12.3	
SNOW WATER	0.00	0.0

MAXIMUM VEG. SOIL WATER (VOL/VOL) 0.4630

MINIMUM VEG. SOIL WATER (VOL/VOL) 0.1150

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FINAL WATER STORAGE AT END OF YEAR 5

LAYER	(INCHES)	(VOL/VOL)
1	4.34	0.3616
2	10.32	0.4300
SNOW WATER	0.00	

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|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
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Title: LEAD FILE SLLEA01.INP

Solubility (mg/l)	0.41600E+00
Recharge rate (cm/hr).....	0.15000E-02
Sorption constant (cc/g).....	0.16800E+03
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.99700E+00
Saturated hydraulic conductivity	0.63000E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.88400E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+08

For application 1 the active ingredient (ai) applied is 0.262E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

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Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.113E-01
Pollutant velocity [cm/hr]	0.519E-05
Length of pollutant slug [cm]	0.218E+03
Mass decayed prior to recharge [kg]	0.000E+00

SANITARY LANDFILLS
OCTOBER 1993
FILE SLLEA01.BTC

DAYS	UG/L
0.100000E-29	0.000000
101010.	0.000000
202020.	0.000000
303030.	0.000000
404040.	0.000000
505051.	0.000000
606061.	0.000000
707071.	0.000000
808081.	0.000000
909091.	0.000000
0.101010E+07	0.000000
0.111111E+07	0.384331E-03
0.121212E+07	0.150013E-02
0.131313E+07	0.469875E-02
0.141414E+07	0.125093E-01
0.151515E+07	0.292215E-01
0.161616E+07	0.609722E-01
0.171717E+07	0.116911
0.181818E+07	0.208146
0.191919E+07	0.348117
0.202020E+07	0.551961
0.212121E+07	0.835857
0.222222E+07	1.21639
0.232323E+07	1.70971
0.242424E+07	2.33092
0.252525E+07	3.09328
0.262626E+07	4.00793
0.272727E+07	5.08333
0.282828E+07	6.32513
0.292929E+07	7.73604
0.303030E+07	9.31583
0.313131E+07	11.0614
0.323232E+07	12.9672
0.333333E+07	15.0250
0.343434E+07	17.2247
0.353535E+07	19.5543
0.363636E+07	22.0005
0.373737E+07	24.5489
0.383838E+07	27.1840
0.393939E+07	29.8902
0.404040E+07	32.6512
0.414141E+07	35.4512
0.424242E+07	38.2743
0.434343E+07	41.1050
0.444444E+07	43.9286
0.454545E+07	46.7310
0.464646E+07	49.4987
0.474747E+07	52.2194
0.484848E+07	54.8815
0.494949E+07	57.4747
0.505050E+07	59.9892
0.515151E+07	62.4167
0.525253E+07	64.7497
0.535354E+07	66.9815
0.545455E+07	69.1068
0.555556E+07	71.1207
0.565657E+07	73.0195
0.575758E+07	74.8004
0.585859E+07	76.4610
0.595960E+07	78.0001
0.606061E+07	79.4168
0.616162E+07	80.7110
0.626263E+07	81.8831
0.636364E+07	82.9342
0.646465E+07	83.8656
0.656566E+07	84.6793
0.666667E+07	85.3775
0.676768E+07	85.9627
0.686869E+07	86.4379
0.696970E+07	86.8061
0.707071E+07	87.0706
0.717172E+07	87.2351
0.727273E+07	87.3030
0.737374E+07	87.2782
0.747475E+07	87.1645
0.757576E+07	86.9658
0.767677E+07	86.6861
0.777778E+07	86.3293
0.787879E+07	85.8994
0.797980E+07	85.4004
0.808081E+07	84.8361
0.818182E+07	84.2104
0.828283E+07	83.5272
0.838384E+07	82.7900
0.848485E+07	82.0027
0.858586E+07	81.1687
0.868687E+07	80.2915
0.878788E+07	79.3745
0.888889E+07	78.4210
0.898990E+07	77.4340
0.909091E+07	76.4168
0.919192E+07	75.3722
0.929293E+07	74.3030
0.939394E+07	73.2120
0.949495E+07	72.1017
0.959596E+07	70.9747
0.969697E+07	69.8333
0.979798E+07	68.6797
0.989899E+07	67.5161
0.100000E+08	66.3446

```
-----------------------------------------------
|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support       |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: CHLOROBENZENE FILE SLCHB01.INP

Solubility (mg/l)	0.47170E+03
Recharge rate (cm/hr).....	0.15000E-02
Sorption constant (cc/g).....	0.18800E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.99700E+00
Saturated hydraulic conductivity	0.63000E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.88400E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.25000E+06

For application 1 the active ingredient (ai) applied is 0.239E+03 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.113E-01
Pollutant velocity [cm/hr]	0.446E-03
Length of pollutant slug [cm]	0.151E+01
Mass decayed prior to recharge [kg]	0.000E+00

SANITARY LANDFILLS
FILE SLCHB01.BTC
OCTOBER 1993

DAYS	UG/L		
0.100000E-29	0.000000	121212.	408.940
2525.25	0.000000	123737.	388.289
5050.50	0.000000	126263.	368.243
7575.76	0.000000	128788.	348.857
10101.0	0.000000	131313.	330.104
12626.3	0.140578E-01	133838.	312.096
15151.5	0.182751	136364.	294.791
17676.8	1.11056	138889.	278.189
20202.0	4.14704	141414.	262.304
22727.3	11.3306	143939.	247.149
25252.5	24.7557	146465.	232.698
27777.8	46.0813	148990.	218.921
30303.0	76.0665	151515.	205.848
32828.3	114.543	154040.	193.421
35353.5	160.455	156566.	181.640
37878.8	212.216	159091.	170.492
40404.0	267.913	161616.	159.935
42929.3	325.507	164141.	149.954
45454.5	383.130	166667.	140.521
47979.8	439.108	169192.	131.651
50505.0	491.993	171717.	123.244
53030.3	540.732	174242.	115.358
55555.6	584.493	176768.	107.935
58080.8	622.759	179293.	100.921
60606.1	655.274	181818.	94.3697
63131.3	681.928	184343.	88.1984
65656.6	702.818	186869.	82.3925
68181.8	718.133	189394.	76.9381
70707.1	728.178	191919.	71.8351
73232.3	733.330	194444.	67.0695
75757.6	→ 734.001 ✓	196970.	62.5711
78282.8	730.620	199495.	58.3819
80808.1	723.646	202020.	54.4597
83333.3	713.503	204545.	50.7766
85858.6	700.612	207071.	47.3184
88383.8	685.389	209596.	44.1132
90909.1	668.200	212121.	41.1049
93434.3	649.416	214646.	38.2933
95959.6	629.345	217172.	35.6645
98484.8	608.286	219697.	33.2185
101010.	586.490	222222.	30.9271
103535.	564.222	224747.	28.8043
106061.	541.645	227273.	26.8081
108586.	518.991	229798.	24.9385
111111.	496.372	232323.	23.2094
113636.	473.957	234848.	21.5927
116162.	451.858	237374.	20.0885
118687.	430.167	239899.	18.6828
		242424.	17.3754
		244949.	16.1524
		247475.	15.0137
		250000.	13.9734

Appendix F

APPENDIX F

POTENTIAL SOIL ACTION LEVEL REPORT

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1.0 INTRODUCTION

A potential soil action level (PSAL) report was submitted to EPA on June 5, 1993. The PSAL report documented the analysis and results of contaminant transport modeling performed to develop PSALs for the old plant (CPC) landfill and the area west of the former CPC plant. This appendix presents the technical approach, model input and output data and the results from the June 5 PSAL report.

For development of remedial alternatives in this FS report, the estimated dimensions of the area west of the former CPC plant were refined based on more accurate topographic maps than were used in the June 5, 1993 PSAL report. The PSALs were then recalculated with these updated dimensions. The calculations using the updated dimensions are presented as Attachment E of this appendix. The results of the June 5, modeling for the area west of the CPC plant are summarized on Table 5-2, which has been modified to also show the recalculated values. However, not all tables and text reflect the modification included in Attachment E.

1.1 OBJECTIVE

The objective of this analysis was to develop conservative potential soil action levels such that the concentration of leachate percolating through the soils to the groundwater would not cause exceedances of the potential applicable or relevant and appropriate requirements (ARARs) for groundwater. The Safe Drinking Water Act maximum contaminant levels (MCLs) and non-zero maximum contaminant level goals (MCLGs) have been identified as potential ARARs for groundwater at the site. In the analysis, conservative assumptions were made such that the soil action levels developed are lower than levels required to protect groundwater.

1.2 SOIL ACTION LEVEL CONSTITUENTS

Table 1-1 lists the groundwater chemicals of potential concern from the baseline risk assessment that was conducted as part of the draft RI (WCC, 1993). Potential soil

action levels were evaluated for a subset of this list, which was developed based on the relative concentrations in the soils and the fate and transport properties, as described below.

Four volatile constituents are listed as chemicals of potential concern (benzene, bromodichloromethane, chlorobenzene and chloroform). Potential soil action levels were developed for benzene and chlorobenzene. The other volatile constituents were either not detected or detected at very low concentrations (< 0.5 mg/kg) in the soil samples from the old plant (CPC) landfill area and the former CPC plant area.

Six semivolatile constituents are listed as chemicals of potential concern. Soil action levels were developed for 1,2,4-trichlorobenzene and the three dichlorobenzene isomers. The other two, pentachlorobenzene and pentachloronitrobenzene are significantly less mobile due to their lower solubility and higher Koc values. Similarly, the one pesticide constituent on the chemicals of potential concern list (alpha-BHC) has low mobility as indicated by a low solubility and high Koc, and potential soil action levels were not developed for this compound.

Mercury was the only inorganic constituent detected in the soils from the old plant (CPC) landfill area above a concentration commonly found for naturally occurring soils. Consequently, mercury was the only inorganic constituent for which a potential soil action level was developed for this area. Concentrations of inorganic constituents detected in the soil samples from the former CPC plant area were all within a range commonly found for naturally occurring soils and soil action levels for inorganic constituents were not developed for this area.

The following table summarizes the constituents for which soil action levels were developed and their respective MCLs. An MCL has not been finalized for 1,2,4-trichlorobenzene and the MCLG is listed.

2.0
TECHNICAL APPROACH

Development of potential soil action levels involved the following four steps 1) estimation of a concentration reduction factor (CRF) due to migration of potential groundwater chemicals of concern through the unsaturated zone; 2) estimation of a concentration reduction factor due to near-field mixing of constituents in the Alluvial Aquifer; 3) back-calculation of allowable leachate concentrations using the values obtained in steps 1 and 2 and the groundwater MCLs or MCLGs; and 4) estimation of potential soil action levels based on the estimated allowable leachate concentrations, chemical-specific factors and soil properties.

The general approach used is that rainwater percolating through a source (soil containing contaminants) would generate leachate by partitioning of the contaminants from the soil to the water. Soil action levels are theoretical soil concentrations at the source that would generate sufficient leachate to cause exceedances of the groundwater MCLs or MCLGs. The analyses were conducted for two source intervals in the old plant (CPC) landfill,the upper fill/waste and clay material, and the underlying unsaturated sand. The contaminated materials in the upper 14 feet (i.e., 4 to 14 feet) were considered the source for the former CPC plant area. Boring logs from old plant (CPC) landfill and former CPC plant areas are presented in Attachment A.

Two one-dimensional, publicly available contaminant transport models were used to estimate concentration reduction factors for migration through the unsaturated zone, and the results were compared. Models are useful tools to study the effect of variations in the wide range of soil and chemical properties specific to an area. Model results should be interpreted by qualified professionals familiar with site-specific factors. Using two models provided additional insight on the validity of the analyses. The models, PESTAN (CSMS, 1992) and SOLUTE (IGWMC, 1991), consider advection, longitudinal dispersion, linear adsorption and natural decay (e.g., biodegradation) through the soil column. The source concentration for SOLUTE was selected as unity and the concentration at the top of the aquifer was expressed as a fraction of the source concentration. For PESTAN, the concentration in the leachate at the source was

estimated to be the chemical-specific aqueous solubility and the model estimated the resulting concentrations at the base of the unsaturated zone.

In addition to estimating the attenuation in the unsaturated zone using the SOLUTE and PESTAN models, a mass balance equation/model was used to estimate the reduction in concentrations due to the near-field mixing of the contaminants in the Alluvial Aquifer. This analysis is equivalent to the Summers model (Summers et al., 1980).

The unsaturated zone transport analyses and near-field mixing were used in combination with the allowable concentrations in the groundwater (MCLs and MCLGs) to back-calculate the potential soil action levels. The relationships between soil and liquid concentrations were calculated from chemical-specific sorption coefficients (Kd), dimensionless Henry's Law constant (H) and soil-specific properties. Figures 2-1 and 2-2 show the conceptual approach for estimating the soil action levels for both the SOLUTE and PESTAN analyses.

Soil action levels for the unsaturated sand in the old plant (CPC) landfill area were estimated with the Summers model approach considering only near-field mixing of contaminants within the Alluvial Aquifer (i.e., no attenuation in the unsaturated zone). This is a very conservative approach and would only be applicable for the sand directly above the Alluvial Aquifer.

Details of the PESTAN and SOLUTE model analyses are described in Sections 2.1. and 2.2, respectively. The near-field mixing analysis, or Summers model, is described in Section 2.3. The calculations used to estimate soil action levels are described in Section 2.4.

2.1 SOLUTE MODEL

One-dimensional vertical transport through the unsaturated zone was simulated using the publicly available model, SOLUTE (IGWMC, 1991). This model was developed by the International Ground Water Modeling Center and is based on the van Genuchten and Alves' (1982) analytical solution to the one-dimensional transport problem. SOLUTE has the capability to simulate contaminant migration from an exponentially decreasing

finite source concentration due to one-dimensional uniform advection, longitudinal dispersion, linear reversible adsorption, and first-order decay of the chemical.

Transport simulations were conducted in the transient mode to estimate the peak concentration at the bottom of the unsaturated zone relative to the initial concentration at the source. The contaminant source consists of a finite contaminant mass in the soil that is released over time due to recharge. Thus, the source concentration reduces over time. Based on a mass balance approach similar to the continuous flushing model described by the U.S. EPA (1988), the source can be expressed as an exponentially decreasing concentration:

$$C_w(t) = C_o \exp(-\beta t) \qquad \textbf{(2-1)}$$

where:

$C_w(t)$	=	the aqueous source concentration (mg/l) at time = t (d)
C_o	=	the maximum initial source concentration (mg/l)
β	=	exponential source concentration reduction rate (d^{-1})

The derivation of the constant β is based on mass balance considerations and accounts for linear adsorption of the chemicals to soil particles and the vertical recharge rate. The expression for β is approximated by:

$$\beta = I/(\theta_w dR) + \lambda \qquad \textbf{(2-2)}$$

where:

I	=	the recharge rate (m/d)
θ_w	=	the volumetric water content of the soil (cm^3/cm^3)
d	=	the thickness of the contaminated source (m)
R	=	the chemical-specific retardation factor (unitless)
λ	=	the chemical decay rate constant [d^{-1}] (assumed zero for source decay)

The retardation factor, R, is the ratio of seepage velocity to contaminant migration velocity due to linear adsorption. For the unsaturated zone, R can be approximated as:

$$R = 1 + \frac{\rho_b K_d}{\theta_w} + \frac{(\theta - \theta_w)\, H'}{\theta_w} \qquad \textbf{(2-3)}$$

where:

ρ_b	=	the bulk density of the soil (g/cm^3)
K_d	=	the sorption coefficient ($g/g/g/cm^3$)
θ	=	saturated water content (total porosity) (cm^3/cm^3)
θ_w	=	the volumetric water content (cm^3/cm^3)
H'	=	the dimensionless Henry's Law Constant

Note when the soil is saturated, the saturated water content $\theta = \theta_w$ and Equation 2-3 reduces to:

$$R \doteq 1 + \rho_b K_d / \theta \qquad \textbf{(2.3a)}$$

For organic constituents the sorption coefficient, K_d, was estimated by using the expression provided in CSMS, 1992:

$$K_d = K_{oc} f_{oc} \qquad \textbf{(2-4)}$$

where:

K_{oc}	=	the normalized chemical-specific organic carbon partition coefficient ($g/g/g/cm^3$)
f_{oc}	=	the fractional organic carbon content of the soil (unitless)

For mercury, the sorption coefficient was estimated using the following relationship between Kd and pH provided in Loux et al. (1990):

$$Log\ K_d = 0.122 \times pH + 1.42 \qquad (2\text{-}5)$$

Using the estimated source reduction rate, β, and other necessary parameters based on site-specific data (discussed in Section 3.0) such as the vertical seepage velocity and longitudinal dispersivity, the SOLUTE program was implemented to estimate concentration over time at the base of the unsaturated zone. From these results, the peak concentration, C_1, was estimated and a concentration reduction factor (CRF_1) for transport through the unsaturated zone was defined as:

$$CRF_1 = C_o / C_1 \qquad (2\text{-}6)$$

For this (SOLUTE) analysis, the aqueous concentration at the source, C_o term was assumed to be unity so that CRF_1 could be expressed as a fraction of the source concentration.

2.2 PESTAN MODEL

The PESTAN (Pesticide Analytical) model is a computer code for estimating the transport of constituents through soil to the groundwater. The model is based on a closed-form analytical solution of the advective dispersive transport equation. The model simulates the movement of a "slug" of contaminated liquid migrating through a homogeneous soil column. Once the slug enters the soil, contaminant transport is influenced by sorption, dispersion and loss of mass by liquid-phase decay and migration out of the soil column.

The PESTAN model estimates the concentration in the liquid phase as a function of depth for a total pollutant mass of the "slug" applied per unit area (M_a). For site-specific application, the mass of the "slug" was estimated based on site-specific data. The model

assumes that the mass is distributed uniformly throughout the specified area (A) and thickness (d) at a concentration C_s. The area and thickness were estimated from the soil sampling data. The mass per unit area was then calculated for selected source concentrations using the following equation:

$$M_a = d\ \rho_b C_s \times 1 \times 10^6\ mg/kg \qquad (2\text{-}7)$$

where:

M_a	=	mass per unit area at the source (kg/m^2)
ρ_b	=	the bulk density of the soil (kg/m^3)
d	=	thickness of the contaminated source (m)
C_s	=	source concentration (mg/kg)

The PESTAN model uses the following assumptions:

- Leachate concentration equals the maximum possible concentration, i.e., aqueous solubility (a very conservative assumption).

- The slug enters the soil at the steady state velocity equal to that of the pore-water. This velocity is the ratio of recharge rate to the pore-water content.

- Linear isotherms describe the partitioning of the pollutant between the liquid and solid phases.

- The water content is related to the hydraulic conductivity as described by Campbell (1974):

$$\frac{K}{K_{sat}} = \left(\frac{\theta_w}{\theta}\right)^{2b+3} \qquad (2\text{-}8)$$

where:

K	=	the hydraulic conductivity at a volumetric water content (m/d)
b	=	the characteristic curve coefficient for the soil (unitless)
K_{sat}	=	the hydraulic conductivity at the saturated water content (m/d)
θ	=	saturated water content or total soil porosity (cm^3/cm^3)
θ_w	=	volumetric water content (cm^3/cm^3)

The original paper detailing the model theory is presented in Enfield et al. (1982).

2.3 NEAR-FIELD MIXING IN THE AQUIFER

As contaminants enter the Alluvial Aquifer, they will mix with the water flowing through the aquifer. The contaminants penetrate the aquifer and spread vertically beneath the source area due to the combined effects of vertical dispersion and vertical velocity of the recharge. Vertical spreading and mixing was simulated using a mass balance near-field mixing algorithm that is analogous to the approach used by U.S. EPA in the EPA's Composite Model for Landfill (U.S. EPA, 1990) model. This well publicized and publicly scrutinized algorithm (noticed in the Federal Register) estimates the penetration depth, H, by adding the thickness of the plume due to the effects of vertical dispersion and vertical recharge rate:

$$H = (2\alpha_v L_b)^{1/2} + B(1 - \exp[-L_b I/\{VB\}]) \qquad \textbf{(2-9)}$$

where:

H	=	contaminant penetration depth (m)
α_v	=	the vertical dispersivity in the Alluvial Aquifer (m)
L_b	=	the horizontal length of the plume at the bottom of the unsaturated zone (m)
I	=	the vertical recharge rate (m/d)
B	=	the thickness of the Alluvial Aquifer (m)
V	=	the Darcy velocity in the Alluvial Aquifer (m/d)

Note L_b is the horizontal length parallel to the flow direction, and is equal to the characteristic length of the source. If the computed value of H is equal to or larger than the thickness of the aquifer, it is assumed to be equal to the thickness.

Using the principle of mass balance and assuming a uniform vertical concentration over the penetration depth and in the transverse direction over the width of the source, the concentration reduction factor (CRF_2) for near-field mixing can be expressed as:

$$CRF_2 = C_1/C_2 = VA_1/IA_2 \qquad \textbf{(2-10)}$$

where:

C_1	=	peak concentration at top of Alluvial Aquifer (mg/l)
C_2	=	the average concentration over the contaminant penetration depth (mg/l)
A_1	=	cross-sectional area of groundwater flow (m^2)
A_2	=	source surface area (m^2)

Near-field mixing is a function of the area modeled and therefore the same CRF_2 were used with SOLUTE and PESTAN models.

2.4 ESTIMATION OF THE SOIL ACTION LEVELS

The approach for developing soil action levels from the analysis of migration through the unsaturated zone and near-field mixing within the Alluvial Aquifer is described in Sections 2.4.1 and 2.4.2 for the SOLUTE and PESTAN models, respectively. The approach for estimating soil action levels for the unsaturated sand in the old plant (CPC) landfill area is described in Section 2.4.3.

2.4.1 SOLUTE Model

For the SOLUTE model approach, the individual concentration reduction factors were used to develop an overall concentration reduction factor (CRF_T) as:

$$CRF_T = CRF_1 \times CRF_2 \tag{2-11}$$

Based on the estimated overall concentration reduction factor, the allowable leachate concentration was estimated using the following:

$$C_{TARGET} = C_{All} \times CRF_T \tag{2-12}$$

where:

C_{TARGET} = target concentration in the aqueous phase at the source (mg/l)
C_{All} = allowable concentration in groundwater, which is equal to the MCL or MCLG (mg/l)

The potential soil action level concentration on a wet weight basis was then estimated as:

$$C_{Sal} = C_{TARGET} \times Ad \tag{2-13}$$

where:

C_{Sal} = potential soil action level (mg/kg)
Ad = the Adsorption factor estimated using:

$$Ad = \frac{\theta_w + \rho_b K_d + (\theta - \theta_w)H'}{(\theta_w \rho_w + \rho_b)} \tag{2-14}$$

where:

H′ = Henry's law coefficient (dimensionless).
ρ_w = the density of water (g/cm^3) and all other symbols have been defined above.

2.4.2 PESTAN Model

For the PESTAN model, the allowable concentration at the top of the Alluvial Aquifer, C_1, was calculated based on the near-field mixing concentration reduction factor (CRF_2) and the MCL (C_{All}) as follows:

$$C_1 = C_{All} \times CRF_2 \qquad (2\text{-}15)$$

In order to estimate the allowable soil concentrations, the PESTAN model was run to estimate time versus concentration curves at the water table for the different source masses per unit area. From these curves, the allowable source mass per unit area (M_{All}) was estimated as the mass that resulted in a curve where the peak concentration value was less than or equal to the allowable concentration at the top of the Alluvial Aquifer after near-field mixing (i.e., $C_1 \leq C_{All} \times CRF_2$). This allowable source mass was then used to estimate the soil action levels using:

$$C_{Sal} = \frac{M_{All}}{(\rho_b)\ d} \times 1 \times 10^6\ mg/kg \qquad (2\text{-}16)$$

where:

M_{All}	=	the allowable source mass (kg/m^2)
d	=	thickness of source (m)
ρ_b	=	the bulk density of soil (kg/m^3)

Data used and results of the application of the SOLUTE and PESTAN models are presented in Section 3.0.

2.4.3 Summers Model

Potential soil action levels for the unsaturated sand immediately above the aquifer in the old plant (CPC) landfill area were estimated with the Summers model approach

considering only near-field mixing of contaminants within the Alluvial Aquifer (or CRF_2) as follows:

$$C_{TARGET} = C_{All} \times CRF_2$$

and:

$$C_{Sal} = C_{TARGET} \times Ad$$

Because attenuation in the unsaturated zone was not considered, these potential soil action levels would only be applicable for the sands directly above the Alluvial Aquifer.

3.0
MODEL INPUT DATA

This section describes the input data used in the implementation of the approach presented in Section 2.0. Input data are divided into the following categories and discussed in Sections 3.1, 3.2 and 3.3:

- Source data
- Subsurface data
- Chemical specific data

3.1 SOURCE DATA

The source data describe the characteristics of the contaminant source from the old plant (CPC) landfill and former CPC plant area. The mass of each constituent was estimated for both potential source areas. These mass calculations are presented in Attachment B and summarized in Table 3-1. The source input data for PESTAN and SOLUTE are summarized in Table 3-2.

Old Plant (CPC) Landfill. The constituents in the soils underling the old plant (CPC) landfill are contained in the fill/waste material as well as the underlying clay and sand as shown in Table 3-1. For the purpose of this analysis, two intervals (upper and lower) were designated as potential sources. Potential soil action levels were developed separately for each interval. The upper source interval, a combination of the fill/waste and clay, includes the upper 23 feet (7 m) of soil. The lower source interval was designated as the unsaturated sand above the Alluvial Aquifer. Potential soil action levels were developed for the upper source interval considering attenuation in the unsaturated zone by PESTAN and SOLUTE and near-field mixing within the Alluvial Aquifer. For the lower source, conservative potential soil action levels were developed by only considering near-field mixing.

The initial aqueous concentration at the source, C_o, for the SOLUTE model was selected as 1.0 so that attenuation in the unsaturated zone could be expressed as a fraction of the

source concentration (i.e., the resulting calculated transport concentration ratios are expressed directly as decimal fractions of the source concentration).

For PESTAN the allowable mass in the slug was calculated using the procedure described in Section 2.2. The allowable source mass, M_{All} was estimated as the mass that resulted in the peak leachate concentration C_1 value less than or equal to the allowable concentration at the top of the Alluvial Aquifer (C_{All}) as discussed in Section 2.2. The PESTAN model assumes that the mass leaches at the chemical-specific aqueous solubility.

Former CPC Plant Area. For both the SOLUTE and PESTAN models, the source area for the western portion of the former CPC plant area was assumed to be from 4 feet below ground surface (bgs) to 14 feet bgs (3.05 m), which is where most of the contaminants were detected. The estimated affected area (A_2), as described in the draft FS, is 27,500 square feet (2,555 square meters). The initial source concentration for SOLUTE was selected as 1.0 (i.e., the resulting calculated transport concentration ratios are expressed directly as decimal fractions of the source concentration). The source mass for PESTAN was calculated as discussed above.

3.2 SUBSURFACE DATA

Subsurface data include hydrogeologic properties for the unsaturated zone and the Alluvial Aquifer. These data are summarized in Table 3-3.

Unsaturated Zone Properties

The unsaturated zone properties that were used for the PESTAN and SOLUTE models include:

- Infiltration rate (I)
- Saturated hydraulic conductivity (K_{sat})
- Saturated water content or total porosity (θ)
- Bulk density of soil (ρ_b)
- Characteristic curve coefficient (b)

- Volumetric water content (θ_w)
- Transport distance (L)
- Seepage velocity in the unsaturated zone (V_s)
- Longitudinal dispersivity (α_L)
- Fractional organic carbon content of the soil (f_{oc})

PESTAN uses input values of infiltration rate, saturated hydraulic conductivity, characteristic curve coefficient, and saturated water content to estimate the volumetric water content and the seepage velocity. This estimated seepage velocity is used by PESTAN for contaminant transport calculations and is an input for the SOLUTE model.

Infiltration Rate. The annual infiltration rate was estimated from the Hydrologic Evaluation Landfill Performance (HELP) model (EPA, 1992). The HELP model calculations indicated an infiltration rate of 5.25×10^{-4} ft/d (1.60×10^{-4} m/d) in the old plant (CPC) landfill area. An infiltration rate of 7.31×10^{-4} ft/d (2.22×10^{-4} m/d) was estimated for the former CPC plant area. The calculation for the old plant CPC landfill was for infiltration through a recompacted clay layer, whereas uncompacted natural soil was assumed for the former CPC plant area.

Saturated Hydraulic Conductivity. The vertical saturated hydraulic conductivity in the old plant (CPC) landfill area was estimated from literature values typical of silt, 0.28 ft/d (0.0853 m/d). This is considered conservative (i.e., high) because flow through the unsaturated zone would be controlled by the layer which has the lowest hydraulic conductivity. The old plant (CPC) landfill has been capped with clay and there is clay between the fill/waste material and the sand.

The saturated hydraulic conductivity was estimated as 30 ft/day (9.14 m/day) for the former CPC plant area, or one-tenth of the horizontal hydraulic conductivity of the underlying Alluvial Aquifer.

Saturated Water Content. The saturated water content was assumed to be 0.40 for the old plant (CPC) landfill, which is a typical saturated water content (i.e., porosity) for a silt based on published values in Table 5.1 in Driscoll, 1986. This value is consistent with the selected hydraulic conductivity value. A saturated water content of 0.35 was

used for the former CPC plant, a typical value for a sand based on published values (Table 5.1 in Driscoll, 1986).

Bulk Density. The bulk density of soil (weight of dry soil divided by the field or net volume of soil) was calculated from the relationship.

$$\rho_b = \rho_s (1-\theta) \tag{3-1}$$

where:

ρ_b	=	bulk density of soil (g/cm^3)
ρ_s	=	particle mass density (g/cm^3)
θ	=	porosity or the saturated water content (cm^3/cm^3)

The particle mass density was estimated to be 2.65 g/cm^3 (Freeze and Cherry, 1979).

Characteristic Curve Coefficient. The characteristic curve coefficient (b) is a dimensionless empirical value (Clapp and Hornberger, 1978) that relates the relative saturation of soil to the relative hydraulic conductivity under steady-state conditions. This coefficient was estimated from tabulated values presented with the PESTAN Version 4.0 program documentation (CSMS, 1992) and are dependent on the soil type. A characteristic curve coefficient of 5.0, typical of silt, was used for the old plant (CPC) landfill. A coefficient of 4.0, typical of a sand, was used for the former CPC plant area.

Volumetric Water Content. As discussed in Section 2.1, PESTAN calculates the volumetric water content. For the old plant (CPC) landfill, the calculated volumetric water content was 0.254. A value of 0.133 was calculated for the former CPC plant area.

Transport Distance. The transport distance from the upper source to the Alluvial Aquifer in the old plant (CPC) landfill area was assumed to be 22.4 feet (6.83 m). This is the estimated distance from the center of the clay layer to the water table. The travel distance in the former CPC plant area was estimated to be 18 feet (5.49 m), the estimated distance from the base of the source area to the water table. The source area depth was estimated as 3 feet into the sand layer (about 14 feet bgs).

Seepage Velocity. The vertical seepage velocity or interstitial pore water velocity is an input parameter for SOLUTE and was estimated as follows:

$$V_s = \frac{I}{\theta_w} \tag{3-2}$$

Based on this calculation, the seepage velocity used for the old plant (CPC) landfill was 2.13×10^{-3} ft/d (6.50×10^{-4} m/d). The seepage velocity calculated for the former CPC plant area was 5.49×10^{-3} ft/d (1.67×10^{-3} m/d).

Longitudinal Dispersivity. Longitudinal dispersivities are difficult to measure and are not easily related to the soil type. A typical relationship between longitudinal dispersivity (α_L) and the mean travel distance (transport distance) (Walton, 1988) is:

$$\alpha_L = 0.1\ L \tag{3-3}$$

where:

α_L	=	the longitudinal dispersivity (m)
L	=	the travel distance (m)

Therefore, a value of 2.24 ft (0.68 m) was used for the old plant (CPC) landfill, and a value of 1.8 ft or (0.55 m) was used for the former CPC plant area.

Fractional Organic Carbon Content. The fractional organic carbon content f_{oc} of the soil was assumed to be 1.0 percent for the base case, which is the same estimate EPA used for a similar analysis conducted for the Ciba Geigy site to the north (BCM Engineers, 1991).

Alluvial Aquifer Properties

Data required to evaluate near-field mixing in the Alluvial Aquifer consisted of the following:

- Vertical dispersivity in the Alluvial Aquifer (α_v)
- Horizontal hydraulic conductivity in the Alluvial Aquifer (K)
- Horizontal hydraulic gradient (i)
- Darcy velocity in the Alluvial Aquifer (V)
- Aquifer thickness (B)
- Vertical penetration depth (H)
- Cross-sectional area in direction of groundwater flow (A_1)
- Source surface area (A_2)
- Infiltration rate (I)

The specific values used are shown in Table 3-4 and summarized below:

Vertical Dispersivity. The vertical dispersivity in the Alluvial Aquifer was estimated as one-tenth the longitudinal dispersivity. The longitudinal dispersivity was estimated as one-tenth the travel (transport) distance below the facility, similar to the relationship used to estimate longitudinal dispersivity in the unsaturated zone.

$$\alpha_L = 0.1\ L \tag{3-3}$$

$$\alpha_V = 0.1\ \alpha_L \tag{3-4}$$

Based on this analysis and assuming a longitudinal travel distance of 400 feet (the length of old plant (CPC) landfill in the groundwater flow direction) the longitudinal dispersivity for the old plant (CPC) landfill area was estimated as 40 feet. The vertical dispersivity was therefore estimated as 4.0 feet (1.2 m).

The longitudinal travel distance in the groundwater flow direction was estimated as 100 feet in the former CPC plant area and the longitudinal and vertical dispersivities were estimated as 10 feet and 1.0 feet (0.305 m), respectively.

Hydraulic Conductivity. Historical data presented in the Draft RI Report (WCC, 1993) were used to estimate the hydraulic conductivity. Available hydraulic conductivity data

include single-well response tests from four wells located in the area, and one pump test from a corrective action well approximately 1,500 feet to the northeast. The single-well response tests were generally reported as minimum values due to the rapid recovery of the wells during testing. The average K value from these four tests was 24.5 ft/day. The K value from the pump test was estimated as 578 ft/day. Since pump tests generally yield more reliable estimates of hydraulic conductivity, the average of 24.5 ft/day and 578 ft/day, which is 300 ft/day (91.4 m/day), was used as the estimate for the hydraulic conductivity.

Hydraulic Gradient. The hydraulic gradients were estimated from the September 1991 potentiometric maps presented in the Draft RI Report (WCC, 1993). These estimates were obtained by calculating the gradient at several locations in both the upper and lower zones of the aquifer. For the old plant (CPC) landfill, the gradient was estimated as 0.0025 to the east, and the gradient in the area to the west of the former CPC plant area was estimated as 0.004 to the west. These gradient calculations are presented in Attachment C.

Darcy Velocity. The Darcy velocity in the aquifer was calculated from the following equation:

$$V = Ki \qquad (3\text{-}5)$$

where:

K	=	hydraulic conductivity of the Alluvial Aquifer (ft/d)
i	=	hydraulic gradient (unitless)

The Darcy velocity for the old plant (CPC) landfill was estimated as 0.75 ft/day (0.23 m/d), and the Darcy velocity in the former (CPC) plant area was estimated as 1.2 ft/day (0.37 m/d).

Aquifer Thickness. The aquifer thickness, which is used to calculate the vertical penetration depth was estimated as 50 feet (15.2 m). This is based on the difference

between the elevation of the potentiometric surface (about 10 feet msl) and the elevation of the base of the aquifer (about -40 feet msl).

Horizontal Length of the Source. The horizontal length of the source was estimated as the length of the source in the groundwater flow direction, which is 400 ft (122 m) for the old plant (CPC) landfill and 100 ft (30.5 m) for the former CPC plant area.

Vertical Penetration Depth. The vertical penetration depth was calculated from Equation 2-9. For the old plant (CPC) landfill, the value exceeded the thickness of the aquifer and the penetration depth therefore was assumed to be the aquifer thickness. The vertical penetration depth in the former CPC plant area based on Equation 2-9 is 10 feet (3.05 m).

Cross-Sectional Area. The cross-sectional area in the direction of groundwater flow (A_1) was estimated as the vertical penetration depth times the source width. For the old plant (CPC) landfill, the estimated source width is 300 feet (91.44 m) and therefore A_1 is estimated as 15,000 ft^2 (1,393 m^2). The source width for the former CPC plant area is estimated as 100 feet and A_1 is estimated as 1,000 ft^2 (92.9 m^2).

Source Surface Area. The source surface area (A_2) is estimated as 120,000 ft^2 (11,148 m^2) for the old plant (CPC) landfill and 27,500 ft^2 (2555 m^2) for the area west of the former CPC plant.

Infiltration Rate. The estimated infiltration rates are discussed in Section 3.2.

3.3 CHEMICAL DATA

The chemical data used to estimate soil action levels are presented in Table 3-5. The listed values were obtained from several standard references and include Henry's Law Constant, aqueous solubility, organic carbon partition coefficients K_{oc}, and biodegradation in soil.

The K_{oc} for each chemical constituent was estimated as the mean of values listed in Montgomery and Welkom (1990), Jeng et al. (1992) and the EPA Soil Transport and

Fate Database (EPA, 1991) (excluding the high and low values). Using the mean appropriately eliminates the variation in literature values, which vary because of different conditions of testing by different investigators. The sorption coefficient Kd for mercury was estimated with Equation 2-5 and an estimated pH of 5.0.

A range of half lives was presented in Howard et al. (1991). Some half life values were developed under laboratory conditions favorable to biological degradation. Because conditions in contaminated soils such as found at McIntosh may not be so favorable, it is appropriate as a conservative approach, to apply a "safety factor" to literature half life data. For this analysis, a multiplier of 50 was applied to half lives at the high end of the range from the literature for use as the model input parameter. This is similar to an approach used by Ciba Geigy in developing soil action levels for their site directly north of the Olin McIntosh site (BCM Engineers, 1991). To develop a complete range of potential soil action levels, the analysis was also conducted considering no biodegradation in soil. The range of potential soil action levels developed from both approaches is presented in Section 4.0.

4.0 MODELING RESULTS

Potential soil action levels were developed using the methods outlined in Section 2.0 and the conservative input parameters listed in Section 3.0. Several different approaches were used providing a range of potential soil action levels. The results for each approach are presented in this section. Attachment D provides the model input and output. Based on these results, the recommended potential soil action levels for each source area were determined and are presented in Section 5.0.

4.1 OLD PLANT (CPC) LANDFILL

Table 4-1 summarizes the modeling for the fill/waste and clay (upper source area) in the old plant CPC landfill area. The estimated concentration reduction factor for near-field mixing (CRF_2, See Section 2.3) was 178.5. The SOLUTE concentration reduction factor for attenuation in the unsaturated zone (CRF_1) was estimated as 2.02 without consideration of decay (i.e., biodegradation). The analyses predicted a target concentration for the leachate (C_{TARGET}) for 1,2-dichlorobenzene, 1,3-dichlorobenzene and mercury higher than the aqueous solubility, indicating that these constituents could not transfer from the soil to the aqueous phase (leachate) at concentrations high enough to cause exceedances of MCLs in groundwater.

When a very conservative biodegradation factor was input to the SOLUTE model, the analyses predicted complete biodegradation of the organic constituents in the unsaturated zone and the CRF_1 could either not be calculated or the resulting C_{TARGET} value was too high to calculate a potential soil action level. The biodegradation rates were estimated based on literature values. Site-specific tests would be required to more accurately predict biodegradation rates.

Table 4-1 also lists the PESTAN model results for the fill/waste and clay in the old plant (CPC) landfill area. The CRF_2 (See Section 2.3) was the same as for the SOLUTE analysis (178.5). Table 4-1 lists the predicted source mass (M_{ALL}) and associated soil action levels that would cause exceedances of the groundwater MCL/MCLGs. For each

constituent, these predicted mass values are more than the calculated mass in the soil based on the RI data (Table 3-1) (i.e., the mass required as input in PESTAN to simulate leachate concentrations that would cause exceedances of the MCL/MCLGs is greater than the mass calculated to be present in the source areas).

As discussed in Section 2.0, the PESTAN model assumes leaching at the aqueous solubility. The literature value used for aqueous solubility of mercury, 0.35 mg/l, (Table 3-5) is lower than the allowable concentration at the top of the aquifer; therefore, potential soil action levels could not be developed using this value. The solubility of mercury varies considerably depending on the ionic form. The analysis was therefore conducted assuming a solubility of twice the literature value (0.70), which is consistent with the allowable leachate concentrations at the top of the Alluvial Aquifer based on the SOLUTE results.

The PESTAN results considering biodegradation are also listed in Table 4-1. These results predict complete biodegradation of 1,2-dichlorobenzene, 1,3-dichlorobenzene and 1,2,4-trichlorobenzene in the unsaturated zone. Potential soil action levels were developed for benzene, chlorobenzene and 1,4, dichlorobenzene.

The unsaturated sand above the Alluvial Aquifer was also considered a source (i.e., lower source interval) for estimating potential soil action levels. The results are summarized in Table 4-2. As a very conservative approach, the concentrations entering the Alluvial Aquifer were calculated as the liquid-phase concentration at the source (i.e., CRF_1 was designated as 1.0) and potential soil action levels were estimated based on the near-field mixing concentration reduction factor (CRF_2) of 178.5. This analysis would be applicable for sands directly above the Alluvial Aquifer; however, with increasing distance above the water table, CRF_1 would increase and approach the value used for the upper source interval (Table 4-1), resulting in higher potential soil action levels than those calculated.

4.2 FORMER CPC PLANT AREA

Potential soil action levels for the former CPC plant area are summarized in Table 4-3. The SOLUTE concentration reduction factor for attenuation in the unsaturated zone

(CRF_1) was estimated as 2.70 without consideration of biodegradation. The near-field mixing concentration reduction factor (CRF_2) was estimated as 55.24. This value is less than the CRF_2 for the old plant (CPC) landfill primarily due to the size of the source. The former CPC plant source surface area is smaller that the old plant (CPC) landfill source surface area. There would be less net infiltration through the former plant area, but the vertical penetration depth would also be less (10 feet as compared to 50 feet). This illustrates one reason why the modeling results are applicable only to area which is modeled.

The analysis was also conducted for a very conservative biodegradation factor as discussed in Section 3.3. The SOLUTE model predicted that benzene, 1,2-dichlorobenzene, 1,3-dichlorobenzene and 1, 2,4-trichlorobenzene would completely degrade in the unsaturated zone and not reach the Alluvial Aquifer. For the other two constituents, the predicted allowable leachate concentrations at the top of the aquifer (C_{TARGET}) are higher than the aqueous solubility and therefore the analyses predict that MCL/MCLGs would not be exceeded.

Table 4-3 also lists the results of the PESTAN model with and without biodegradation. Similar to the old plant (CPC) landfill, the source mass for each constituent that the model predicts would cause exceedance of the MCL/MCLG in the Alluvial Aquifer is greater than the mass calculated from the RI data (Table 3-1).

5.0
RECOMMENDED POTENTIAL ACTION LEVELS

Tables 5-1 and 5-2 summarize the potential soil action levels that were developed for the old plant (CPC) landfill and the former CPC plant area, respectively. These tables also provide recommended levels based on the modeling results and site conditions. Potential soil action levels were developed using three models. The Summers model was used to predict concentration reduction factors due to near-field mixing in the Alluvial Aquifer. Two one-dimensional, publicly available contaminant transport models (SOLUTE and PESTAN) were used to estimate concentration reduction factors for migration through the unsaturated zone. Using both SOLUTE and PESTAN provided insight on the validity of the analyses. The SOLUTE and PESTAN models were applied with and without biodegradation.

The Summers model results produced soil action levels that were lower than the other two models because the Summers model does not account for any attenuation in the unsaturated zone. The soil action levels from the Summers model are only applicable for the sands directly above the water table in the old plant CPC landfill. PESTAN (without biodegradation) typically produced soil action values that were lower than SOLUTE because of PESTAN's assumption of instantaneous equilibrium (see paragraph below). The range of values from the PESTAN and SOLUTE models were used to develop soil action levels in the fill/waste and clay material in the old plant (CPC) landfill and the clay/upper sand in the former CPC plant area.

The potential action levels from the PESTAN model (without biodegradation) are considered to be biased low due to the assumptions used in the model relative to actual site conditions. The PESTAN model assumes that the source area leaches at the chemical-specific aqueous solubility and that equilibrium between the soil and water is reached instantaneously as rainfall percolates through the soil column. The SOLUTE model uses a more technically rigorous approach by calculating leachate concentrations at the source from the sorption coefficient, which is based on chemical-specific factors and soil properties and is considered to more accurately simulate site conditions.

Biodegradation is an important attenuation mechanism and should be considered for development of soil action levels, particularly for constituents such as benzene and chlorobenzene with relatively short half lives. The biodegradation rate is dependent on the physical and chemical conditions of the soil and the contaminant concentrations, and therefore would vary both spatially and temporally. Site-specific biodegradation data were not available, so the selected degradation rates used in the models were from the literature. The literature values were commonly developed from experiments that were conducted under controlled conditions that may be more favorable to biodegradation than conditions at the site. The approach for the modelling was to use conservative biodegradation rates based on these literature values and apply a safety factor of 50.

When these degradation rates were input in the SOLUTE model, the model predicted complete or near complete degradation of the organic constituents in the unsaturated zone. The site groundwater data indicate that this has been the case in the past, particularly for the more common constituents detected more frequently in the groundwater such as chlorobenzene and 1,4-dichlorobenzene. The results from the PESTAN model with biodegradation did allow calculation of potential soil action levels for most of the constituents.

As stated above, the potential soil action levels produced by the PESTAN model (without biodegradation) were considered biased low due to the method in which the leachate concentration is estimated. Further, the SOLUTE results with biodegradation are not considered appropriate considering the site conditions. Therefore, the recommended soil action values were selected between the values from SOLUTE, without biodegradation, and those from PESTAN with biodegradation. In some cases, the specific values selected within this range were determined based on comparing the mass in the source areas to the allowable mass based on the PESTAN model (without biodegradation). Comparison of these mass calculations provide an indication of the safety factor for each model result without considering biodegradation. The larger the safety factor, the more weight was placed on the results from PESTAN with biodegradation in selecting the recommended soil action level values. For example, the recommended soil action levels are close to the SOLUTE results (i.e., are on the low end of the range and only minimal biodegradation is considered) for constituents for which calculations of actual mass values present were close to those that the PESTAN

model predicted would be required to cause exceedances of MCLs/MCLGs. This specific reasoning for each recommended potential soil action level is noted in Tables 5-1 and 5-2.

6.0
REFERENCES

BCM Engineers, 1991. Final Report on Soil Cleanup Levels for CIBA-GEIGY at the McIntosh, Alabama Facility Using the PESTAN Contaminant Transport Model, BCM Project 05-4294-37, September.

Campbell, G. S., 1974. A Simple Method for Determining Unsaturated Conductivity from Moisture Retention Data, Soil Science, Volume 117, No. 6, Pages 313-314.

Clapp, R. B., and Hornberger, G. M., 1978. Empirical Equations for Some Soil Hydraulic Properties, Water Resources Research, Volume 14, Page 601-604.

Center for Subsurface Modeling Support (CSMS). 1992. PESTAN, Pesticide Analytical Model, Version 5.0. Developed by V. Ravi and J. A. Johnson. Dynamac Corporation, Center for Subsurface Modeling Support. Robert S. Kerr Environmental Research Laboratory. Ada, Oklahoma.

Driscoll, F. G., 1986. Groundwater and Wells. Johnson Division. St. Paul.

Enfield, C. G., Carsel, R. F., and Cohen, S. Z., Phan, T., and Walters, D. M., 1982. Approximating Pollutant Transport to Groundwater, Groundwater, Volume 20, No. 6.

ERM, 1989. Remedial Investigation and Risk Assessment for Olin Corporation McIntosh, Alabama. November.

Freeze, R. A., and Cherry, J. A., 1979. Groundwater. Prentice-Hall, Inc.

Howard, P. H., Boething, R. S., Jarvis, W. F., Meylan, W. M., and Michalenko, E. M., 1991. Handbook of Environmental Degradation Rates. Lewis Publishers, Inc. Chelsea, Michigan.

International Ground Water Modeling Center (IGWMS). 1991. SOLUTE, A Program Package of Analytical Models for SOLUTE Transport in Groundwater Version 2.03. Developed by M. S. Beljin. Colorado School of Mines.

Jeng, C. Y., Chen, D. H., and Yaws, C. L., 1992. Data Compilation for Soil Coefficient, Pollution Engineering, Volume 24, No. 12, Pages 54-60.

Loux, Nicholas T., Chafin, Claudia R., and Hassan, Sayed M., 1990. Statistics of Aquifer Material Properties and Empirical pH-dependent Partitioning Relationships for As (III), As (V), Ba (II), Be (II), Cd (II), Cr (VI), Cu (II), Hg (II), Pb (II), Sb (V), Se (IV), Se (VI), Tl (I), and Zn (II). Research and Development, U. S. EPA.

Montgomery, J. H., and Welkom, L. M., 1990. Groundwater Chemicals Desk Reference. Lewis Publishers.

Summers, K., Gherini, S., and Chen, C., 1980. Methodology to Evaluate the Potential for Groundwater Contamination from Geothermal Fluid Releases, Industrial Environmental Research Laboratory, U. S. Environmental Protection Agency (EPA), Cincinnati, Ohio.

U. S. Environmental Protection Agency, 1986. Superfund Public Health Evaluation Manual, Office of Emergency and Remedial Response, Washington, D. C. EPA/540/1-86/060.

U. S. Environmental Protection Agency, 1988. Guidance on Remedial Actions for Contaminated Groundwater at Superfund Sites, Office of Emergency and Remedial Response, Washington, D. C. EPA/540/G-88/003.

U. S. Environmental Protection Agency, 1990. Background Document for EPA's Composite Model for Landfills (EPACML), Office of Solid Wasted, Washington, D. C.

U. S. Environmental Protection Agency, 1991. Soil Transport and Fate Database 2.0 and Model Management System. Robert S. Kerr Environmental Research Laboratory, Office of Research and Development, Ada, Oklahoma.

U. S. Environmental Protection Agency, 1992. Hydrologic Evaluation of Landfill Performance (HELP) Model. Department of the Army. Internal Working Document EL-92-1.

van Genuchten, M. Th., and W. J. Alves, 1982. Analytical Solutions of the One-Dimensional Convective-Dispersive Solute Transport Equation. U. S. Salinity Lab., Riverside, California.

Walton, W. C., 1988. Practical Aspects of Groundwater Modeling, National Water Well Association, Ohio.

Woodward-Clyde Consultants (WCC), 1993a. Draft Remedial Investigation Report, McIntosh Plant Site, Olin Corporation, McIntosh, Alabama. February.

Woodward-Clyde Consultants (WCC), 1993b. Draft Feasibility Study Report, McIntosh Plant Site, Olin Corporation McIntosh, Alabama. May.

TABLES

TABLE 1-1

GROUNDWATER CHEMICALS OF POTENTIAL CONCERN DEVELOPED FOR BASELINE RISK ASSESSMENT[1]

VOLATILES
Benzene
Bromodichloromethane
Chlorobenzene
Chloroform
SEMIVOLATILES
1,2,4-Trichlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
Pentachloronitrobenzene
Pentachlorobenzene
PESTICIDES
Alpha-BHC
INORGANICS
Antimony
Arsenic
Beryllium
Cadmium
Chromium
Copper
Lead
Mercury

NOTES:

1 1,3-Dichlorobenzene was not on the list of chemicals of concern for the baseline risk assessment, but is listed here because of its close association with the other dichlorobenzene isomers.

TABLE 3-1

ESTIMATED MASS OF CONSTITUENTS IN SOIL[1]
(Mass in kg)

Constituents	Old Plant (CPC) Landfill			Former CPC Plant Area	
	Residual Waste/Fill	Clay and Loose Saturated Silt/Clay	Sand	Clay	Sand
Benzene	0	58.4	22.0	0.01	0
Chlorobenzene	208	824	1,331	2.71	1.60
1,2-Dichlorobenzene	1,258	2,398	2,058	130	14
1,3-Dichlorobenzene	94.4	167	167	10.8	0.88
1,4-Dichlorobenzene	1,524	2,678	2,446	10.4	8.80
1,2,4-Trichlorobenzene	297.4	376	75.2	3,034	34.0
Mercury	5,701	8.04	0	--	--

NOTES:

1 Assumes bulk density of sand, ρ_b = 1,720 kg/m^3, and ρ_b = 1,590 kg/m^3 for all other units.

TABLE 3-2

SUMMARY OF SOURCE INPUT DATA

OLD PLANT (CPC) LANDFILL (Fill Waste and Clay Material)					
SOLUTE Model			PESTAN Model		
Parameter	Units		Parameter	Units	All Cases
Source Concentration (C_o)	mg/l	1.0	Area (A)	ft^2 (m^2)	120,000 (11,148)
			Thickness (d)	(ft) (m)	23 (7)
			Bulk Density (ρ_b)	lbs/ft^3 (kg/m^3)	99.2 (1,590)
			Source Concentration (C_s)	mg/kg	See Note 1

FORMER CPC PLANT AREA					
SOLUTE Model			PESTAN Model		
Parameter	Units		Parameter	Units	All Cases
Source Concentration (C_o)	mg/l	1.0	Area (A)	ft^2 (m^2)	27,500 (2,555)
			Thickness (d)	ft (m)	10 (3.05)
			Bulk Density (ρ_b)	lbs/ft^3 (kg/m^3)	99.2 (1,590)
			Source Concentration (C_s)	mg/kg	See Note 1

NOTES: [1] Input source concentration varied for each chemical constituent.

TABLE 3-3

SUMMARY OF UNSATURATED ZONE INPUT DATA

Parameter	Symbol	Units	Old Plant (CPC) Landfill	Former CPC Plant Area	Comments
Infiltration Rate	I	ft/day (m/day)	5.25×10^{-4} (1.60×10^{-4})	7.31×10^{-4} (2.22×10^{-4})	HELP Model calculations presented in WCC, 1993b
Saturated Hydraulic Conductivity	K_{Sat}	ft/day (m/day)	0.28 (0.0864)	30 (9.14)	Literature values representative of silt for old plant (CPC) landfill (Freeze and Cherry, 1979) -- one-tenth of horizontal K for former CPC plant area.
Saturated Water Content	θ	Dimensionless	0.40	0.35	Literature values representative of silt for old plant (CPC) landfill and sand for former CPC plant area (Table 5.1 in Driscoll, 1986)
Characteristic Curve Coefficient	b	Dimensionless	5.0	4.0	Literature values representative of silt for old plant (CPC) landfill and sand for former CPC plant area (CSMS, 1992)
Volumetric Water Content	θ_w	Dimensionless	0.246	0.133	Calculated by PESTAN Model using empirical relationship from Clapp and Hornberger (1978)
Bulk Density	ρ_b	lbs/ft^3 (Kg/m^3)	99.2 (1,590)	107.5 (1,720)	Calculated from volumetric water content (Equation 3-1)
Transport Distance	L	ft (m)	22.4 (6.83)	18 (5.5)	Old plant (CPC) landfill—Distance from center of clay layer to water table Former CPC plant area—Distance from source depth to water table
Seepage Velocity	V_s	ft/day (m/day)	2.13×10^{-3} (6.50×10^{-4})	5.49×10^{-3} (1.67×10^{-3})	Calculated from I/θ_w

TABLE 3-3 (Continued)

SUMMARY OF UNSATURATED ZONE INPUT DATA

Parameter	Symbol	Units	Old Plant (CPC) Landfill	Former CPC Plant Area	Comments
Longitudinal Dispersivity	α_L	ft (m)	2.2 (0.68)	1.8 (0.55)	Estimated as 0.1 x L
Fractional Organic Carbon	f_{oc}	%	1.0	1.0	Estimated-Same value as used by EPA for similar analysis at Ciba Geigy site to the north (BCM Engineers, 1991)

TABLE 3-4

DATA USED TO CALCULATE CRF_2

Parameter	Symbol	Units	Old Plant (CPC) Landfill	Former CPC Plant Area	Comments
Vertical Dispersivity	α_v	ft (m)	4.0 (1.2)	1.0 (0.305)	Estimated as 1/100 of longitudinal transport distance
Hydraulic Conductivity	K	ft/day (m/day)	300 (91.4)	300 (91.4)	Single-Well response tests and pump test data
Gradient	i	Dimensionless	0.0025	0.004	September 1991 potentiometric map (See Attachment C)
Darcy Velocity	V	ft/day (m/day)	0.75 (0.23)	1.2 (0.37)	V = Ki
Aquifer Thickness	B	ft (m)	50 (15.2)	50 (15.2)	Site stratigraphic and potentiometric data
Horizontal Length of the Source	L_b	ft (cm)	400 (122)	100 (30.5)	Length of the source area in the groundwater flow direction
Vertical Penetration Depth	H	ft (m)	50 (15.2)	10 (3.05)	Equation 2-9
Cross-Sectional Area of Groundwater Flow	A_1	ft^2 (m^2)	15,000 (1,393)	1,000 (92.9)	H x width of source
Source Surface Area	A_2	ft^2 (m^2)	120,000 (11,148)	27,500 (2,555)	Draft FS Report (WCC, 1993a)
Infiltration Rate	I	ft/day (cm/yr)	5.25×10^{-4} (1.60×10^{-4})	7.31×10^{-4} (2.22×10^{-4})	HELP Model calculations, presented in WCC, 1993b

TABLE 4-1

POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL AREA
FILL/WASTE AND CLAY

SOLUTE MODEL WITHOUT BIODEGRADATION						
Constituent	CRF_1	CRF_2	MCL/MCLG (mg/l)	C_{TARGET} (mg/l)	A_d	C_{SAL} (mg/Kg)
Benzene	2.02	178.5	0.005	1.8	0.8	1.4
Chlorobenzene	2.02	178.5	0.100	36.1	1.8	65
1,2-Dichlorobenzene	2.02	178.5	0.600	216.4[1]	7.6	1,644
1,3-Dichlorobenzene	2.02	178.5	0.600	216.4[1]	5.7	1,233
1,4-Dichlorobenzene	2.02	178.5	0.075	27.0	3.9	105
1,2,4-Trichlorobenzene	2.02	178.5	0.070	25.2	42.3	1,066
Mercury	2.02	178.5	0.002	0.7[1]	92.9	65

SOLUTE MODEL WITH BIODEGRADATION							
Constituent	CRF_1	CRF_2	MCL/MCLG (mg/l)	C_{TARGET} (mg/l)	A_d	Biodegradation Input Factor (Half-life x 50) (days)	C_{SAL} (mg/Kg)
Benzene	-[2]	178.5	0.005	-[2]	0.8	800	-[2]
Chlorobenzene	5,000	178.5	0.100	892,500[2]	1.8	7,500	-[3]
1,2-Dichlorobenzene	-[2]	178.5	0.600	-[2]	7.6	9,000	-[2]
1,3-Dichlorobenzene	-[2]	178.5	0.600	-[2]	5.7	9,000	-[2]
1,4-Dichlorobenzene	-[2]	178.5	0.075	-[2]	3.9	9,000	-[2]
1,2,4-Trichlorobenzene	-[2]	178.5	0.070	-[2]	42.3	9,000	-[2]
Mercury	2.02	178.5	0.002	0.7[1]	92.9	NA	65

TABLE 4-1 (Continued)

POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL AREA
FILL/WASTE AND CLAY

PESTAN MODEL WITHOUT BIODEGRADATION						
Constituent	CRF_2	MCL/MCLG (mg/l)	C_t (mg/l)	M_{All} (Kg)	A_d	C_{SAL} (mg/Kg)
Benzene	178.5	0.005	0.89	104	0.8	0.83
Chlorobenzene	178.5	0.100	17.85	4,905	1.8	39
1,2-Dichlorobenzene	178.5	0.600	107.1	182,832	7.6	1,472
1,3-Dichlorobenzene	178.5	0.600	107.1	261,984	5.7	2,109
1,4-Dichlorobenzene	178.5	0.075	13.39	8,361	3.9	67
1,2,4-Trichlorobenzene	178.5	0.070	12.50	89,186	42.3	718
Mercury	178.5	0.002	0.36	6,466	92.9	52

PESTAN MODEL WITH BIODEGRADATION							
Constituent	CRF_2	MCL/MCLG (mg/l)	C_t (mg/l)	M_{All} (Kg)	A_d	Biodegradation Input Factor (Half-life x 50) (days)	C_{SAL} (mg/Kg)
Benzene	178.5	0.005	0.89	5,797	0.8	800	467
Chlorobenzene	178.5	0.100	17.85	10,367	1.8	7,500	83
1,2-Dichlorobenzene	178.5	0.600	107.1	-[2]	7.6	9,000	-[2]
1,3-Dichlorobenzene	178.5	0.600	107.1	-[2]	5.7	9,000	-[2]
1,4-Dichlorobenzene	178.5	0.075	13.39	22,297	3.9	9,000	179
1,2,4-Trichlorobenzene	178.5	0.070	12.50	-[2]	42.3	9,000	-[2]
Mercury	178.5	0.002	0.36	6,468	92.9	NA	52

NOTES:
1. C_{TARGET} is higher than chemical-specific aqueous solubility.
2. Model indicates complete biodegradation before contaminant reaches the Alluvial Aquifer.
3. C_{TARGET} is too high to calculate concentration.

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TABLE 4-2

POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL AREA
UNSATURATED SAND

SUMMERS MODEL						
Constituent	CRF_1[1]	CRF_2	MCL/MCLG (mg/l)	C_{TARGET} (mg/l)	A_d	C_{SAL} (mg/Kg)
Benzene	1.00	178.5	0.005	0.89	0.8	0.71
Chlorobenzene	1.00	178.5	0.100	17.85	1.8	32
1,2-Dichlorobenzene	1.00	178.5	0.600	107.1	7.6	814
1,3-Dichlorobenzene	1.00	178.5	0.600	107.1	5.7	610
1,4-Dichlorobenzene	1.00	178.5	0.075	13.39	3.9	52
1,2,4-Trichlorobenzene	1.00	178.5	0.070	12.50	42.3	528
Mercury	1.00	178.5	0.002	0.36	92.9	33

NOTES:

[1] Analysis does not consider attenuation in the unsaturated zone and would only be applicable for sands directly above the water table.

TABLE 4-3

POTENTIAL SOIL ACTION LEVELS
FORMER CPC PLANT AREA

SOLUTE MODEL WITHOUT BIODEGRADATION						
Constituent	CRF_1	CRF_2	MCL/MCLG (mg/l)	C_{TARGET} (mg/l)	A_d	C_{SAL}[3] (mg/Kg)
Benzene	2.74	55.24	0.005	0.8	0.8	0.64
Chlorobenzene	2.74	55.24	0.100	15.1	1.8	27
1,2-Dichlorobenzene	2.74	55.24	0.600	90.8	8.1	735
1,3-Dichlorobenzene	2.74	55.24	0.600	90.8	6.1	554
1,4-Dichlorobenzene	2.74	55.24	0.075	11.4	4.1	47
1,2,4-Trichlorobenzene	2.74	55.24	0.070	10.6	45.3	480

SOLUTE MODEL WITH BIODEGRADATION							
Constituent	CRF_1	CRF_2	MCL/MCLG (mg/l)	C_{TARGET} (mg/l)	A_d	Biodegradation Input Factor (Half-life x 50) (days)	C_{SAL}[3] (mg/Kg)
Benzene	-[1]	55.24	0.005	-[1]	0.8	800	-[1]
Chlorobenzene	435	55.24	0.100	2,403[2]	1.8	7500	4,324
1,2-Dichlorobenzene	-[1]	55.24	0.600	-[1]	8.1	9000	-[1]
1,3-Dichlorobenzene	-[1]	55.24	0.600	-[1]	6.1	9000	-[1]
1,4-Dichlorobenzene	10,000	55.24	0.075	552,400[2]	4.1	9000	1.69×10^5
1,2,4-Trichlorobenzene	-[1]	55.24	0.070	-[1]	45.3	9000	-[1]

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TABLE 4-3 (Continued)

POTENTIAL SOIL ACTION LEVELS
FORMER CPC PLANT AREA

PESTAN MODEL WITHOUT BIODEGRADATION						
Constituent	CRF_2	MCL/MCLG (mg/l)	C_1 (mg/l)	M_{AII} (Kg)	A_d	C_{SAL}[3] (mg/Kg)
Benzene	55.24	0.005	0.28	6	0.8	0.5
Chlorobenzene	55.24	0.100	5.52	294	1.8	24
1,2-Dichlorobenzene	55.24	0.600	33.14	8,227	8.1	666
1,3-Dichlorobenzene	55.24	0.600	33.14	6,439	6.1	522
1,4-Dichlorobenzene	55.24	0.075	4.15	498	4.1	40
1,2,4-Trichlorobenzene	55.24	0.070	3.87	5,136	45.3	416

PESTAN MODEL WITH BIODEGRADATION							
Constituent	CRF_2	MCL/MCLG (mg/l)	C_1 (mg/l)	M_{AII} (Kg)	A_d	Biodegradation Input Factor (Half-life x 50) (days)	C_{SAL}[3] (mg/Kg)
Benzene	55.24	0.005	0.28	49	0.8	800	3.9
Chlorobenzene	55.24	0.100	5.52	383	1.8	7,500	31
1,2-Dichlorobenzene	55.24	0.600	33.14	11,038	8.1	9,000	894
1,3-Dichlorobenzene	55.24	0.600	33.14	9,045	6.1	9,000	733
1,4-Dichlorobenzene	55.24	0.075	4.15	639	4.1	9,000	52
1,2,4-Trichlorobenzene	55.24	0.070	3.87	6,643	45.3	9,000	538

NOTES:

1. Model indicates complete biodegradation before contaminant reaches the Alluvial Aquifer.
2. C_{TARGET} is higher than chemical-specific aqueous solubility.
3. Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. Attachment E of this appendix provides the calculations of PSALs using the recalculated dimensions. The original and recalculated values are shown on Table 5-2.

TABLE 5-1

SUMMARY OF POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL

FILL/WASTE AND CLAY					
Constituent	SOLUTE without Biodegradation (mg/kg)	SOLUTE with Biodegradation (mg/kg)	PESTAN without Biodegradation (mg/kg)	PESTAN with Biodegradation (mg/kg)	Recommended Soil Action Level (mg/kg)
Benzene	1.4	-[2]	0.83	467	5.0[4]
Chlorobenzene	65	-[3]	39	83	79[5]
1,2-Dichlorobenzene	1,644[1]	-[2]	1,472	-[2]	1,645[6]
1,3-Dichlorobenzene	1,233[1]	-[2]	2,109	-[2]	1,670[7]
1,4-Dichlorobenzene	105	-[2]	67	179	140[5]
1,2,4-Trichlorobenzene	1,066	-[2]	718	-[2]	1,000[6]
Mercury	65[1]	65	52	52	55[8]

UNSATURATED SAND			
Constituent	Summers Model (mg/kg)	Recommended Soil Action Levels Lower Portion of Sand (mg/kg)	Recommended Soil Action Levels Upper Portion of Sand
Benzene	0.71	5.0[9]	5.0[9]
Chlorobenzene	32	30[10]	55[11]
1,2-Dichlorobenzene	814	800[10]	1,200[11]
1,3-Dichlorobenzene	610	600[10]	1,130[11]
1,4-Dichlorobenzene	52	50[10]	95[11]
1,2,4-Trichlorobenzene	528	520[10]	750[11]
Mercury	33	30[10]	42[11]

TABLE 5-1 (Continued)

SUMMARY OF POTENTIAL SOIL ACTION LEVELS
OLD PLANT (CPC) LANDFILL

NOTES:

1. C_{TARGET} is higher than chemical-specific aqueous solubility.
2. Model indicates complete biodegradation before contaminant reaches the Alluvial Aquifer.
3. C_{TARGET} is too high to calculate concentration.
4. The relationship provided in Note 5 results in a benzene soil action value of 206 mg/kg. Considering that the SOLUTE result was 1.4 mg/kg, a value closer to SOLUTE was considered more appropriate.
5. Recommended value is approximately equal to the following:

$$\textit{PESTAN Value With Biodegradation} - \textit{SOLUTE Value Without Biodegradation} \times \left(\frac{\textit{Calculated Mass Table 3-1}}{M_{all}\ \textit{Table 4-1}} \right)$$

6. Approximately equal to SOLUTE without biodegradation.
7. Approximate average of PESTAN without biodegradation and SOLUTE without biodegradation.
8. Approximate average of PESTAN and SOLUTE values.
9. Selected as reasonable value above the Summers model result. The benzene action level from the Summers model was unreasonably low considering the high solubility, low half-life and the mass of benzene in the sand.
10. Based on the Summers model result rounded down to the nearest 10 mg/l mg/kg.
11. Approximate average of the recommended values in the fill/waste and the clay and the recommended values in the sand.

TABLE 5-2

SUMMARY OF POTENTIAL SOIL ACTION LEVELS
FORMER CPC PLANT AREA

Constituent	SOLUTE without Biodegradation (mg/kg)	SOLUTE with Biodegradation (mg/kg)	PESTAN without[3] Biodegradation (mg/kg)	PESTAN with[3] Biodegradation (mg/kg)	Recommended[3] Soil Action Level (mg/kg)	PESTAN without[4] Biodegradation (Recalculated) (mg/kg)
Benzene	0.64	-[1]	0.5	3.9	3.9[2]	4.17
Chlorobenzene	27	4,324	24	31	30[2]	217
1,2-Dichlorobenzene	735	-[1]	666	894	890[2]	--[5]
1,3-Dichlorobenzene	554	-[1]	522	733	730[2]	--[5]
1,4-Dichlorobenzene	47	1.65×10^5	40	52	50[2]	429
1,2,4-Trichlorobenzene	480	-[1]	416	538	500[2]	6,062

NOTES: Potential soil action levels (PSALs) based on protection of groundwater were developed for the area west of the former CPC plant and submitted to EPA on June 5, 1993. The PSALs were recalculated for this FS report using dimensions from a more accurate topographic map. Attachment E of this appendix provides the calculations of PSALs using the recalculated dimensions. The original and recalculated values are shown on this table.

1 Model indicates complete biodegradation in the unsaturated zone.

2 $$\textit{PESTAN Value With Biodegradation} - \textit{SOLUTE Value Without Biodegradation} \times \left(\frac{\textit{Calculated Mass Table 3-1, Appendix F}}{M_{all}\ \textit{Table 4-3, Appendix F}} \right)$$

Values are sometimes rounded down to the nearest 10 mg/kg.

3 Based on the values calculated for the June 5, 1993 potential soil action level report. See Note 4.

4 For development of the remedial alternatives in this FS report, the estimated dimensions of the area west of the former CPC plant were refined based on more accurate topographic maps. The recalculated PSALs are presented in this column. See Appendix F for more discussion.

5 C_{TARGET} is higher than the chemical-specific aqueous solubility.

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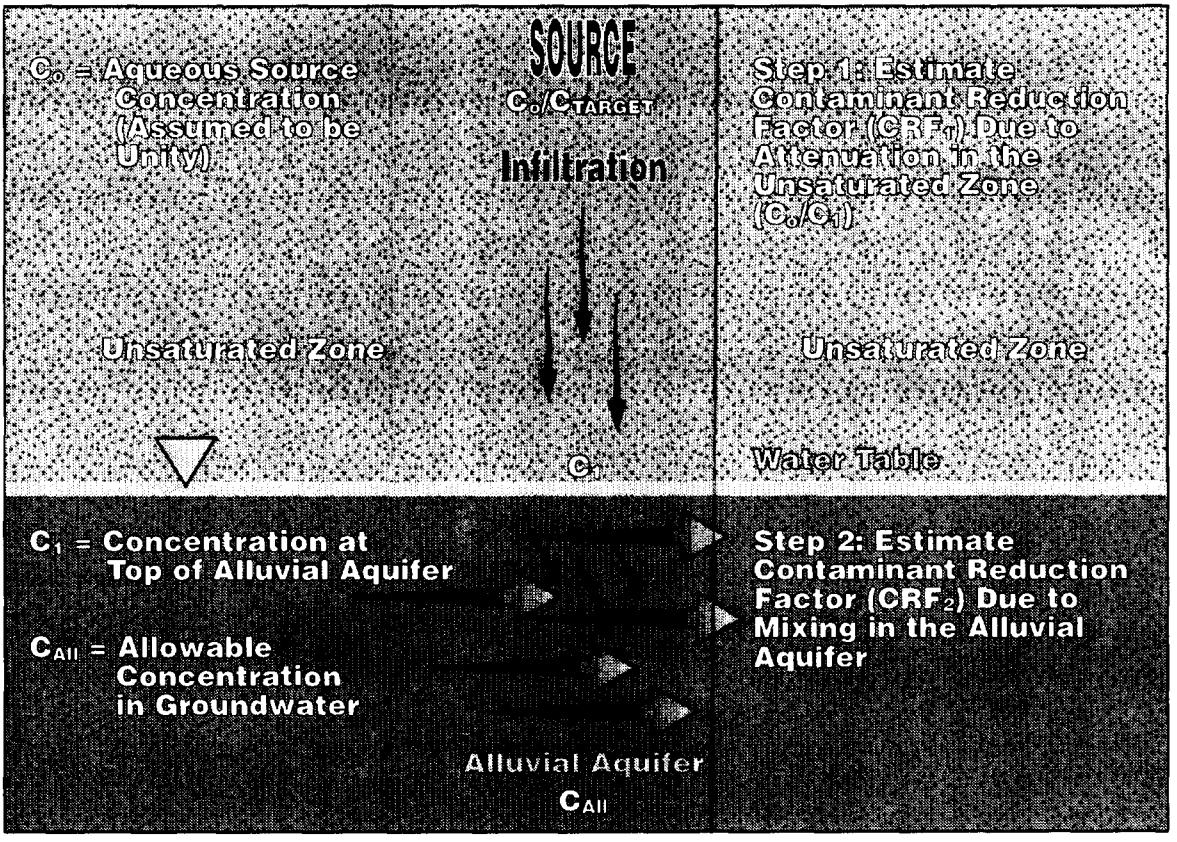
FIGURES



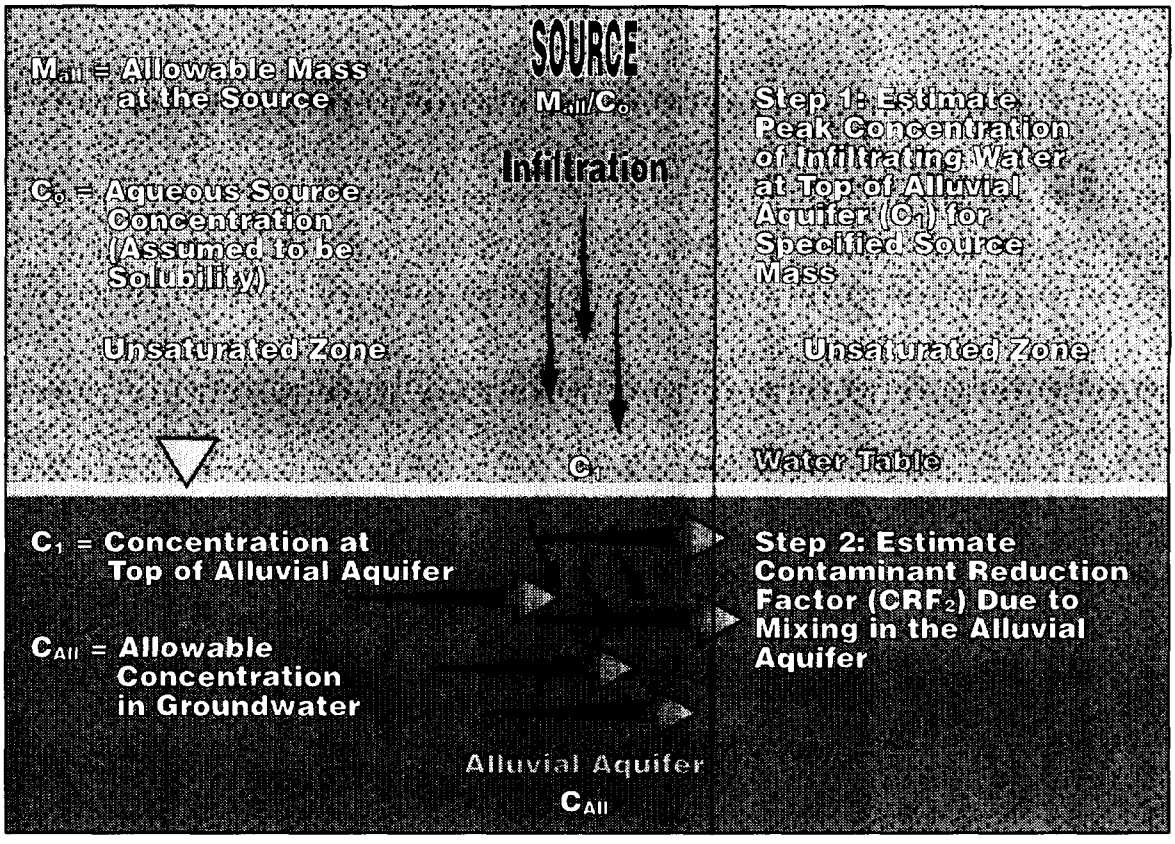
Step 3: Back Calculate Allowable Leachate Concentrations (C_{TARGET}) at Source Based on Allowable Concentrations in Groundwater (C_{All})

$$C_{TARGET} = (C_{All})\ (CRF_1)\ (CRF_2)$$

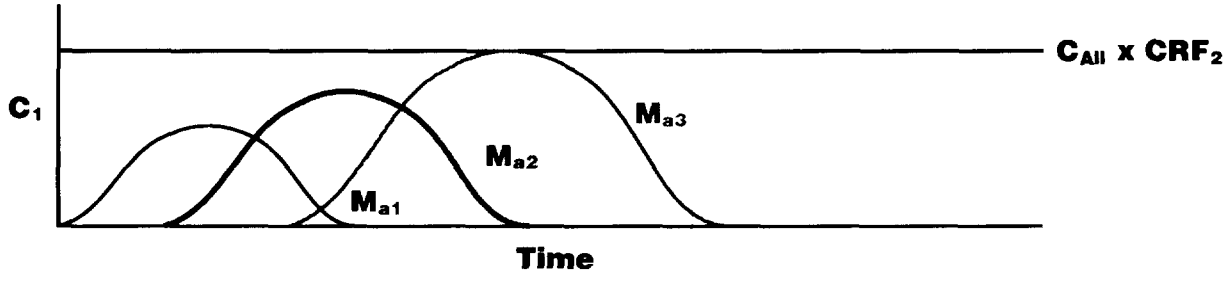
Step 4: Estimate Soil Action Levels (C_{SAL}) Using C_{All} and the Adsorption Factor (A_d) Which is Based on Chemical Specific Factors and Soil Properties

$$C_{SAL} = (C_{TARGET})\ (A_d)$$

RI/FS McINTOSH PLANT SITE Olin CHEMICALS CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Engineering & sciences applied to the earth & its environment			CONCEPTUAL APPROACH TO ESTIMATING SOIL ACTION LEVELS (SOLUTE MODEL)	FILE NO. 90B449C -T11
	SCALE: NTS	DRAWN BY: D.OLSON	DATE: 05/29/93		FIG. NO. 2-1
		CHKD. BY: W.BEAL	DATE: 05/29/93		



Step 3: Simulate Time vs. Concentration Curves For Different Source Masses (M_a) Until $C_1 = C_{All} \times CRF_2$



Step 4: Estimate Soil Action Levels C_{SAL} From the Bulk Density of the Soil (ρ_b) and the Adsorption Factor (A_d) Which is Based on Chemical-Specific Factors and Soil Properties

$$C_{SAL} = \frac{M_{all}}{A_d \rho_b}$$

RI/FS McINTOSH PLANT SITE Olin CHEMICALS CHARLESTON, TENNESSEE	Woodward-Clyde Consultants Engineering & sciences applied to the earth & its environment		CONCEPTUAL APPROACH TO ESTIMATING SOIL ACTION LEVELS (PESTAN MODEL)	FILE NO. 90B449C-T11
	SCALE: NTS	DRAWN BY: D.OLSON DATE: 05/29/93 CHKD. BY: W.BEAL DATE: 05/29/93		FIG. NO. 2-2

ATTACHMENTS

ATTACHMENT A

BORING LOGS FROM OLD PLANT (CPC) LANDFILL AND FORMER CPC PLANT AREAS

SAMPLER SYMBOLS

Pushing Split-Spoon

No Recovery

Auger

Shelby tube (California Sampler)

Split-Spoon with blow counts

No sample taken at this interval

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BCP1
FILE: 90B449C-3F
DATE: 8/12/92
TECHNICIAN: F. Sierra
APPROVED: VP.
PAGE: 1 of 1

Hollow-stem Augered: **Full Depth**

No free water was encountered during hollow-stem augering.

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DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		2.0	N/A	N/A	4	Shell and fill material (FILL)
			BKG	N/A		
		2.75	1	N/A	9	Stiff dark brown (7.5YR 4/4) Silty CLAYS, dry (CL)
						—mottled with red (10R 4/8) and no silt after 2'
		3.5	BKG	N/A	15	—with mottled pattern of gray (2.5YR N6) at 4'
5						
		3.5	N/A	BKG	12	—gray (2.5Y N6) with red (2.5YR 5/8) iron staining below 6'
		3.5	N/A	4	20	
10			46	N/A	1	
			186	N/A	12	Firm light brownish gray (10YR 6/2) Clayey SANDS, dry, with brown yellow (10YR 6/6) iron staining (SC)
		12 b/ft	6	N/A	13	—interbedded with clayey silt and with red (2.5YR 4/6) iron staining, 12'- 14' —no clayey silt below 14'
15						
		22 b/ft	6	N/A	13	
		18 b/ft	5	N/A	20	—firm light gray (10YR 7/1) fine sand, well sorted, dry, 18'- 22'
20		25 b/ft	21	N/A	22	—slightly clayey at 20'
		28 b/ft	15	1	11	—brownish yellow (10YR 5/8), coarse grained, 22'- 24'
		21 b/ft	5	1	18	—brownish yellow and light gray (10YR 7/1), 24'- 26'
25		20 b/ft	6	1	14	—brownish yellow and light gray below 26'
			5	0.5	12	
30			3	0.5	24	
						Bottom of boring at 32'. Borehole grouted full depth.

Soil samples retained for lab analysis from 2'-4', 8'-10', 12'-14' and 30'- 32'.

NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.

N/A = Not Available

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

BORING: BCP2
FILE: 90B449C-3F
DATE: 8/13/92
TECHNICIAN: F. Sierra
APPROVED: NR
PAGE: 1 of 1

Hollow-stem Augered: Full Depth
No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum	
0		NR				Shells	(FILL)
		2.5	5	0.5	23	Stiff gray (2.5Y N6) and red (10R 4/8) CLAYS, damp	(CH)
		2.5	5	0.25	14		
5		2.5	3	0.5	17		
			2	BKG	16		
10			1	0.25	14	Firm brown (10YR 5/3) Clayey SILTS, damp, with iron stains	(ML)
		NR	2	0.5		—olive yellow (2.5Y 6/8) below 10'	
			4	0.5	12	—becoming clayey below 14'	
15		NR	1	BKG		Loose, light gray (10YR 7/1) SILTS, damp	(ML)
			1	BKG	10		
20						Bottom of boring at 20'. Borehole grouted full depth.	

Soil samples retained for lab analysis from 2'-4', 8'-10', 14'-16' and 18'-20'.
10" Carbon steel casing set from 0'-9'.
NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.
N/A = Not Available

Unified Soil Classifications based on visual observations.

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BOP1
FILE: 90B449C-3F
DATE: 8/17/92
TECHNICIAN: F. Sierra
APPROVED: VP.
PAGE: 1 of 2

Hollow-stem Augered: Full Depth

No free water was encountered during hollow stem augering.

4 9 0539

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		1.0	BKG	BKG	23	Medium brownish yellow (10YR 6/6) CLAYS, dry (FILL)
		1.5	BKG	BKG	14	
5		1.5	BKG	BKG	13	Medium dark brown (7.5YR 3/2) Silty CLAYS, damp, with roots, rock and shell fragments (FILL)
		1.5	8	BKG	14	—light yellowish brown (2.5Y 6/4) with wood fragments and iron staining below 6'
		1.5	8	2	15	—with 4" white (10YR 8/1) coarse sand and clay pockets at 9.5'
10		2.0	BKG	BKG	13	—with 6" dark brown (10YR 3/3) soil with roots at 10' —yellow brown (10YR 5/8) and gray (10YR 6/1) clay, 10.5'- 12' —with 1" granular, very coarse white material, wet at 11.5'
		NR	8	7		Loose dark brown SILT/CLAY, saturated (ML/CH)
		NR				
15		NR				—with sudden drop of tools at 16'- 18'
		NR				
20		NR				
		2.5	3.6	100	8	Stiff gray (5Y 6/1) and yellowish brown (10YR 5/8) CLAYS (CH)
			N/A	N/A	11	
		NR	268	77		
25		3.0	493	173	13	—gray (5Y 6/1) with ferrous stains below 26'
			53	2	18	Interbedded medium gray (5YR 6/1) CLAYS, dry, with iron staining and light gray (5YR 7/1) loose fine SANDS (CH/ML)
30			243	63	14	Loose reddish yellow (5YR 7/6) fine SANDS, well sorted, dry (ML)
			63	18	12	
			73	18	13	
35			891	399	14	
			141	59	14	—coarse below 38'
40						

Continued Next Page

Soil samples retained for lab analysis from 10'-12', 12'-21', 26'-28', 38'-40' and 46'-48'.
8" Carbon steel casing set from 0'-23'.
NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.
NR = No Recovery
N/A = Not Available
Unified Soil Classifications based on visual observations.

LOG OF BORING

PROJECT: RI/FS Phase III

LOCATION: Olin Chemicals
McIntosh, Alabama

CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BOP1
FILE: 90B449C-3F
DATE: 8/17/92
TECHNICIAN: F. Sierra
APPROVED: VP.
PAGE: 2 of 2

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
40			306	189	15	Loose reddish yellow (5YR 7/6) fine SANDS, well sorted, dry (ML)
			441	109	6	—wet below 41'
			141	30	16	
45					20	
						Bottom of boring at 48'. Borehole grouted full depth.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: **RI/FS Phase III**
LOCATION: **Olin Chemicals McIntosh, Alabama**
CLIENT: **Olin Chemical Corporation Charleston, Tennessee**

BORING: **BOP2**
FILE: **90B449C-3F**
DATE: **8/18/92**
TECHNICIAN: **F. Sierra**
APPROVED: VP.
PAGE: **1 of 1**

Hollow-stem Augered: **Full Depth**
No free water was encountered during hollow-stem augering.

4 9 0590

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		2.0	N/A	N/A	22	Stiff gray (10YR 6/1) and yellow brown (10YR 5/8) CLAYS, blocky with grass roots, dry (FILL)
		NR	N/A	N/A		White (10YR 8/1) brine well sand, dry lime and fragments of brine well sand (FILL)
5		NR	N/A	N/A		
		NR	N/A	N/A		
			N/A	N/A	14	—with layers of lime and dark gray (5YR 3/1) soil with roots, 8'- 12'
10			N/A	N/A	8	—with yellowish borwn (10YR 5/8) and gray (10YR 6/1) clay at 11'
			N/A	N/A	14	Very soft dark brown (7.5YR 4/2) CLAYS with sand and roots, very wet (CH)
15		NR	N/A	N/A		Loose yellowish red (5YR 5/8) SILT/CLAY, saturated (ML/CH)
		NR				
		0.75	8	2	12	Soft gray (10YR 6/1) and red (10YR 4/8) CLAYS, dry (CH)
20		2.0	3	BKG	18	—stiff below 20'
			BKG	BKG	20	Loose brownish yellow (10YR 5/8) fine SANDS, dry (ML) —yellow (10YR 7/8) medium sands
25			3	0.5	10	—fine
			0.5	BKG	20	—medium
			7	0.5	20	—white (10YR 8/2) below 28'
30			3	0.4	20	
			3	0.9	20	
			5	0.6	24	
35			5	0.8	18	—coarse
						—very coarse, gravelly, wet
			8	1.9	18	Bottom of boring at 40'. Borehole grouted full depth.
40						

Soil samples retained for lab analysis from 2'-8', 18'-19', 20'-21', 28'-30' and 38'-40'.
8" Carbon steel casing set from 0'- 19'.
NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.
N/A = Not Available

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals
McIntosh, Alabama
CLIENT: Olin Chemical Corporation
Charleston, Tennessee

BORING: BOP3
FILE: 90B449C-3F
DATE: 9/1/92
TECHNICIAN: F. Sierra
APPROVED: VP.
PAGE: 1 of 2

Hollow-stem Augered: **Full Depth**

Free water was encountered at a depth of 39' during hollow stem augering. The water level rose to a depth of 38.1' after an observation period of 30 minutes.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		1.5			19	Topsoil
		1.5			12	Medium reddish yellow (7.5YR 6/8) and gray (7.5YR N6) CLAYS with grass and roots, dry (FILL)
5		1.0			12 19	Medium reddish yellow, gray and dark brown (7.5YR 3/4) Silty CLAYS (FILL) —dark yellowish brown (10YR 3/4) with shell and rock fragments, 5'- 6' —soft below 6' —black (5Y 2.5/2) at 7'
10		2.5 3.5			16 20	Stiff gray (2.5YR N5) and red (2.5YR 4/8) CLAYS, dry (CH) —with small pockets of silty clay at 9'
		3.0	45	0.5	8	
15		3.0	46	BKG	21	—with thin (1/2") lenses of silty clay, 15'- 18'
		3.0	71	0.5	12	
		3.0	21	0.5	10	—with some very small pockets of silty clay and ferrous stains at 18'
20		2.5	10	0.5	23	
		2.0	6	0.5	13	—with a layer of silty clay and small silty clay pockets at 22'
		2.0	5	0.5	24	
25			1	BKG	8	Loose strong brown (7.5YR 5/8) coarse SANDS, dry to damp (SP) —white (5Y 8/2) below 26'
			0.5	BKG	8	
30			1	BKG	16	
			1	0.5	8	
35			1	0.5	24	
			2	1	10	—reddish yellow (7.5YR 6/6) below 36'
40			1	1.5	14	—wet and very coarse with gravel below 39'

Continued Next Page

Soil samples retained for lab analysis from 4'-5', 24'-25', 38'-40' and 40'-42'.
8" Carbon steel casing set from 0'-11'.
NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.
N/A = Not Available
NR = No Recovery
Unified Soil Classifications based on visual observations.

LOG OF BORING

PROJECT: RI/FS Phase III
LOCATION: Olin Chemicals McIntosh, Alabama
CLIENT: Olin Chemical Corporation Charleston, Tennessee

BORING: BOP3
FILE: 90B449C-3F
DATE: 9/1/92
TECHNICIAN: F. Sierra
APPROVED: VP.
PAGE: 2 of 2

4 9 0591

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
40			3	1	12	Loose reddish yellow (7.5YR 6/6) coarse SANDS with gravel (SP)
		NR				
		NR				
45						Bottom of boring at 45'. Borehole grouted full depth.

Unified Soil Classifications based on visual observations.

Woodward-Clyde Consultants

LOG OF BORING

PROJECT: **RI/FS Phase III**
LOCATION: **Olin Chemicals McIntosh, Alabama**
CLIENT: **Olin Chemical Corporation Charleston, Tennessee**

BORING: **BOP4**
FILE: **90B449C-3F**
DATE: **8/31/92**
TECHNICIAN: **F. Sierra**
APPROVED: VP.
PAGE: **1 of 1**

Hollow-stem Augered: **Full Depth**

No free water was encountered during hollow-stem augering.

DEPTH (FEET)	SAMPLE	P.Pen. (tsf)	OVA (ppm)	HNu (ppm)	Recovery (inch)	Description of Stratum
0		2.0			18	Dark brown (7.5YR 3/2) Soil with roots (FILL)
						Medium strong brown (7.5YR 5/8) and gray (7.5YR N6) CLAYS with roots, dry (FILL)
		NR				Dark brown (7.5YR 3/2) Silty CLAYS with sand, shell, wood fragments, rocks, brine well sand and metal scraps (FILL)
5		0.5			14	—with very soft strong brown (7.5YR 5/8) clay with plastic and glass fragments at 4'
		NR				—with large pieces of metal, wood and white powder at 6'
		NR				Loose dark brown (7.5YR 4/2) SILT/CLAY, saturated (ML/CH)
10		NR				
		3.0			20	Stiff gray (5YR 6/1) and red (10R 4/8) CLAYS (CH)
		3.5			20	
15		3.0	140	89	22	
		2.0	390	169	24	
20			170	250	22	Interbedded Clayey SILTS and reddish yellow (7.5YR 6/8) fine SANDS, dry (ML/SP)
			120	103	20	
			15	5	14	Reddish yellow (7.5YR 6/8) fine SANDS, dry (SP)
25						—coarse, 24'- 36'
			2	1		
			18	5		—reddish yellow (7.5YR 6/8) and pink (7.5YR 8/4) below 28'
30			15	3.5	14	
			1	1.5	10	
			4	2	12	
35			5	1	24	—fine below 36'
						—with a 2" layer of clayey sand, damp at 39'
			1.5	1	24	Bottom of boring at 40'. Borehole grouted full depth.
40						

Soil samples retained for lab analysis from 4'-6', 18'-20', 20'-22' and 38'-40'. 8" Carbon steel casing set from 0'-15'.

NOTE: Headspace readings shown indicate organic vapor levels, within the headspace sample, above background conditions at that time.

N/A = Not Available

NR = No Recovery

Unified Soil Classifications based on visual observations.

ATTACHMENT B

CONTAMINATED MASS CALCULATIONS

FORMER CPC PLANT AREA

1,2,4-TRICHLOROBENZENE						
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)
BCP1	CLAY	2.13	2555.00	1590	350.65	3034.18
	UPPER SAND	0.91	2555.00	1720	8.5	33.99
	LOW. SAND	0.00	2555.00	1720	0	0.00
					TOTAL	3068.17

1,2-DICHLOROBENZENE						
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)
BCP1	CLAY	2.13	2555.00	1590	15	129.80
	UPPER SAND	0.91	2555.00	1720	3.5	14.00
	LOW. SAND	0.00	2555.00	1720	0	0.00
					TOTAL	143.79

1,3-TRICHLOROBENZENE						
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)
BCP1	CLAY	2.13	2555.00	1590	1.25	10.82
	UPPER SAND	0.91	2555.00	1720	0.22	0.88
	LOW. SAND	0.00	2555.00	1720	0	0.00
					TOTAL	11.70

1,4-TRICHLOROBENZENE						
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)
BCP1	CLAY	2.13	2555.00	1590	1.2	10.38
	UPPER SAND	0.91	2555.00	1720	2.2	8.80
	LOW. SAND	0.00	2555.00	1720	0	0.00
					TOTAL	19.18

BENZENE						
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)
BCP1	CLAY	2.13	2555.00	1590	0.0015	0.01
	UPPER SAND	0.91	2555.00	1720	0	0.00
	LOW. SAND	0.00	2555.00	1720	0	0.00
					TOTAL	0.01

CHLOROBENZENE						
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)
BCP1	CLAY	2.13	2555.00	1590	0.313	2.71
	UPPER SAND	0.91	2555.00	1720	0.4	1.60
	LOW. SAND	0.00	2555.00	1720	0	0.00
					TOTAL	4.31

NOTE: THIS TABLE WAS GENERATED BASED ON AN AREA OF 27,500 SQUARE FEET.
THE ACTUAL AREA OF THE CPC PLANT IS 15,000 SQUARE FEET

dential. Olin does not believe remedial decisions should be based on this ario because it will never happen.

se let me know if you have any questions.

Sincerely,

OLIN CORPORATION

J. C. Brown

J. C. Brown
Manager, Environmental Technology

chment and Enclosures

W. A. Beal
D. E. Cooper (2)
L. S. Casteel (w/o att.)
A. S. Karlin
W. G. McGlasson (w/o att.)
T. B. Odom

OLD PLANT (CPC) LANDFILL

1,2-DICHLOROBENZENE							
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)	TOTAL MASS (kg)
BOP1	WASTE	3.66	2787.09	1590	2.900	47.00	
	LOOSE SI/CL	2.74	2787.09	1590	120.000	1458.77	
	CLAY	1.98	2787.09	1590	1.800	15.80	
	SAND	3.98	2787.09	1720	6.950	132.73	
							1654.30
BOP2	WASTE	4.27	2787.09	1590	0.000	0.00	
	CLAY	2.13	2787.09	1590	0.000	0.00	
	SAND	5.09	2787.09	1720	0.000	0.00	
							0.00
BOP3	WASTE	2.44	2787.09	1590	110.000	1188.63	
	CLAY	5.18	2787.09	1590	0.000	0.00	
	SAND	4.06	2787.09	1720	0.000	0.00	
							1188.63
BOP4	WASTE	2.44	2787.09	1590	2.100	22.69	
	CLAY	3.66	2787.09	1590	57.000	923.89	
	SAND	6.18	2787.09	1720	65.000	1925.14	
							2871.72
							5714.65

SUMMARY (MASS IN kg)		ALL BORINGS	BOP1 + BOP4 (WEST)	BOP2+BOP3 (EAST)
	WASTE	1258.32	69.70	1188.63
	LOOSE SI/CL	1458.77	1458.77	----
	CLAY	939.69	939.69	0.00
	SAND	2057.86	2057.86	0.00
	ALL UNITS	**5714.65**	**4526.02**	**1188.63**

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OLD PLANT (CPC) LANDFILL

1,3-DICHLOROBENZENE							
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)	TOTAL MASS (kg)
BOP1	WASTE	3.66	2787.09	1590	0.160	2.59	
	LOOSE SI/CL	2.74	2787.09	1590	7.100	86.31	
	CLAY	1.98	2787.09	1590	0.000	0.00	
	SAND	3.98	2787.09	1720	0.215	4.11	
							93.01
BOP2	WASTE	4.27	2787.09	1590	0.000	0.00	
	CLAY	2.13	2787.09	1590	0.000	0.00	
	SAND	5.09	2787.09	1720	0.000	0.00	
							0.00
BOP3	WASTE	2.44	2787.09	1590	6.600	71.32	
	CLAY	5.18	2787.09	1590	0.000	0.00	
	SAND	4.06	2787.09	1720	0.000	0.00	
							71.32
BOP4	WASTE	2.44	2787.09	1590	1.900	20.53	
	CLAY	3.66	2787.09	1590	5.000	81.04	
	SAND	6.18	2787.09	1720	5.500	162.90	
							264.47
							428.80

SUMMARY (MASS IN kg)		ALL BORINGS	BOP1 + BOP4 (WEST)	BOP2+BOP3 (EAST)
	WASTE	94.44	23.12	71.32
	LOOSE SI/CL	86.31	86.31	----
	CLAY	81.04	81.04	0.00
	SAND	167.00	167.00	0.00
	ALL UNITS	428.80	357.48	71.32

OLD PLANT (CPC) LANDFILL

1,4-DICHLOROBENZENE							
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)	TOTAL MASS (kg)
BOP1	WASTE	3.66	2787.09	1590	2.700	43.76	
	LOOSE SI/CL	2.74	2787.09	1590	120.000	1458.77	
	CLAY	1.98	2787.09	1590	2.200	19.32	
	SAND	3.98	2787.09	1720	11.750	224.39	
							1746.24
BOP2	WASTE	4.27	2787.09	1590	0.000	0.00	
	CLAY	2.13	2787.09	1590	0.000	0.00	
	SAND	5.09	2787.09	1720	0.000	0.00	
							0.00
BOP3	WASTE	2.44	2787.09	1590	120.000	1296.69	
	CLAY	5.18	2787.09	1590	0.000	0.00	
	SAND	4.06	2787.09	1720	0.000	0.00	
							1296.69
BOP4	WASTE	2.44	2787.09	1590	17.000	183.70	
	CLAY	3.66	2787.09	1590	74.000	1199.43	
	SAND	6.18	2787.09	1720	75.000	2221.31	
							3604.44
							6647.37

SUMMARY (MASS IN kg)		ALL BORINGS	BOP1 + BOP4 (WEST)	BOP2+BOP3 (EAST)
	WASTE	1524.15	227.46	1296.69
	LOOSE SI/CL	1458.77	1458.77	----
	CLAY	1218.75	1218.75	0.00
	SAND	2445.71	2445.71	0.00
	ALL UNITS	6647.37	5350.69	1296.69

OLD PLANT (CPC) LANDFILL

1,2,4-TRICHLOROBENZENE							
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)	TOTAL MASS (kg)
BOP1	WASTE	3.66	2787.09	1590	0.750	12.16	
	LOOSE SI/CL	2.74	2787.09	1590	30.000	364.69	
	CLAY	1.98	2787.09	1590	0.000	0.00	
	SAND	3.98	2787.09	1720	2.695	51.47	
							428.32
BOP2	WASTE	4.27	2787.09	1590	0.000	0.00	
	CLAY	2.13	2787.09	1590	0.000	0.00	
	SAND	5.09	2787.09	1720	0.000	0.00	
							0.00
BOP3	WASTE	2.44	2787.09	1590	20.000	216.11	
	CLAY	5.18	2787.09	1590	0.000	0.00	
	SAND	4.06	2787.09	1720	0.000	0.00	
							216.11
BOP4	WASTE	2.44	2787.09	1590	6.400	69.16	
	CLAY	3.66	2787.09	1590	0.710	11.51	
	SAND	6.18	2787.09	1720	0.800	23.69	
							104.36
							748.79

SUMMARY (MASS IN kg)		ALL BORINGS	BOP1 + BOP4 (WEST)	BOP2+BOP3 (EAST)
	WASTE	297.43	81.31	216.11
	LOOSE SI/CL	364.69	364.69	----
	CLAY	11.51	11.51	0.00
	SAND	75.16	75.16	0.00
	ALL UNITS	**748.79**	**532.67**	**216.11**

OLD PLANT (CPC) LANDFILL

BENZENE							
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)	TOTAL MASS (kg)
BOP1	WASTE	3.66	2787.09	1590	0.00	0.00	
	LOOSE SI/CL	2.74	2787.09	1590	2.40	29.18	
	CLAY	1.98	2787.09	1590	3.30	28.97	
	SAND	3.98	2787.09	1720	1.15	21.96	
							80.11
BOP2	WASTE	4.27	2787.09	1590	0.00	0.00	
	CLAY	2.13	2787.09	1590	0.03	0.28	
	SAND	5.09	2787.09	1720	0.00	0.00	
							0.28
BOP3	WASTE	2.44	2787.09	1590	0.00	0.00	
	CLAY	5.18	2787.09	1590	0.00	0.00	
	SAND	4.06	2787.09	1720	0.00	0.00	
							0.00
BOP4	WASTE	2.44	2787.09	1590	0.00	0.00	
	CLAY	3.66	2787.09	1590	0.00	0.00	
	SAND	6.18	2787.09	1720	0.00	0.00	
							0.00
							80.39

SUMMARY (MASS IN kg)		ALL BORINGS	BOP1 + BOP4 (WEST)	BOP2+BOP3 (EAST)
	WASTE	0.00	0.00	0.00
	LOOSE SI/CL	29.18	29.18	----
	CLAY	29.26	28.97	0.28
	SAND	21.96	21.96	0.00
	ALL UNITS	80.39	80.11	0.28

4 9 0596

C:\FSIERRA\OLINFATE\002.XLS

OLD PLANT (CPC) LANDFILL

CHLOROBENZENE							
	UNIT SAMPLED	THICKNESS (m)	AREA (m2)	DENSITY (kg/m3)	AVE. CONC. (mg/kg)	MASS (kg)	TOTAL MASS (kg)
BOP1	WASTE	3.66	2787.09	1590	6.300	102.11	
	LOOSE SI/CL	2.74	2787.09	1590	60.000	729.39	
	CLAY	1.98	2787.09	1590	7.300	64.09	
	SAND	3.98	2787.09	1720	34.000	649.31	
							1544.90
BOP2	WASTE	4.27	2787.09	1590	0.004	0.08	
	CLAY	2.13	2787.09	1590	0.075	0.70	
	SAND	5.09	2787.09	1720	0.001	0.02	
							0.80
BOP3	WASTE	2.44	2787.09	1590	0.057	0.62	
	CLAY	5.18	2787.09	1590	0.007	0.16	
	SAND	4.06	2787.09	1720	0.000	0.00	
							0.78
BOP4	WASTE	2.44	2787.09	1590	9.700	104.82	
	CLAY	3.66	2787.09	1590	1.800	29.18	
	SAND	6.18	2787.09	1720	23.000	681.20	
							815.19
							2361.67

SUMMARY (MASS IN kg)		ALL BORINGS	BOP1 + BOP4 (WEST)	BOP2+BOP3 (EAST)
	WASTE	207.62	206.93	0.69
	LOOSE SI/CL	729.39	729.39	----
	CLAY	94.13	93.27	0.87
	SAND	1330.53	1330.51	0.02
	ALL UNITS	2361.67	2360.09	1.58

ATTACHMENT C

GROUNDWATER GRADIENT CALCULATIONS

Woodward-Clyde Consultants

4 9 0598

Project Notes

Subject: HORIZONTAL GRADIENT

Project Name: Olin McIntosh

Project No.: 90B449C

Task No.: 11 File No.:

Sheet of

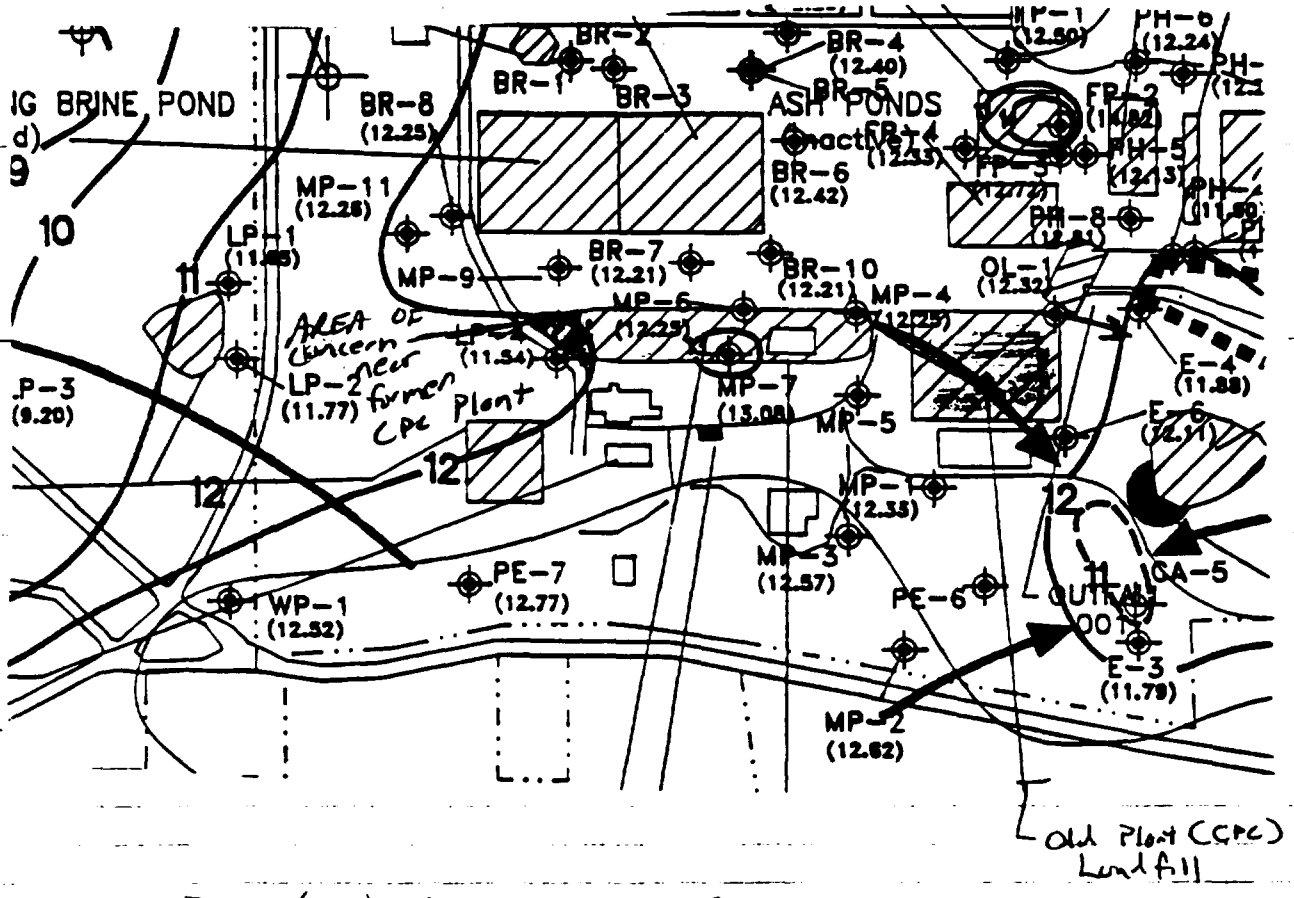
WAB Date: 5/25/93

Checked By: DER Date: 5-25-93

PURPOSE - TO ESTIMATE THE HORIZONTAL GRADIENT IN THE VICINITY OF THE OLD PLANT (CPC) LANDFILL AND FORMER CPC PLANT AREA FOR THE ALLUVIAL AQUIFER

PROCEDURE - GRADIENT MEASUREMENTS WERE TAKEN AT SEVERAL LOCATIONS AROUND BOTH AREAS FOR BOTH THE UPPER AND LOWER ZONES OF THE AQUIFER

POTENTIOMETRIC MAP OF UPPER ZONE - SEPTEMBER 1991
FIGURE 3-11 OF RI DRAFT RI REPORT (Feb 1993)
SCALE 1" = 500'



OLD PLANT (CPC) LANDFILL AREA

FROM MP-4 TO E-6 $\frac{12.25 - 12.11}{680} = 0.0001$

FROM OL-1 TO EAST $\frac{12.32 - 12.0}{190} = 0.0017$

Woodward-Clyde Consultants

Project Notes

Subject: HORIZONTAL GRADIENT

By: LAB Date: 5/25/93

Checked By: DER Date: 5-25-93

Project Name: OLIN McINTOSH

Project No.: 50B4YEC

Task No.: 11 File No.:

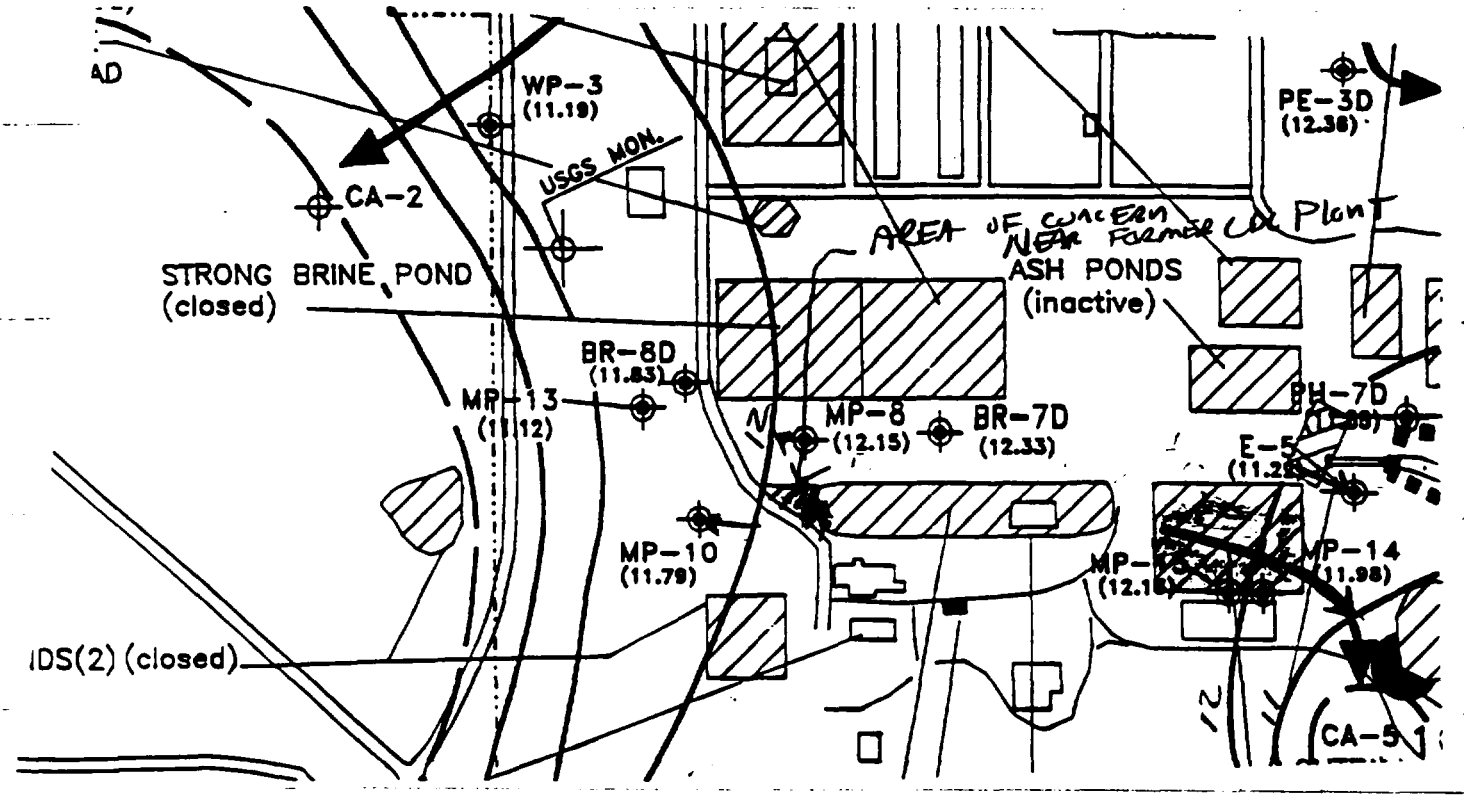
Sheet 2 of 3

AVG – UPPER ZONE = 0.0009

FORMER CPC PLANT AREA

SOUTHWEST FLOW $\frac{12-11.54}{80} = 0.0058$

POTENTIOMETRIC MAP OF LOWER ZONE – SEPTEMBER 1991
FIGURE 3-12 OF RI DRAFT RI REPORT (FEB 1993)
SCALE 1" = 500'



OLD PLANT (CPC) LANDFILL (LOWER ZONE

SOUTHEAST FLOW

SOUTEAST CORNER $\frac{12-11}{250} = 0.004$ ft/ft

NORTHEAST CORNER $\frac{12-11.22}{180} = 0.0043$

AVG LOWER ZONE 0.004

Woodward-Clyde Consultants

4 9 0599

Project Notes

Subject: HORIZONTAL GRADIENT
By: WAB Date: 5/25/93
Checked By: DER Date: 5-25-93

Project Name: Olin McIntosh
Project No.: 5484/5L
Task No.: 11 File No.:
Sheet 3 of 3

FORMER CPL PLANT AREA

WESTERLY ROW
12 NATURL TO MP-10

$\frac{12 - 11.75}{150}$ 0.0014

MP-6 TO 12 CONTOUR
$\frac{12.15 - 12}{75} = 0.002$

AVERAGE = 0.002

SUMMARY

OLD PLANT CPL LANDFILL

AVE GRADIENT FOR UPPER ZONE = 0.0009

AVE GRADIENT FOR LOWER ZONE = 0.004

SELECTED GRADIENT (AVG) = 0.0025 EAST/SE

FORMER CPL PLANT AREA

GRADIENT FOR UPPER ZONE = 0.00575

AVE GRADIENT FOR LOWER ZONE = 0.002

SELECTED GRADIENT (AVG) = 0.004 WEST

ATTACHMENT D

SOLUTE AND PESTAN MODELING DATA

Filename Identification System

4 9 0601

First Character: S or P

S = Solute run
P = Pestan run

Second Character: P or L

P = Former CPC Plant Area
L = Old Plant (CPC) Landfill Area

3rd through 5th characters: Three letters of chemical name

BEN = Benzene
CHB = Chlorobenzene
12D = 1,2 Dichlorobenzene
13D = 1,3 Dichlorobenzene
14D = 1,4 Dichlorobenzene
124 = 1,2,4 Trichlorobenzene
MER = Mercury

6th Character: B or 1

B = no decay
1 = with decay

Example: **Filename SPBEN1**

Contents: **Solute run**
Plant area
Chemical: Benzene
With decay

OLD PLANT (CPC) LANDFILL AREA

SOLUTE RUNS
NO DECAY

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SLBENB.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SLBENB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 5.69
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 5 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 117.9 [y]
DECAY CONSTANT (alpha)..... = .5879D-02 [1/y]

CONCENTRATION C [mg/l]

4 9 0603

TIME [y]	1 DISTANCE 6.83 [m]
5.0000	0.0000
10.0000	0.0000
15.0000	0.0000
20.0000	0.0000
25.0000	0.0000
30.0000	0.0000
35.0000	0.0000
40.0000	0.0002
45.0000	0.0005
50.0000	0.0014
55.0000	0.0031
60.0000	0.0061
65.0000	0.0107
70.0000	0.0172
75.0000	0.0258
80.0000	0.0367
85.0000	0.0499
90.0000	0.0653
95.0000	0.0826
100.0000	0.1017
105.0000	0.1226
110.0000	0.1445
115.0000	0.1671
120.0000	0.1904
125.0000	0.2139
130.0000	0.2373
135.0000	0.2605
140.0000	0.2831
145.0000	0.3051
150.0000	0.3261
155.0000	0.3462
160.0000	0.3650
165.0000	0.3827
170.0000	0.3991
175.0000	0.4141
180.0000	0.4278
185.0000	0.4401
190.0000	0.4511
195.0000	0.4607
200.0000	0.4690
205.0000	0.4761
210.0000	0.4820
215.0000	0.4866
220.0000	0.4902
225.0000	0.4927
230.0000	0.4942
235.0000	0.4947
240.0000	0.4944
245.0000	0.4932
250.0000	0.4913
255.0000	0.4887
260.0000	0.4855
265.0000	0.4816
270.0000	0.4772
275.0000	0.4723
280.0000	0.4670
285.0000	0.4613
290.0000	0.4552
295.0000	0.4488
300.0000	0.4422
305.0000	0.4353
310.0000	0.4282
315.0000	0.4209
320.0000	0.4135
325.0000	0.4059
330.0000	0.3983
335.0000	0.3906
340.0000	0.3828
345.0000	0.3750
350.0000	0.3672
355.0000	0.3594
360.0000	0.3517
365.0000	0.3439
370.0000	0.3362
375.0000	0.3286
380.0000	0.3210
385.0000	0.3135
390.0000	0.3061
395.0000	0.2988
400.0000	0.2916

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SLCHBB.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SLCHBB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 13.24
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 10 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 274.6 [y]
DECAY CONSTANT (alpha)..... = .2524D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]		
10.0000	0.0000	570.0000	0.4935
20.0000	0.0000	580.0000	0.4919
30.0000	0.0000	590.0000	0.4898
40.0000	0.0000	600.0000	0.4872
50.0000	0.0000	610.0000	0.4841
60.0000	0.0000	620.0000	0.4806
70.0000	0.0000	630.0000	0.4768
80.0000	0.0000	640.0000	0.4726
90.0000	0.0001	650.0000	0.4680
100.0000	0.0003	660.0000	0.4632
110.0000	0.0008	670.0000	0.4580
120.0000	0.0018	680.0000	0.4527
130.0000	0.0036	690.0000	0.4471
140.0000	0.0062	700.0000	0.4413
150.0000	0.0101	710.0000	0.4354
160.0000	0.0154	720.0000	0.4293
170.0000	0.0222	730.0000	0.4230
180.0000	0.0307	740.0000	0.4167
190.0000	0.0409	750.0000	0.4103
200.0000	0.0527	760.0000	0.4037
210.0000	0.0661	770.0000	0.3972
220.0000	0.0810	780.0000	0.3905
230.0000	0.0972	790.0000	0.3839
240.0000	0.1148	800.0000	0.377[illegible]
250.0000	0.1332		
260.0000	0.1523		
270.0000	0.1719		
280.0000	0.1920		
290.0000	0.2122		
300.0000	0.2323		
310.0000	0.2524		
320.0000	0.2720		
330.0000	0.2913		
340.0000	0.3099		
350.0000	0.3279		
360.0000	0.3451		
370.0000	0.3615		
380.0000	0.3769		
390.0000	0.3915		
400.0000	0.4050		
410.0000	0.4176		
420.0000	0.4292		
430.0000	0.4398		
440.0000	0.4493		
450.0000	0.4579		
460.0000	0.4655		
470.0000	0.4721		
480.0000	0.4779		
490.0000	0.4827		
500.0000	0.4867		
510.0000	0.4898		
520.0000	0.4922		
530.0000	0.4938		
540.0000	0.4947		
550.0000	0.4949		
560.0000	0.4945		

4 9 0604

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SL12DB.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SL12DB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 56.68
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 50 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 1175.3 [y]
DECAY CONSTANT (alpha)..... = .5898D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]
50.0000	0.0000
100.0000	0.0000
150.0000	0.0000
200.0000	0.0000
250.0000	0.0000
300.0000	0.0000
350.0000	0.0000
400.0000	0.0002
450.0000	0.0005
500.0000	0.0015
550.0000	0.0032
600.0000	0.0063
650.0000	0.0110
700.0000	0.0176
750.0000	0.0264
800.0000	0.0375
850.0000	0.0509
900.0000	0.0664
950.0000	0.0840
1000.0000	0.1033
1050.0000	0.1244
1100.0000	0.1464
1150.0000	0.1692
1200.0000	0.1926
1250.0000	0.2162
1300.0000	0.2397
1350.0000	0.2629
1400.0000	0.2856
1450.0000	0.3075
1500.0000	0.3286
1550.0000	0.3485
1600.0000	0.3674
1650.0000	0.3849
1700.0000	0.4012
1750.0000	0.4161
1800.0000	0.4297
1850.0000	0.4419
1900.0000	0.4527
1950.0000	0.4622
2000.0000	0.4703
2050.0000	0.4772
2100.0000	0.4829
2150.0000	0.4874
2200.0000	0.4908
2250.0000	0.4931
2300.0000	0.4945
2350.0000	0.4949
2400.0000	0.4944
2450.0000	0.4931
2500.0000	0.4911
2550.0000	0.4883
2600.0000	0.4849
2650.0000	0.4809
2700.0000	0.4764
2750.0000	0.4714
2800.0000	0.4660
2850.0000	0.4602
2900.0000	0.4540
2950.0000	0.4475
3000.0000	0.4408
3050.0000	0.4338
3100.0000	0.4266
3150.0000	0.4193
3200.0000	0.4118
3250.0000	0.4042
3300.0000	0.3965
3350.0000	0.3888
3400.0000	0.3810
3450.0000	0.3732
3500.0000	0.3653
3550.0000	0.3575
3600.0000	0.3497
3650.0000	0.3420
3700.0000	0.3343
3750.0000	0.3266
3800.0000	0.3190
3850.0000	0.3115
3900.0000	0.3041
3950.0000	0.2968
4000.0000	0.2896

```
*********************************************************
*                    ONED                               *
*                                                       *
*     INTERNATIONAL GROUND WATER MODELING CENTER        *
*   Golden, Colorado, USA - Delft, The Netherlands      *
*                                                       *
*            S O L U T E   version 2.03                 *
*                                                       *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT           *
*                                                       *
*********************************************************
```

PROJECT..... = SL130B.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SL130B.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 42.8
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 30 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 887.5 [y]
DECAY CONSTANT (alpha)..... = .7810D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]
30.0000	0.0000
60.0000	0.0000
90.0000	0.0000
120.0000	0.0000
150.0000	0.0000
180.0000	0.0000
210.0000	0.0000
240.0000	0.0000
270.0000	0.0000
300.0000	0.0001
330.0000	0.0004
360.0000	0.0010
390.0000	0.0019
420.0000	0.0035
450.0000	0.0060
480.0000	0.0095
510.0000	0.0141
540.0000	0.0200
570.0000	0.0274
600.0000	0.0362
630.0000	0.0464
660.0000	0.0581
690.0000	0.0711
720.0000	0.0853
750.0000	0.1006
780.0000	0.1172
810.0000	0.1342
840.0000	0.1520
870.0000	0.1702
900.0000	0.1888
930.0000	0.2075
960.0000	0.2262
990.0000	0.2449
1020.0000	0.2633
1050.0000	0.2814
1080.0000	0.2990
1110.0000	0.3161
1140.0000	0.3325
1170.0000	0.3483
1200.0000	0.3634
1230.0000	0.3777
1260.0000	0.3912
1290.0000	0.4038
1320.0000	0.4156
1350.0000	0.4265
1380.0000	0.4366
1410.0000	0.4458
1440.0000	0.4541
1470.0000	0.4616
1500.0000	0.4683
1530.0000	0.4741
1560.0000	0.4792
1590.0000	0.4835
1620.0000	0.4871
1650.0000	0.4899
1680.0000	0.4921
1710.0000	0.4936
1740.0000	0.4946
1770.0000	0.4949
1800.0000	0.4947
1830.0000	0.4939
1860.0000	0.4926
1890.0000	0.4909
1920.0000	0.4888
1950.0000	0.4862
1980.0000	0.4832
2010.0000	0.4799
2040.0000	0.4763
2070.0000	0.4723
2100.0000	0.4681
2130.0000	0.4636
2160.0000	0.4589
2190.0000	0.4540
2220.0000	0.4489
2250.0000	0.4436
2280.0000	0.4381
2310.0000	0.4325
2340.0000	0.4268
2370.0000	0.4210
2400.0000	0.415

4 9 0605

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SL14DB.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SL14DB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 28.9
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 20 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .00000+00 [1/y]
HALF-LIFE at Source..... = 599.2 [y]
DECAY CONSTANT (alpha)..... = .1157D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]
20.0000	0.0000
40.0000	0.0000
60.0000	0.0000
80.0000	0.0000
100.0000	0.0000
120.0000	0.0000
140.0000	0.0000
160.0000	0.0000
180.0000	0.0000
200.0000	0.0001
220.0000	0.0004
240.0000	0.0008
260.0000	0.0017
280.0000	0.0032
300.0000	0.0055
320.0000	0.0087
340.0000	0.0130
360.0000	0.0186
380.0000	0.0255
400.0000	0.0338
420.0000	0.0436
440.0000	0.0547
460.0000	0.0671
480.0000	0.0808
500.0000	0.0956
520.0000	0.1117
540.0000	0.1283
560.0000	0.1456
580.0000	0.1635
600.0000	0.1817
620.0000	0.2001
640.0000	0.2186
660.0000	0.2371
680.0000	0.2554
700.0000	0.2734
720.0000	0.2910
740.0000	0.3081
760.0000	0.3247
780.0000	0.3406
800.0000	0.3558
820.0000	0.3703
840.0000	0.3841
860.0000	0.3970
880.0000	0.4091
900.0000	0.4204
920.0000	0.4308
940.0000	0.4404
960.0000	0.4491
980.0000	0.4570
1000.0000	0.4641
1020.0000	0.4704
1040.0000	0.4759
1060.0000	0.4807
1080.0000	0.4847
1100.0000	0.4880
1120.0000	0.4906
1140.0000	0.4926
1160.0000	0.4939
1180.0000	0.4947
1200.0000	0.4949
1220.0000	0.4945
1240.0000	0.4936
1260.0000	0.4923
1280.0000	0.4905
1300.0000	0.4883
1320.0000	0.4857
1340.0000	0.4827
1360.0000	0.4794
1380.0000	0.4758
1400.0000	0.4719
1420.0000	0.4677
1440.0000	0.4632
1460.0000	0.4585
1480.0000	0.4537
1500.0000	0.4486
1520.0000	0.4434
1540.0000	0.4380
1560.0000	0.4324
1580.0000	0.4268
1600.0000	0.4210

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SL124B.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SL124B.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 315.74
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 180 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 6547 [y]
DECAY CONSTANT (alpha)..... = .1059D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]		
180.0000	0.0000	%10260.0000	0.4400
360.0000	0.0000	%10440.0000	0.4473
540.0000	0.0000	%10620.0000	0.4540
720.0000	0.0000	%10800.0000	0.4601
900.0000	0.0000	%10980.0000	0.4658
1080.0000	0.0000	%11160.0000	0.4708
1260.0000	0.0000	%11340.0000	0.4754
1440.0000	0.0000	%11520.0000	0.4794
1620.0000	0.0000	%11700.0000	0.4829
1800.0000	0.0000	%11880.0000	0.4860
1980.0000	0.0000	%12060.0000	0.4886
2160.0000	0.0001	%12240.0000	0.4907
2340.0000	0.0003	%12420.0000	0.4923
2520.0000	0.0006	%12600.0000	0.4936
2700.0000	0.0011	%12780.0000	0.4944
2880.0000	0.0020	%12960.0000	0.4948
3060.0000	0.0032	%13140.0000	0.4949
3240.0000	0.0050	%13320.0000	0.4945
3420.0000	0.0074	%13500.0000	0.4939
3600.0000	0.0106	%13680.0000	0.4929
3780.0000	0.0145	%13860.0000	0.4916
3960.0000	0.0193	%14040.0000	0.4900
4140.0000	0.0251	%14220.0000	0.4881
4320.0000	0.0318	%14400.0000	0.4860
4500.0000	0.0394		
4680.0000	0.0481		
4860.0000	0.0576		
5040.0000	0.0680		
5220.0000	0.0792		
5400.0000	0.0913		
5580.0000	0.1040		
5760.0000	0.1176		
5940.0000	0.1315		
6120.0000	0.1458		
6300.0000	0.1604		
6480.0000	0.1754		
6660.0000	0.1905		
6840.0000	0.2057		
7020.0000	0.2210		
7200.0000	0.2362		
7380.0000	0.2513		
7560.0000	0.2662		
7740.0000	0.2809		
7920.0000	0.2953		
8100.0000	0.3093		
8280.0000	0.3229		
8460.0000	0.3362		
8640.0000	0.3489		
8820.0000	0.3612		
9000.0000	0.3730		
9180.0000	0.3842		
9360.0000	0.3949		
9540.0000	0.4051		
9720.0000	0.4147		
9900.0000	0.4237		
%10080.0000	0.4321		

4 9 0606

```
*********************************************************
*                       ONED                            *
*                                                       *
*     INTERNATIONAL GROUND WATER MODELING CENTER        *
*   Golden, Colorado, USA - Delft, The Netherlands      *
*                                                       *
*             S O L U T E   version 2.03                *
*                                                       *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT           *
*                                                       *
*********************************************************
```

PROJECT..... = SLMERB.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SLMERB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 693.5599999999999
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 480 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .00000+00 [1/y]
HALF-LIFE at Source..... = 14381.1 [y]
DECAY CONSTANT (alpha)..... = .48200-04 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]		
480.0000	0.0000	X27360.0000	0.492
960.0000	0.0000	X27840.0000	0.493
1440.0000	0.0000	X28320.0000	0.494
1920.0000	0.0000	X28800.0000	0.494
2400.0000	0.0000	X29280.0000	0.494
2880.0000	0.0000	X29760.0000	0.493
3360.0000	0.0000	X30240.0000	0.492
3840.0000	0.0000	X30720.0000	0.490
4320.0000	0.0000	X31200.0000	0.488
4800.0000	0.0001	X31680.0000	0.485
5280.0000	0.0004	X32160.0000	0.482
5760.0000	0.0008	X32640.0000	0.479
6240.0000	0.0017	X33120.0000	0.475
6720.0000	0.0032	X33600.0000	0.471
7200.0000	0.0055	X34080.0000	0.467
7680.0000	0.0087	X34560.0000	0.463
8160.0000	0.0130	X35040.0000	0.458
8640.0000	0.0186	X35520.0000	0.453
9120.0000	0.0255	X36000.0000	0.448
9600.0000	0.0338	X36480.0000	0.443
X10080.0000	0.0436	X36960.0000	0.438
X10560.0000	0.0547	X37440.0000	0.432
X11040.0000	0.0672	X37920.0000	0.426
X11520.0000	0.0808	X38400.0000	0.421
X12000.0000	0.0956		
X12480.0000	0.1117		
X12960.0000	0.1283		
X13440.0000	0.1456		
X13920.0000	0.1635		
X14400.0000	0.1817		
X14880.0000	0.2001		
X15360.0000	0.2187		
X15840.0000	0.2371		
X16320.0000	0.2554		
X16800.0000	0.2734		
X17280.0000	0.2910		
X17760.0000	0.3081		
X18240.0000	0.3247		
X18720.0000	0.3406		
X19200.0000	0.3559		
X19680.0000	0.3704		
X20160.0000	0.3841		
X20640.0000	0.3970		
X21120.0000	0.4091		
X21600.0000	0.4204		
X22080.0000	0.4308		
X22560.0000	0.4404		
X23040.0000	0.4491		
X23520.0000	0.4570		
X24000.0000	0.4641		
X24480.0000	0.4704		
X24960.0000	0.4759		
X25440.0000	0.4807		
X25920.0000	0.4847		
X26400.0000	0.4880		
X26880.0000	0.4906		

OLD PLANT (CPC) LANDFILL AREA

SOLUTE RUNS
WITH DECAY

4 9 0608

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SLBEN1.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SLBEN1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 5.69
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 4 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 2.2 [y]
DECAY CONSTANT (lambda)..... = .3151D+00 [1/y]
HALF-LIFE at Source..... = 117.9 [y]
DECAY CONSTANT (alpha)..... = .5879D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]
4.0000	0.0000
8.0000	0.0000
12.0000	0.0000
16.0000	0.0000
20.0000	0.0000
24.0000	0.0000
28.0000	0.0000
32.0000	0.0000
36.0000	0.0000
40.0000	0.0000
44.0000	0.0000
48.0000	0.0000
52.0000	0.0000
56.0000	0.0000
60.0000	0.0000
64.0000	0.0000
68.0000	0.0000
72.0000	0.0000
76.0000	0.0000
80.0000	0.0000
84.0000	0.0000
88.0000	0.0000
92.0000	0.0000
96.0000	0.0000
100.0000	0.0000
104.0000	0.0000
108.0000	0.0000
112.0000	0.0000
116.0000	0.0000
120.0000	0.0000
124.0000	0.0000
128.0000	0.0000
132.0000	0.0000
136.0000	0.0000
140.0000	0.0000
144.0000	0.0000
148.0000	0.0000
152.0000	0.0000
156.0000	0.0000
160.0000	0.0000
164.0000	0.0000
168.0000	0.0000
172.0000	0.0000
176.0000	0.0000
180.0000	0.0000
184.0000	0.0000
188.0000	0.0000
192.0000	0.0000
196.0000	0.0000
200.0000	0.0000
204.0000	0.0000
208.0000	0.0000
212.0000	0.0000
216.0000	0.0000
220.0000	0.0000
224.0000	0.0000
228.0000	0.0000
232.0000	0.0000
236.0000	0.0000
240.0000	0.0000
244.0000	0.0000
248.0000	0.0000
252.0000	0.0000
256.0000	0.0000
260.0000	0.0000
264.0000	0.0000
268.0000	0.0000
272.0000	0.0000
276.0000	0.0000
280.0000	0.0000
284.0000	0.0000
288.0000	0.0000
292.0000	0.0000
296.0000	0.0000
300.0000	0.0000
304.0000	0.0000
308.0000	0.0000
312.0000	0.0000
316.0000	0.0000
320.0000	0.0000

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SLCHB1.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SLCHB1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 13.24
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 6 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 20.5 [y]
DECAY CONSTANT (lambda)..... = .3381D-01 [1/y]
HALF-LIFE at Source..... = 274.6 [y]
DECAY CONSTANT (alpha)..... = .2524D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]		
6.0000	0.0000	342.0000	0.0002
12.0000	0.0000	348.0000	0.0002
18.0000	0.0000	354.0000	0.0002
24.0000	0.0000	360.0000	0.0002
30.0000	0.0000	366.0000	0.0002
36.0000	0.0000	372.0000	0.0002
42.0000	0.0000	378.0000	0.0002
48.0000	0.0000	384.0000	0.0002
54.0000	0.0000	390.0000	0.0002
60.0000	0.0000	396.0000	0.0002
66.0000	0.0000	402.0000	0.0002
72.0000	0.0000	408.0000	0.0002
78.0000	0.0000	414.0000	0.0002
84.0000	0.0000	420.0000	0.0002
90.0000	0.0000	426.0000	0.0002
96.0000	0.0000	432.0000	0.0002
102.0000	0.0000	438.0000	0.0002
108.0000	0.0000	444.0000	0.0002
114.0000	0.0000	450.0000	0.0002
120.0000	0.0000	456.0000	0.0002
126.0000	0.0001	462.0000	0.0002
132.0000	0.0001	468.0000	0.0001
138.0000	0.0001	474.0000	0.0001
144.0000	0.0001	480.0000	0
150.0000	0.0001		
156.0000	0.0001		
162.0000	0.0002		
168.0000	0.0002		
174.0000	0.0002		
180.0000	0.0002		
186.0000	0.0002		
192.0000	0.0002		
198.0000	0.0002		
204.0000	0.0002		
210.0000	0.0002		
216.0000	0.0002		
222.0000	0.0002		
228.0000	0.0002		
234.0000	0.0002		
240.0000	0.0002		
246.0000	0.0002		
252.0000	0.0002		
258.0000	0.0002		
264.0000	0.0002		
270.0000	0.0002		
276.0000	0.0002		
282.0000	0.0002		
288.0000	0.0002		
294.0000	0.0002		
300.0000	0.0002		
306.0000	0.0002		
312.0000	0.0002		
318.0000	0.0002		
324.0000	0.0002		
330.0000	0.0002		
336.0000	0.0002		

4 9 0609

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SL12D1.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SL12D1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 56.68
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 4 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 1175.3 [y]
DECAY CONSTANT (alpha)..... = .5898D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]		
4.0000	0.0000	228.0000	0.0000
8.0000	0.0000	232.0000	0.0000
12.0000	0.0000	236.0000	0.0000
16.0000	0.0000	240.0000	0.0000
20.0000	0.0000	244.0000	0.0000
24.0000	0.0000	248.0000	0.0000
28.0000	0.0000	252.0000	0.0000
32.0000	0.0000	256.0000	0.0000
36.0000	0.0000	260.0000	0.0000
40.0000	0.0000	264.0000	0.0000
44.0000	0.0000	268.0000	0.0000
48.0000	0.0000	272.0000	0.0000
52.0000	0.0000	276.0000	0.0000
56.0000	0.0000	280.0000	0.0000
60.0000	0.0000	284.0000	0.0000
64.0000	0.0000	288.0000	0.0000
68.0000	0.0000	292.0000	0.0000
72.0000	0.0000	296.0000	0.0000
76.0000	0.0000	300.0000	0.0000
80.0000	0.0000	304.0000	0.0000
84.0000	0.0000	308.0000	0.0000
88.0000	0.0000	312.0000	0.0000
92.0000	0.0000	316.0000	0.0000
96.0000	0.0000	320.0000	0.0000
100.0000	0.0000		
104.0000	0.0000		
108.0000	0.0000		
112.0000	0.0000		
116.0000	0.0000		
120.0000	0.0000		
124.0000	0.0000		
128.0000	0.0000		
132.0000	0.0000		
136.0000	0.0000		
140.0000	0.0000		
144.0000	0.0000		
148.0000	0.0000		
152.0000	0.0000		
156.0000	0.0000		
160.0000	0.0000		
164.0000	0.0000		
168.0000	0.0000		
172.0000	0.0000		
176.0000	0.0000		
180.0000	0.0000		
184.0000	0.0000		
188.0000	0.0000		
192.0000	0.0000		
196.0000	0.0000		
200.0000	0.0000		
204.0000	0.0000		
208.0000	0.0000		
212.0000	0.0000		
216.0000	0.0000		
220.0000	0.0000		
224.0000	0.0000		

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SL13D1.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SL13D1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 42.8
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 5 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 887.5 [y]
DECAY CONSTANT (alpha)..... = .7810D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]
5.0000	0.0000
10.0000	0.0000
15.0000	0.0000
20.0000	0.0000
25.0000	0.0000
30.0000	0.0000
35.0000	0.0000
40.0000	0.0000
45.0000	0.0000
50.0000	0.0000
55.0000	0.0000
60.0000	0.0000
65.0000	0.0000
70.0000	0.0000
75.0000	0.0000
80.0000	0.0000
85.0000	0.0000
90.0000	0.0000
95.0000	0.0000
100.0000	0.0000
105.0000	0.0000
110.0000	0.0000
115.0000	0.0000
120.0000	0.0000
125.0000	0.0000
130.0000	0.0000
135.0000	0.0000
140.0000	0.0000
145.0000	0.0000
150.0000	0.0000
155.0000	0.0000
160.0000	0.0000
165.0000	0.0000
170.0000	0.0000
175.0000	0.0000
180.0000	0.0000
185.0000	0.0000
190.0000	0.0000
195.0000	0.0000
200.0000	0.0000
205.0000	0.0000
210.0000	0.0000
215.0000	0.0000
220.0000	0.0000
225.0000	0.0000
230.0000	0.0000
235.0000	0.0000
240.0000	0.0000
245.0000	0.0000
250.0000	0.0000
255.0000	0.0000
260.0000	0.0000
265.0000	0.0000
270.0000	0.0000
275.0000	0.0000
280.0000	0.0000
285.0000	0.0000
290.0000	0.0000
295.0000	0.0000
300.0000	0.0000
305.0000	0.0000
310.0000	0.0000
315.0000	0.0000
320.0000	0.0000
325.0000	0.0000
330.0000	0.0000
335.0000	0.0000
340.0000	0.0000
345.0000	0.0000
350.0000	0.0000
355.0000	0.0000
360.0000	0.0000
365.0000	0.0000
370.0000	0.0000
375.0000	0.0000
380.0000	0.0000
385.0000	0.0000
390.0000	0.0000
395.0000	0.0000
400.0000	0.[illegible]

4 9 0610

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*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
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PROJECT..... = SL14D1.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SL14D1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 28.9
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 5 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 599.2 [y]
DECAY CONSTANT (alpha)..... = .1157D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]		
5.0000	0.0000	285.0000	0.0000
10.0000	0.0000	290.0000	0.0000
15.0000	0.0000	295.0000	0.0000
20.0000	0.0000	300.0000	0.0000
25.0000	0.0000	305.0000	0.0000
30.0000	0.0000	310.0000	0.0000
35.0000	0.0000	315.0000	0.0000
40.0000	0.0000	320.0000	0.0000
45.0000	0.0000	325.0000	0.0000
50.0000	0.0000	330.0000	0.0000
55.0000	0.0000	335.0000	0.0000
60.0000	0.0000	340.0000	0.0000
65.0000	0.0000	345.0000	0.0000
70.0000	0.0000	350.0000	0.0000
75.0000	0.0000	355.0000	0.0000
80.0000	0.0000	360.0000	0.0000
85.0000	0.0000	365.0000	0.0000
90.0000	0.0000	370.0000	0.0000
95.0000	0.0000	375.0000	0.0000
100.0000	0.0000	380.0000	0.0000
105.0000	0.0000	385.0000	0.0000
110.0000	0.0000	390.0000	0.0000
115.0000	0.0000	395.0000	0.0000
120.0000	0.0000	400.0000	0.0000
125.0000	0.0000		
130.0000	0.0000		
135.0000	0.0000		
140.0000	0.0000		
145.0000	0.0000		
150.0000	0.0000		
155.0000	0.0000		
160.0000	0.0000		
165.0000	0.0000		
170.0000	0.0000		
175.0000	0.0000		
180.0000	0.0000		
185.0000	0.0000		
190.0000	0.0000		
195.0000	0.0000		
200.0000	0.0000		
205.0000	0.0000		
210.0000	0.0000		
215.0000	0.0000		
220.0000	0.0000		
225.0000	0.0000		
230.0000	0.0000		
235.0000	0.0000		
240.0000	0.0000		
245.0000	0.0000		
250.0000	0.0000		
255.0000	0.0000		
260.0000	0.0000		
265.0000	0.0000		
270.0000	0.0000		
275.0000	0.0000		
280.0000	0.0000		

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*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SL1241.INP
USER NAME..... = ASIERRA
DATE..... = 06-03-1993
DATA FILE..... = C:\OLIN\SL1241.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .2339 [m/y]
LONGITUDINAL DISPERSIVITY..... = .68 [m]
RETARDATION FACTOR..... = 315.74
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 5 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 6.83 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 6547 [y]
DECAY CONSTANT (alpha)..... = .1059D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 6.83 [m]
5.0000	0.0000
10.0000	0.0000
15.0000	0.0000
20.0000	0.0000
25.0000	0.0000
30.0000	0.0000
35.0000	0.0000
40.0000	0.0000
45.0000	0.0000
50.0000	0.0000
55.0000	0.0000
60.0000	0.0000
65.0000	0.0000
70.0000	0.0000
75.0000	0.0000
80.0000	0.0000
85.0000	0.0000
90.0000	0.0000
95.0000	0.0000
100.0000	0.0000
105.0000	0.0000
110.0000	0.0000
115.0000	0.0000
120.0000	0.0000
125.0000	0.0000
130.0000	0.0000
135.0000	0.0000
140.0000	0.0000
145.0000	0.0000
150.0000	0.0000
155.0000	0.0000
160.0000	0.0000
165.0000	0.0000
170.0000	0.0000
175.0000	0.0000
180.0000	0.0000
185.0000	0.0000
190.0000	0.0000
195.0000	0.0000
200.0000	0.0000
205.0000	0.0000
210.0000	0.0000
215.0000	0.0000
220.0000	0.0000
225.0000	0.0000
230.0000	0.0000
235.0000	0.0000
240.0000	0.0000
245.0000	0.0000
250.0000	0.0000
255.0000	0.0000
260.0000	0.0000
265.0000	0.0000
270.0000	0.0000
275.0000	0.0000
280.0000	0.0000
285.0000	0.0000
290.0000	0.0000
295.0000	0.0000
300.0000	0.0000
305.0000	0.0000
310.0000	0.0000
315.0000	0.0000
320.0000	0.0000
325.0000	0.0000
330.0000	0.0000
335.0000	0.0000
340.0000	0.0000
345.0000	0.0000
350.0000	0.0000
355.0000	0.0000
360.0000	0.0000
365.0000	0.0000
370.0000	0.0000
375.0000	0.0000
380.0000	0.0000
385.0000	0.0000
390.0000	0.0000
395.0000	0.0000
400.0000	0.0000

FORMER CPC PLANT AREA

SOLUTE RUNS
NO DECAY

4 9 0612

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*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
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```

PROJECT..... = SPBENB.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SPBENB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 10.47
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 3 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 36.7 [y]
DECAY CONSTANT (alpha)..... = .1889D-01 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
3.0000	0.0000
6.0000	0.0000
9.0000	0.0000
12.0000	0.0000
15.0000	0.0000
18.0000	0.0000
21.0000	0.0001
24.0000	0.0003
27.0000	0.0009
30.0000	0.0022
33.0000	0.0047
36.0000	0.0088
39.0000	0.0148
42.0000	0.0230
45.0000	0.0335
48.0000	0.0462
51.0000	0.0610
54.0000	0.0777
57.0000	0.0959
60.0000	0.1154
63.0000	0.1357
66.0000	0.1564
69.0000	0.1773
72.0000	0.1980
75.0000	0.2181
78.0000	0.2374
81.0000	0.2557
84.0000	0.2728
87.0000	0.2886
90.0000	0.3030
93.0000	0.3159
96.0000	0.3272
99.0000	0.3370
102.0000	0.3452
105.0000	0.3520
108.0000	0.3573
111.0000	0.3611
114.0000	0.3637
117.0000	0.3650
120.0000	0.3651
123.0000	0.3641
126.0000	0.3620
129.0000	0.3591
132.0000	0.3553
135.0000	0.3508
138.0000	0.3456
141.0000	0.3397
144.0000	0.3334
147.0000	0.3266
150.0000	0.3194
153.0000	0.3119
156.0000	0.3041
159.0000	0.2961
162.0000	0.2879
165.0000	0.2797
168.0000	0.2713
171.0000	0.2629
174.0000	0.2545
177.0000	0.2461
180.0000	0.2378
183.0000	0.2295
186.0000	0.2214
189.0000	0.2133
192.0000	0.2054
195.0000	0.1977
198.0000	0.1901
201.0000	0.1826
204.0000	0.1754
207.0000	0.1683
210.0000	0.1614
213.0000	0.1548
216.0000	0.1483
219.0000	0.1420
222.0000	0.1359
225.0000	0.1300
228.0000	0.1244
231.0000	0.1189
234.0000	0.1136
237.0000	0.1085
240.0000	0.1036

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*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
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PROJECT..... = SPCHBB.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SPCHBB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 25.58
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 7 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 89.59999999999999 [y]
DECAY CONSTANT (alpha)..... = .7736D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]		
7.0000	0.0000	399.0000	0.2841
14.0000	0.0000	406.0000	0.2762
21.0000	0.0000	413.0000	0.2682
28.0000	0.0000	420.0000	0.2602
35.0000	0.0000	427.0000	0.2521
42.0000	0.0000	434.0000	0.2441
49.0000	0.0000	441.0000	0.2362
56.0000	0.0002	448.0000	0.2283
63.0000	0.0006	455.0000	0.2205
70.0000	0.0015	462.0000	0.2129
77.0000	0.0033	469.0000	0.2053
84.0000	0.0064	476.0000	0.1979
91.0000	0.0111	483.0000	0.1906
98.0000	0.0176	490.0000	0.1835
105.0000	0.0262	497.0000	0.1766
112.0000	0.0368	504.0000	0.1698
119.0000	0.0495	511.0000	0.1632
126.0000	0.0640	518.0000	0.1568
133.0000	0.0802	525.0000	0.1505
140.0000	0.0978	532.0000	0.1444
147.0000	0.1165	539.0000	0.1385
154.0000	0.1359	546.0000	0.1328
161.0000	0.1557	553.0000	0.1273
168.0000	0.1756	560.0000	0.1220
175.0000	0.1954		
182.0000	0.2147		
189.0000	0.2333		
196.0000	0.2510		
203.0000	0.2677		
210.0000	0.2832		
217.0000	0.2974		
224.0000	0.3103		
231.0000	0.3218		
238.0000	0.3319		
245.0000	0.3406		
252.0000	0.3479		
259.0000	0.3538		
266.0000	0.3584		
273.0000	0.3618		
280.0000	0.3639		
287.0000	0.3649		
294.0000	0.3648		
301.0000	0.3638		
308.0000	0.3618		
315.0000	0.3590		
322.0000	0.3554		
329.0000	0.3511		
336.0000	0.3462		
343.0000	0.3408		
350.0000	0.3348		
357.0000	0.3284		
364.0000	0.3217		
371.0000	0.3146		
378.0000	0.3073		
385.0000	0.2997		
392.0000	0.2920		

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*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SP12DB.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP12DB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 112.59
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 25 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .00000+00 [1/y]
HALF-LIFE at Source..... = 394.2 [y]
DECAY CONSTANT (alpha)..... = .17580-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
25.0000	0.0000
50.0000	0.0000
75.0000	0.0000
100.0000	0.0000
125.0000	0.0000
150.0000	0.0000
175.0000	0.0000
200.0000	0.0000
225.0000	0.0001
250.0000	0.0002
275.0000	0.0005
300.0000	0.0012
325.0000	0.0024
350.0000	0.0043
375.0000	0.0071
400.0000	0.0110
425.0000	0.0161
450.0000	0.0225
475.0000	0.0303
500.0000	0.0395
525.0000	0.0500
550.0000	0.0617
575.0000	0.0746
600.0000	0.0884
625.0000	0.1030
650.0000	0.1183
675.0000	0.1341
700.0000	0.1501
725.0000	0.1663
750.0000	0.1824
775.0000	0.1984
800.0000	0.2140
825.0000	0.2292
850.0000	0.2438
875.0000	0.2578
900.0000	0.2710
925.0000	0.2835
950.0000	0.2951
975.0000	0.3059
1000.0000	0.3157
1025.0000	0.3246
1050.0000	0.3326
1075.0000	0.3396
1100.0000	0.3458
1125.0000	0.3510
1150.0000	0.3554
1175.0000	0.3589
1200.0000	0.3615
1225.0000	0.3634
1250.0000	0.3645
1275.0000	0.3649
1300.0000	0.3646
1325.0000	0.3637
1350.0000	0.3621
1375.0000	0.3600
1400.0000	0.3574
1425.0000	0.3543
1450.0000	0.3507
1475.0000	0.3468
1500.0000	0.3424
1525.0000	0.3378
1550.0000	0.3328
1575.0000	0.3275
1600.0000	0.3220
1625.0000	0.3163
1650.0000	0.3105
1675.0000	0.3044
1700.0000	0.2982
1725.0000	0.2920
1750.0000	0.2856
1775.0000	0.2792
1800.0000	0.2727
1825.0000	0.2662
1850.0000	0.2597
1875.0000	0.2532
1900.0000	0.2467
1925.0000	0.2402
1950.0000	0.2338
1975.0000	0.2274
2000.0000	0.2211

```
*********************************************************
*                      ONED                             *
*                                                       *
*      INTERNATIONAL GROUND WATER MODELING CENTER       *
*    Golden, Colorado, USA - Delft, The Netherlands     *
*                                                       *
*             S O L U T E   version 2.03                *
*                                                       *
*       ANALYTICAL MODELS FOR SOLUTE TRANSPORT          *
*                                                       *
*********************************************************
```

PROJECT..... = SP13DB.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP13DB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 84.79000000000001
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 20 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 296.8 [y]
DECAY CONSTANT (alpha)..... = .2335D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
20.0000	0.0000
40.0000	0.0000
60.0000	0.0000
80.0000	0.0000
100.0000	0.0000
120.0000	0.0000
140.0000	0.0000
160.0000	0.0000
180.0000	0.0001
200.0000	0.0004
220.0000	0.0009
240.0000	0.0020
260.0000	0.0039
280.0000	0.0067
300.0000	0.0107
320.0000	0.0161
340.0000	0.0230
360.0000	0.0314
380.0000	0.0413
400.0000	0.0528
420.0000	0.0656
440.0000	0.0796
460.0000	0.0946
480.0000	0.1105
500.0000	0.1270
520.0000	0.1440
540.0000	0.1611
560.0000	0.1783
580.0000	0.1953
600.0000	0.2120
620.0000	0.2281
640.0000	0.2437
660.0000	0.2585
680.0000	0.2725
700.0000	0.2856
720.0000	0.2978
740.0000	0.3089
760.0000	0.3190
780.0000	0.3281
800.0000	0.3361
820.0000	0.3431
840.0000	0.3491
860.0000	0.3540
880.0000	0.3580
900.0000	0.3610
920.0000	0.3631
940.0000	0.3644
960.0000	0.3649
980.0000	0.3645
1000.0000	0.3635
1020.0000	0.3618
1040.0000	0.3594
1060.0000	0.3565
1080.0000	0.3530
1100.0000	0.3491
1120.0000	0.3447
1140.0000	0.3398
1160.0000	0.3347
1180.0000	0.3292
1200.0000	0.3234
1220.0000	0.3174
1240.0000	0.3112
1260.0000	0.3048
1280.0000	0.2983
1300.0000	0.2916
1320.0000	0.2848
1340.0000	0.2780
1360.0000	0.2711
1380.0000	0.2642
1400.0000	0.2573
1420.0000	0.2503
1440.0000	0.2435
1460.0000	0.2366
1480.0000	0.2298
1500.0000	0.2231
1520.0000	0.2164
1540.0000	0.2099
1560.0000	0.2034
1580.0000	0.1970
1600.0000	0.19[illegible]

4 9 0614

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*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SP14DB.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP14DB.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 56.92
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 15 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 199.3 [y]
DECAY CONSTANT (alpha)..... = .3478D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
15.0000	0.0000
30.0000	0.0000
45.0000	0.0000
60.0000	0.0000
75.0000	0.0000
90.0000	0.0000
105.0000	0.0000
120.0000	0.0001
135.0000	0.0004
150.0000	0.0011
165.0000	0.0025
180.0000	0.0049
195.0000	0.0086
210.0000	0.0140
225.0000	0.0212
240.0000	0.0302
255.0000	0.0413
270.0000	0.0541
285.0000	0.0687
300.0000	0.0847
315.0000	0.1019
330.0000	0.1200
345.0000	0.1388
360.0000	0.1579
375.0000	0.1771
390.0000	0.1961
405.0000	0.2147
420.0000	0.2326
435.0000	0.2497
450.0000	0.2659
465.0000	0.2810
480.0000	0.2949
495.0000	0.3076
510.0000	0.3189
525.0000	0.3290
540.0000	0.3378
555.0000	0.3453
570.0000	0.3515
585.0000	0.3565
600.0000	0.3602
615.0000	0.3629
630.0000	0.3644
645.0000	0.3649
660.0000	0.3645
675.0000	0.3631
690.0000	0.3610
705.0000	0.3581
720.0000	0.3544
735.0000	0.3502
750.0000	0.3454
765.0000	0.3400
780.0000	0.3343
795.0000	0.3281
810.0000	0.3216
825.0000	0.3148
840.0000	0.3077
855.0000	0.3004
870.0000	0.2930
885.0000	0.2855
900.0000	0.2778
915.0000	0.2701
930.0000	0.2624
945.0000	0.2547
960.0000	0.2470
975.0000	0.2393
990.0000	0.2317
1005.0000	0.2241
1020.0000	0.2167
1035.0000	0.2094
1050.0000	0.2022
1065.0000	0.1951
1080.0000	0.1881
1095.0000	0.1813
1110.0000	0.1747
1125.0000	0.1682
1140.0000	0.1619
1155.0000	0.1557
1170.0000	0.1497
1185.0000	0.1439
1200.0000	0.1382

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SP124B.INP
USER NAME..... = ASIERRA
DATE..... = 06-04-1993
DATA FILE..... = C:\OLIN\SP124B.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 631.6900000000001
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 120 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 0 [y]
DECAY CONSTANT (lambda)..... = .0000D+00 [1/y]
HALF-LIFE at Source..... = 2211.4 [y]
DECAY CONSTANT (alpha)..... = .3134D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
120.0000	0.0000
240.0000	0.0000
360.0000	0.0000
480.0000	0.0000
600.0000	0.0000
720.0000	0.0000
840.0000	0.0000
960.0000	0.0000
1080.0000	0.0000
1200.0000	0.0000
1320.0000	0.0001
1440.0000	0.0003
1560.0000	0.0006
1680.0000	0.0012
1800.0000	0.0021
1920.0000	0.0036
2040.0000	0.0057
2160.0000	0.0085
2280.0000	0.0121
2400.0000	0.0167
2520.0000	0.0223
2640.0000	0.0288
2760.0000	0.0364
2880.0000	0.0449
3000.0000	0.0544
3120.0000	0.0648
3240.0000	0.0759
3360.0000	0.0878
3480.0000	0.1002
3600.0000	0.1132
3720.0000	0.1265
3840.0000	0.1401
3960.0000	0.1539
4080.0000	0.1677
4200.0000	0.1815
4320.0000	0.1952
4440.0000	0.2086
4560.0000	0.2218
4680.0000	0.2346
4800.0000	0.2469
4920.0000	0.2588
5040.0000	0.2701
5160.0000	0.2809
5280.0000	0.2911
5400.0000	0.3006
5520.0000	0.3094
5640.0000	0.3176
5760.0000	0.3251
5880.0000	0.3320
6000.0000	0.3381
6120.0000	0.3436
6240.0000	0.3484
6360.0000	0.3526
6480.0000	0.3561
6600.0000	0.3590
6720.0000	0.3613
6840.0000	0.363
6960.0000	0.364
7080.0000	0.364
7200.0000	0.364
7320.0000	0.364
7440.0000	0.363
7560.0000	0.362
7680.0000	0.360
7800.0000	0.358
7920.0000	0.356
8040.0000	0.353
8160.0000	0.350
8280.0000	0.346
8400.0000	0.342
8520.0000	0.339
8640.0000	0.334
8760.0000	0.330
8880.0000	0.3258
9000.0000	0.3211
9120.0000	0.3162
9240.0000	0.3112
9360.0000	0.3060
9480.0000	0.3008
9600.0000	0.2954

FORMER CPC PLANT AREA

SOLUTE RUNS
WITH DECAY

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SPBEN1.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SPBEN1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 10.47
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 5 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 2.2 [y]
DECAY CONSTANT (lambda)..... = .3151D+00 [1/y]
HALF-LIFE at Source..... = 36.7 [y]
DECAY CONSTANT (alpha)..... = .1889D-01 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]		
5.0000	0.0000	285.0000	0.0000
10.0000	0.0000	290.0000	0.0000
15.0000	0.0000	295.0000	0.0000
20.0000	0.0000	300.0000	0.0000
25.0000	0.0000	305.0000	0.0000
30.0000	0.0000	310.0000	0.0000
35.0000	0.0000	315.0000	0.0000
40.0000	0.0000	320.0000	0.0000
45.0000	0.0000	325.0000	0.0000
50.0000	0.0000	330.0000	0.0000
55.0000	0.0000	335.0000	0.0000
60.0000	0.0000	340.0000	0.0000
65.0000	0.0000	345.0000	0.0000
70.0000	0.0000	350.0000	0.0000
75.0000	0.0000	355.0000	0.0000
80.0000	0.0000	360.0000	0.0000
85.0000	0.0000	365.0000	0.0000
90.0000	0.0000	370.0000	0.0000
95.0000	0.0000	375.0000	0.0000
100.0000	0.0000	380.0000	0.0000
105.0000	0.0000	385.0000	0.0000
110.0000	0.0000	390.0000	0.0000
115.0000	0.0000	395.0000	0.0000
120.0000	0.0000	400.0000	0.0000
125.0000	0.0000		
130.0000	0.0000		
135.0000	0.0000		
140.0000	0.0000		
145.0000	0.0000		
150.0000	0.0000		
155.0000	0.0000		
160.0000	0.0000		
165.0000	0.0000		
170.0000	0.0000		
175.0000	0.0000		
180.0000	0.0000		
185.0000	0.0000		
190.0000	0.0000		
195.0000	0.0000		
200.0000	0.0000		
205.0000	0.0000		
210.0000	0.0000		
215.0000	0.0000		
220.0000	0.0000		
225.0000	0.0000		
230.0000	0.0000		
235.0000	0.0000		
240.0000	0.0000		
245.0000	0.0000		
250.0000	0.0000		
255.0000	0.0000		
260.0000	0.0000		
265.0000	0.0000		
270.0000	0.0000		
275.0000	0.0000		
280.0000	0.0000		

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SPCHB1.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SPCHB1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 25.58
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 4 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 20.5 [y]
DECAY CONSTANT (lambda)..... = .3381D-01 [1/y]
HALF-LIFE at Source..... = 89.59999999999999 [y]
DECAY CONSTANT (alpha)..... = .7736D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]		
4.0000	0.0000	228.0000	0.0017
8.0000	0.0000	232.0000	0.0017
12.0000	0.0000	236.0000	0.0016
16.0000	0.0000	240.0000	0.0016
20.0000	0.0000	244.0000	0.0015
24.0000	0.0000	248.0000	0.0015
28.0000	0.0000	252.0000	0.0014
32.0000	0.0000	256.0000	0.0014
36.0000	0.0000	260.0000	0.0014
40.0000	0.0000	264.0000	0.0013
44.0000	0.0000	268.0000	0.0013
48.0000	0.0000	272.0000	0.0012
52.0000	0.0000	276.0000	0.0012
56.0000	0.0000	280.0000	0.0012
60.0000	0.0001	284.0000	0.0011
64.0000	0.0001	288.0000	0.0011
68.0000	0.0001	292.0000	0.0011
72.0000	0.0002	296.0000	0.0010
76.0000	0.0003	300.0000	0.0010
80.0000	0.0004	304.0000	0.0010
84.0000	0.0005	308.0000	0.0009
88.0000	0.0006	312.0000	0.0009
92.0000	0.0008	316.0000	0.0009
96.0000	0.0009	320.0000	0.0009
100.0000	0.0011		
104.0000	0.0012		
108.0000	0.0014		
112.0000	0.0015		
116.0000	0.0016		
120.0000	0.0017		
124.0000	0.0018		
128.0000	0.0019		
132.0000	0.0020		
136.0000	0.0021		
140.0000	0.0021		
144.0000	0.0022		
148.0000	0.0022		
152.0000	0.0022		
156.0000	0.0023		
160.0000	0.0023		
164.0000	0.0023		
168.0000	0.0023		
172.0000	0.0022		
176.0000	0.0022		
180.0000	0.0022		
184.0000	0.0022		
188.0000	0.0021		
192.0000	0.0021		
196.0000	0.0021		
200.0000	0.0020		
204.0000	0.0020		
208.0000	0.0019		
212.0000	0.0019		
216.0000	0.0018		
220.0000	0.0018		
224.0000	0.0017		

4 9 0617

```
*********************************************************
*                      ONED                             *
*                                                       *
*      INTERNATIONAL GROUND WATER MODELING CENTER       *
*    Golden, Colorado, USA - Delft, The Netherlands     *
*                                                       *
*              S O L U T E   version 2.03               *
*                                                       *
*       ANALYTICAL MODELS FOR SOLUTE TRANSPORT          *
*                                                       *
*********************************************************
```

PROJECT..... = SP12D1.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP12D1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 112.59
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 3 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 394.2 [y]
DECAY CONSTANT (alpha)..... = .1758D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
3.0000	0.0000
6.0000	0.0000
9.0000	0.0000
12.0000	0.0000
15.0000	0.0000
18.0000	0.0000
21.0000	0.0000
24.0000	0.0000
27.0000	0.0000
30.0000	0.0000
33.0000	0.0000
36.0000	0.0000
39.0000	0.0000
42.0000	0.0000
45.0000	0.0000
48.0000	0.0000
51.0000	0.0000
54.0000	0.0000
57.0000	0.0000
60.0000	0.0000
63.0000	0.0000
66.0000	0.0000
69.0000	0.0000
72.0000	0.0000
75.0000	0.0000
78.0000	0.0000
81.0000	0.0000
84.0000	0.0000
87.0000	0.0000
90.0000	0.0000
93.0000	0.0000
96.0000	0.0000
99.0000	0.0000
102.0000	0.0000
105.0000	0.0000
108.0000	0.0000
111.0000	0.0000
114.0000	0.0000
117.0000	0.0000
120.0000	0.0000
123.0000	0.0000
126.0000	0.0000
129.0000	0.0000
132.0000	0.0000
135.0000	0.0000
138.0000	0.0000
141.0000	0.0000
144.0000	0.0000
147.0000	0.0000
150.0000	0.0000
153.0000	0.0000
156.0000	0.0000
159.0000	0.0000
162.0000	0.0000
165.0000	0.0000
168.0000	0.0000
171.0000	0.0000
174.0000	0.0000
177.0000	0.0000
180.0000	0.0000
183.0000	0.0000
186.0000	0.0000
189.0000	0.0000
192.0000	0.0000
195.0000	0.0000
198.0000	0.0000
201.0000	0.0000
204.0000	0.0000
207.0000	0.0000
210.0000	0.0000
213.0000	0.0000
216.0000	0.0000
219.0000	0.0000
222.0000	0.0000
225.0000	0.0000
228.0000	0.0000
231.0000	0.0000
234.0000	0.0000
237.0000	0.0000
240.0000	0.0000

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*     ANALYTICAL MODELS FOR SOLUTE TRANSPORT        *
*                                                   *
*****************************************************
```

PROJECT..... = SP13D1.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP13D1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 84.79000000000001
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 4 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 296.8 [y]
DECAY CONSTANT (alpha)..... = .2335D-02 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
4.0000	0.0000
8.0000	0.0000
12.0000	0.0000
16.0000	0.0000
20.0000	0.0000
24.0000	0.0000
28.0000	0.0000
32.0000	0.0000
36.0000	0.0000
40.0000	0.0000
44.0000	0.0000
48.0000	0.0000
52.0000	0.0000
56.0000	0.0000
60.0000	0.0000
64.0000	0.0000
68.0000	0.0000
72.0000	0.0000
76.0000	0.0000
80.0000	0.0000
84.0000	0.0000
88.0000	0.0000
92.0000	0.0000
96.0000	0.0000
100.0000	0.0000
104.0000	0.0000
108.0000	0.0000
112.0000	0.0000
116.0000	0.0000
120.0000	0.0000
124.0000	0.0000
128.0000	0.0000
132.0000	0.0000
136.0000	0.0000
140.0000	0.0000
144.0000	0.0000
148.0000	0.0000
152.0000	0.0000
156.0000	0.0000
160.0000	0.0000
164.0000	0.0000
168.0000	0.0000
172.0000	0.0000
176.0000	0.0000
180.0000	0.0000
184.0000	0.0000
188.0000	0.0000
192.0000	0.0000
196.0000	0.0000
200.0000	0.0000
204.0000	0.0000
208.0000	0.0000
212.0000	0.0000
216.0000	0.0000
220.0000	0.0000
224.0000	0.0000
228.0000	0.0000
232.0000	0.0000
236.0000	0.0000
240.0000	0.0000
244.0000	0.0000
248.0000	0.0000
252.0000	0.0000
256.0000	0.0000
260.0000	0.0000
264.0000	0.0000
268.0000	0.0000
272.0000	0.0000
276.0000	0.0000
280.0000	0.0000
284.0000	0.0000
288.0000	0.0000
292.0000	0.0000
296.0000	0.0000
300.0000	0.0000
304.0000	0.0000
308.0000	0.0000
312.0000	0.0000
316.0000	0.0000
320.0000	0.0000

4 9 0618

CONCENTRATION C [mg/l]

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SP14D1.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP14D1.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 56.92
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 3 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 199.3 [y]
DECAY CONSTANT (alpha)..... = .3478D-02 [1/y]

TIME [y]	1 DISTANCE 5.50 [m]		
3.0000	0.0000	171.0000	0.0000
6.0000	0.0000	174.0000	0.0001
9.0000	0.0000	177.0000	0.0001
12.0000	0.0000	180.0000	0.0001
15.0000	0.0000	183.0000	0.0001
18.0000	0.0000	186.0000	0.0001
21.0000	0.0000	189.0000	0.0001
24.0000	0.0000	192.0000	0.0001
27.0000	0.0000	195.0000	0.0001
30.0000	0.0000	198.0000	0.0001
33.0000	0.0000	201.0000	0.0001
36.0000	0.0000	204.0000	0.0001
39.0000	0.0000	207.0000	0.0001
42.0000	0.0000	210.0000	0.0001
45.0000	0.0000	213.0000	0.0001
48.0000	0.0000	216.0000	0.0001
51.0000	0.0000	219.0000	0.0001
54.0000	0.0000	222.0000	0.0001
57.0000	0.0000	225.0000	0.0001
60.0000	0.0000	228.0000	0.0001
63.0000	0.0000	231.0000	0.0001
66.0000	0.0000	234.0000	0.0001
69.0000	0.0000	237.0000	0.0001
72.0000	0.0000	240.0000	0.0001
75.0000	0.0000		
78.0000	0.0000		
81.0000	0.0000		
84.0000	0.0000		
87.0000	0.0000		
90.0000	0.0000		
93.0000	0.0000		
96.0000	0.0000		
99.0000	0.0000		
102.0000	0.0000		
105.0000	0.0000		
108.0000	0.0000		
111.0000	0.0000		
114.0000	0.0000		
117.0000	0.0000		
120.0000	0.0000		
123.0000	0.0000		
126.0000	0.0000		
129.0000	0.0000		
132.0000	0.0000		
135.0000	0.0000		
138.0000	0.0000		
141.0000	0.0000		
144.0000	0.0000		
147.0000	0.0000		
150.0000	0.0000		
153.0000	0.0000		
156.0000	0.0000		
159.0000	0.0000		
162.0000	0.0000		
165.0000	0.0000		
168.0000	0.0000		

```
*****************************************************
*                    ONED                           *
*                                                   *
*     INTERNATIONAL GROUND WATER MODELING CENTER    *
*   Golden, Colorado, USA - Delft, The Netherlands  *
*                                                   *
*            S O L U T E   version 2.03             *
*                                                   *
*      ANALYTICAL MODELS FOR SOLUTE TRANSPORT       *
*                                                   *
*****************************************************
```

PROJECT..... = SP1241.INP
USER NAME..... = ASIERRA
DATE..... = 06-02-1993
DATA FILE..... = C:\OLIN\SP1241.INP

INPUT DATA:

GROUNDWATER (SEEPAGE) VELOCITY = .61 [m/y]
LONGITUDINAL DISPERSIVITY..... = .55 [m]
RETARDATION FACTOR..... = 631.6900000000001
INITIAL CONCENTRATION..... = 0 [mg/l]
CONCENTRATION AT SOURCE..... = 1 [mg/l]
INITIAL TIME..... = 0 [y]
LENGTH OF TIME STEP..... = 4 [y]
NUMBER OF TIME STEPS..... = 80
NUMBER OF OBSERVATION POINTS.. = 1
1 DISTANCE (from source). = 5.5 [m]
DURATION OF SOLUTE PULSE..... = 100000000 [y]
HALF-LIFE (0 if no decay)..... = 24.7 [y]
DECAY CONSTANT (lambda)..... = .2806D-01 [1/y]
HALF-LIFE at Source..... = 2211.4 [y]
DECAY CONSTANT (alpha)..... = .3134D-03 [1/y]

CONCENTRATION C [mg/l]

TIME [y]	1 DISTANCE 5.50 [m]
4.0000	0.0000
8.0000	0.0000
12.0000	0.0000
16.0000	0.0000
20.0000	0.0000
24.0000	0.0000
28.0000	0.0000
32.0000	0.0000
36.0000	0.0000
40.0000	0.0000
44.0000	0.0000
48.0000	0.0000
52.0000	0.0000
56.0000	0.0000
60.0000	0.0000
64.0000	0.0000
68.0000	0.0000
72.0000	0.0000
76.0000	0.0000
80.0000	0.0000
84.0000	0.0000
88.0000	0.0000
92.0000	0.0000
96.0000	0.0000
100.0000	0.0000
104.0000	0.0000
108.0000	0.0000
112.0000	0.0000
116.0000	0.0000
120.0000	0.0000
124.0000	0.0000
128.0000	0.0000
132.0000	0.0000
136.0000	0.0000
140.0000	0.0000
144.0000	0.0000
148.0000	0.0000
152.0000	0.0000
156.0000	0.0000
160.0000	0.0000
164.0000	0.0000
168.0000	0.0000
172.0000	0.0000
176.0000	0.0000
180.0000	0.0000
184.0000	0.0000
188.0000	0.0000
192.0000	0.0000
196.0000	0.0000
200.0000	0.0000
204.0000	0.0000
208.0000	0.0000
212.0000	0.0000
216.0000	0.0000
220.0000	0.0000
224.0000	0.0000
228.0000	0.0000
232.0000	0.0000
236.0000	0.0000
240.0000	0.0000
244.0000	0.0000
248.0000	0.0000
252.0000	0.0000
256.0000	0.0000
260.0000	0.0000
264.0000	0.0000
268.0000	0.0000
272.0000	0.0000
276.0000	0.0000
280.0000	0.0000
284.0000	0.0000
288.0000	0.0000
292.0000	0.0000
296.0000	0.0000
300.0000	0.0000
304.0000	0.0000
308.0000	0.0000
312.0000	0.0000
316.0000	0.0000
320.0000	0.0[illegible]

OLD PLANT (CPC) LANDFILL AREA

PESTAN RUNS
NO DECAY

4 9 0620

```
-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE BENZENE LANDFILL PLBENB

Solubility (mg/l)	0.17910E+04
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.70000E+00
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.50000E+06

For application 1 the active ingredient (ai) applied is 0.930E+02 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.484E-03
Length of pollutant slug [cm]	0.382E+00
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE BENZENE LANDFILL PLBENB

DAYS	UG/L
0.100000E-29	0.000000
5050.50	0.000000
10101.0	0.106752
15151.5	8.27327
20202.0	65.7592
25252.5	204.056
30303.0	397.384
35353.5	594.448
40404.0	755.056
45454.5	860.928
50505.0	910.834
55555.6	913.009
60606.1	879.252
65656.6	821.269
70707.1	749.105
75757.6	670.482
80808.1	591.139
85858.6	514.811
90909.1	443.714
95959.6	379.236
101010.	321.804
106061.	271.523
111111.	227.809
116162.	190.232
121212.	158.366
126263.	131.305
131313.	108.620
136364.	89.5649
141414.	73.7122
146465.	60.5283
151515.	49.6396
156566.	40.6191
161616.	33.1998
166667.	27.0616
171717.	22.0976
176768.	17.9877
181818.	14.6250
186869.	11.9028
191919.	9.66105
196970.	7.84627
202020.	6.35174
207071.	5.17747
212121.	4.16332
217172.	3.36269
222222.	2.72217
227273.	2.18841
232323.	1.76141
237374.	1.44115
242424.	1.17427
247475.	0.960767
252525.	0.800639
257576.	0.587136
262626.	0.480384
267677.	0.373632
272727.	0.320256
277778.	0.266880
282828.	0.213504
287879.	0.160128
292929.	0.106752
297980.	0.160128
303030.	0.106752
308081.	0.106752
313131.	0.533760E-01
318182.	0.000000
323232.	0.533760E-01
328283.	0.000000
333333.	0.533760E-01
338384.	0.533760E-01
343434.	0.533760E-01
348485.	0.533760E-01
353535.	0.000000
358586.	0.533760E-01
363636.	0.000000
368687.	0.000000
373737.	0.000000
378788.	0.533760E-01
383838.	0.000000
388889.	0.000000
393939.	0.000000
398990.	0.000000
404040.	0.000000
409091.	0.000000
414141.	0.000000
419192.	0.000000
424242.	0.000000
429293.	0.000000
434343.	0.000000
439394.	0.000000
444444.	0.000000
449495.	0.000000
454545.	0.000000
459596.	0.000000
464646.	0.000000
469697.	0.000000
474747.	0.000000
479798.	0.000000
484848.	0.000000
489899.	0.000000
494949.	0.000000
500000.	0.000000

```
-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, CHLOROBENZENE LANDFILL PLCHBB

Solubility (mg/l)	0.47170E+03
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.18800E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.40000E+06

For application 1 the active ingredient (ai) applied is 0.440E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.203E-03
Length of pollutant slug [cm]	0.288E+02
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, CHLOROBENZENE LANDFILL PLCHBB

DAYS	UG/L
0.100000E-29	0.000000
4040.40	0.000000
8080.81	0.000000
12121.2	0.000000
16161.6	0.000000
20202.0	0.000000
24242.4	1.34954
28282.8	9.93883
32323.2	43.1433
36363.6	132.283
40404.0	317.888
44444.4	640.190
48484.8	1129.61
52525.3	1800.81
56565.7	2651.29
60606.1	3663.28
64646.5	4807.65
68686.9	6048.38
72727.3	7346.60
76767.7	8664.01
80808.1	9965.21
84848.5	11219.4
88888.9	12400.9
92929.3	13489.8
96969.7	14471.1
101010.	15335.2
105051.	16076.5
109091.	16693.4
113131.	17186.9
117172.	17561.0
121212.	17821.0
125253.	17974.0
129293.	18027.8
133333.	17991.0
137374.	17872.3
141414.	17680.4
145455.	17424.0
149495.	17111.3
153535.	16750.4
157576.	16348.7
161616.	15913.4
165657.	15450.6
169697.	14966.4
173737.	14466.1
177778.	13954.5
181818.	13435.8
185859.	12914.0
189899.	12392.2
193939.	11873.5
197980.	11360.4
202020.	10855.0
206061.	10359.1
210101.	9874.28
214141.	9401.77
218182.	8942.59
222222.	8497.51
226263.	8067.14
230303.	7651.89
234343.	7252.02
238384.	6867.71
242424.	6498.94
246465.	6145.69
250505.	5807.79
254545.	5485.01
258586.	5177.06
262626.	4883.62
266667.	4604.32
270707.	4338.79
274747.	4086.53
278788.	3847.13
282828.	3620.17
286869.	3405.11
290909.	3201.56
294950.	3008.98
298990.	2826.94
303030.	2654.98
307071.	2492.62
311111.	2339.44
315152.	2194.96
319192.	2058.80
323232.	1930.54
327273.	1809.77
331313.	1696.10
335354.	1589.16
339394.	1488.59
343434.	1394.08
347475.	1305.28
351515.	1221.84
355556.	1143.53
359596.	1069.99
363636.	1001.00
367677.	936.275
371717.	875.601
375758.	818.696
379798.	765.360
383838.	715.399
387879.	668.587
391919.	624.755
395960.	583.692
400000.	545.258

```
-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, 1,2 dichlorobenzene. LANDFILL PL12DB

Solubility (mg/l)	0.15600E+03
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.86100E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+07

For application 1 the active ingredient (ai) applied is 0.164E+06 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.472E-04
Length of pollutant slug [cm]	0.754E+03
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, 1,2-DICHLOROBENZENE LANDFILL PL12DB

DAYS	UG/L
0.100000E-29	0.000000
10101.0	0.000000
20202.0	0.000000
30303.0	0.000000
40404.0	0.000000
50505.0	0.000000
60606.1	0.000000
70707.1	0.000000
80808.1	0.000000
90909.1	0.743866E-01
101010.	0.413775
111111.	1.64115
121212.	5.18382
131313.	13.6964
141414.	31.4655
151515.	64.6280
161616.	121.185
171717.	210.793
181818.	344.382
191919.	533.663
202020.	790.599
212121.	1126.89
222222.	1553.50
232323.	2080.30
242424.	2715.74
252525.	3466.73
262626.	4338.44
272727.	5334.37
282828.	6456.31
292929.	7704.48
303030.	9077.59
313131.	10573.0
323232.	12186.9
333333.	13914.6
343434.	15750.3
353535.	17687.6
363636.	19719.7
373737.	21839.1
383838.	24038.3
393939.	26309.3
404040.	28644.2
414141.	31035.1
424242.	33473.8
434343.	35952.7
444444.	38464.1
454545.	41000.3
464646.	43554.2
474747.	46118.6
484848.	48686.7
494949.	51252.0
505051.	53808.1
515152.	56348.9
525253.	58868.8
535354.	61362.1
545455.	63823.6
555556.	66248.4
565657.	68631.6
575758.	70968.9
585859.	73255.9
595960.	75488.8
606061.	77663.8
616162.	79777.3
626263.	81826.2
636364.	83807.4
646465.	85718.2
656566.	87556.0
666667.	89318.5
676768.	91003.6
686869.	92609.4
696970.	94134.4
707071.	95577.1
717172.	96936.4
727273.	98211.3
737374.	99400.9
747475.	100505.
757576.	101523.
767677.	102454.
777778.	103300.
787879.	104059.
797980.	104733.
808081.	105321.
818182.	105826.
828283.	106247.
838384.	106586.
848485.	106843.
858586.	107021.
868687.	107121.
878788.	107143.
888889.	107091.
898990.	106965.
909091.	106768.
919192.	106501.
929293.	106167.
939394.	105768.
949495.	105305.
959596.	104781.
969697.	104199.
979798.	103560.
989899.	102867.
0.100000E+07	102122.

```
-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, 1,3 dichlorobenzene. LANDFILL PL13DB

Solubility (mg/l)	0.11100E+03
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.64600E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.13000E+07

For application 1 the active ingredient (ai) applied is 0.235E+06 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.626E-04
Length of pollutant slug [cm]	0.201E+04
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, 1,3 DICHLOROBENZENE LANDFILL PL13DB

DAYS	UG/L
0.100000E-29	0.000000
13131.3	0.000000
26262.6	0.000000
39393.9	0.000000
52525.3	0.000000
65656.6	0.000000
78787.9	0.479668
91919.2	3.92005
105051.	18.8427
118182.	63.7330
131313.	168.383
144444.	371.581
157576.	716.221
170707.	1243.79
183838.	1989.76
196970.	2980.52
210101.	4231.98
223232.	5749.60
236364.	7529.28
249495.	9558.85
262626.	11819.8
275758.	14289.1
288889.	16940.5
302020.	19746.4
315152.	22678.5
328283.	25709.1
341414.	28811.5
354545.	31960.6
367677.	35133.4
380808.	38308.9
393939.	41468.4
407071.	44595.3
420202.	47675.3
433333.	50696.1
446465.	53647.5
459596.	56521.0
472727.	59309.7
485859.	62008.3
498990.	64612.8
512121.	67120.5
525253.	69529.5
538384.	71839.0
551515.	74049.0
564647.	76160.1
577778.	78173.5
590909.	80090.9
604040.	81914.3
617172.	83646.2
630303.	85289.1
643434.	86846.0
656566.	88319.7
669697.	89713.4
682828.	91030.3
695960.	92273.4
709091.	93445.9
722222.	94551.0
735354.	95591.8
748485.	96571.2
761616.	97492.2
774748.	98357.5
787879.	99170.0
801010.	99932.1
814141.	100646.
827273.	101315.
840404.	101940.
853535.	102524.
866667.	103068.
879798.	103574.
892929.	104043.
906061.	104477.
919192.	104878.
932323.	105245.
945455.	105580.
958586.	105883.
971717.	106155.
984849.	106396.
997980.	106607.
0.101111E+07	106787.
0.102424E+07	106936.
0.103737E+07	107054.
0.105051E+07	107141.
0.106364E+07	107196.
0.107677E+07	107219.
0.108990E+07	107209.
0.110303E+07	107165.
0.111616E+07	107087.
0.112929E+07	106973.
0.114242E+07	106824.
0.115556E+07	106638.
0.116869E+07	106414.
0.118182E+07	106152.
0.119495E+07	105850.
0.120808E+07	105509.
0.122121E+07	105127.
0.123434E+07	104704.
0.124747E+07	104239.
0.126061E+07	103732.
0.127374E+07	103183.
0.128687E+07	102590.
0.130000E+07	101955.

```
-----------------------------------------------
|                 PESTAN                      |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, 1,4 dichlorobenzene. LANDFILL PL14DB

Solubility (mg/l)	0.87000E+02
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.43100E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.40000E+06

For application 1 the active ingredient (ai) applied is 0.750E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.927E-04
Length of pollutant slug [cm]	0.121E+03
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE 1,4 DICHLOROBENZENE LANDFILL PL14DB

DAYS	UG/L
0.100000E-29	0.000000
4040.40	0.000000
8080.81	0.000000
12121.2	0.000000
16161.6	0.000000
20202.0	0.000000
24242.4	0.000000
28282.8	0.000000
32323.2	0.000000
36363.6	0.000000
40404.0	0.000000
44444.4	0.000000
48484.8	0.907481E-01
52525.3	0.313729
56565.7	0.907481
60606.1	2.24537
64646.5	4.99114
68686.9	10.0808
72727.3	18.7874
76767.7	32.7108
80808.1	53.7488
84848.5	84.0249
88888.9	125.816
92929.3	181.434
96969.7	253.151
101010.	343.082
105051.	453.121
109091.	584.853
113131.	739.516
117172.	917.966
121212.	1120.65
125253.	1347.63
129293.	1598.57
133333.	1872.78
137374.	2169.22
141414.	2486.57
145455.	2823.28
149495.	3177.54
153535.	3547.42
157576.	3930.85
161616.	4325.67
165657.	4729.68
169697.	5140.66
173737.	5556.42
177778.	5974.80
181818.	6393.72
185859.	6811.16
189899.	7225.22
193939.	7634.10
197980.	8036.14
202020.	8429.77
206061.	8813.58
210101.	9186.31
214141.	9546.77
218182.	9893.98
222222.	10227.0
226263.	10545.1
230303.	10847.7
234343.	11134.2
238384.	11404.1
242424.	11657.2
246465.	11893.3
250505.	12112.2
254545.	12313.9
258586.	12498.4
262626.	12665.8
266667.	12816.2
270707.	12950.0
274747.	13067.3
278788.	13168.5
282828.	13254.0
286869.	13324.1
290909.	13379.3
294950.	13420.0
298990.	13446.7
303030.	13459.8
307071.	13460.0
311111.	13447.6
315152.	13423.3
319192.	13387.5
323232.	13340.8
327273.	13283.7
331313.	13216.8
335354.	13140.4
339394.	13055.3
343434.	12961.8
347475.	12860.6
351515.	12752.0
355556.	12636.5
359596.	12514.7
363636.	12386.9
367677.	12253.6
371717.	12115.3
375758.	11972.4
379798.	11825.2
383838.	11674.2
387879.	11519.8
391919.	11362.2
395960.	11201.8
400000.	11039.0

```
-----------------------------------------------
|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamsc) |
| Center for Subsurface Modeling Support       |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: BASE CASE, 1,2,4-Trichlorobenzene. LANDFILL PL124B

Solubility (mg/l)	0.48800E+02
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.48690E+02
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.13000E+08

For application 1 the active ingredient (ai) applied is 0.800E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.847E-05
Length of pollutant slug [cm]	0.211E+03
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE 1,2,4 TRICHLOROBENZENE LANDFILL PL124B

DAYS	UG/L		
0.100000E-29	0.000000		
131313.	0.000000		
262626.	0.000000		
393939.	0.000000		
525253.	0.436306E-01		
656566.	1.12712		
787879.	9.81688	0.695960E+07	3413.95
919192.	45.6114	0.709091E+07	3162.89
0.105050E+07	143.132	0.722222E+07	2927.55
0.118182E+07	344.523	0.735353E+07	2707.33
0.131313E+07	687.383	0.748485E+07	2501.60
0.144444E+07	1194.63	0.761616E+07	2309.67
0.157576E+07	1869.80	0.774747E+07	2130.87
0.170707E+07	2697.69	0.787879E+07	1964.53
0.183838E+07	3648.53	0.801010E+07	1809.95
0.196970E+07	4683.51	0.814141E+07	1666.48
0.210101E+07	5760.30	0.827273E+07	1533.45
0.223232E+07	6837.54	0.840404E+07	1410.22
0.236364E+07	7878.03	0.853535E+07	1296.19
0.249495E+07	8850.61	0.866667E+07	1190.76
0.262626E+07	9731.09	0.879798E+07	1093.35
0.275758E+07	10502.3	0.892929E+07	1003.45
0.288889E+07	11153.5	0.906061E+07	920.516
0.302020E+07	11679.7	0.919192E+07	844.075
0.315151E+07	12080.9	0.932323E+07	773.661
0.328283E+07	12360.5	0.945454E+07	708.845
0.341414E+07	12525.2	0.958586E+07	649.212
0.354545E+07	12583.6	0.971717E+07	594.383
0.367677E+07	12545.4	0.984848E+07	543.997
0.380808E+07	12421.5	0.997980E+07	497.718
0.393939E+07	12222.6	0.101111E+08	455.230
0.407071E+07	11959.6	0.102424E+08	416.246
0.420202E+07	11642.9	0.103737E+08	380.488
0.433333E+07	11282.3	0.105050E+08	347.705
0.446465E+07	10886.8	0.106364E+08	317.661
0.459596E+07	10464.7	0.107677E+08	290.139
0.472727E+07	10023.6	0.108990E+08	264.935
0.485859E+07	9569.94	0.110303E+08	241.866
0.498990E+07	9109.59	0.111616E+08	220.752
0.512121E+07	8647.54	0.112929E+08	201.438
0.525252E+07	8188.06	0.114242E+08	183.775
0.538384E+07	7734.75	0.115556E+08	167.627
0.551515E+07	7290.59	0.116869E+08	152.869
0.564646E+07	6858.00	0.118182E+08	139.382
0.577778E+07	6438.91	0.119495E+08	127.061
0.590909E+07	6034.80	0.120808E+08	115.810
0.604040E+07	5646.77	0.122121E+08	105.538
0.617172E+07	5275.58	0.123434E+08	96.1604
0.630303E+07	4921.71	0.124747E+08	87.6030
0.643434E+07	4585.41	0.126061E+08	79.7945
0.656566E+07	4266.69	0.127374E+08	72.6711
0.669697E+07	3965.41	0.128687E+08	66.1760
0.682828E+07	3681.30	0.130000E+08	60.2509

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-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, MERCURY LANDFILL PLMERB

Solubility (mg/l)	0.70000E+00
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.10715E+03
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+08

For application 1 the active ingredient (ai) applied is 0.580E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.386E-05
Length of pollutant slug [cm]	0.486E+03
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE MERCURY LANDFILL PLMERB

DAYS	UG/L
0.100000E-29	0.000000
101010.	0.000000
202020.	0.000000
303030.	0.000000
404040.	0.000000
505051.	0.000000
606061.	0.000000
707071.	0.000000
808081.	0.000000
909091.	0.000000
0.101010E+07	0.000000
0.111111E+07	0.333786E-03
0.121212E+07	0.135601E-02
0.131313E+07	0.448525E-02
0.141414E+07	0.124544E-01
0.151515E+07	0.301659E-01
0.161616E+07	0.653595E-01
0.171717E+07	0.129196
0.181818E+07	0.236571
0.191919E+07	0.406176
0.202020E+07	0.660166
0.212121E+07	1.02366
0.222222E+07	1.52400
0.232323E+07	2.19001
0.242424E+07	3.05097
0.252525E+07	4.13584
0.262626E+07	5.47251
0.272727E+07	7.08676
0.282828E+07	9.00254
0.292929E+07	11.2405
0.303030E+07	13.8182
0.313131E+07	16.7498
0.323232E+07	20.0461
0.333333E+07	23.7140
0.343434E+07	27.7573
0.353535E+07	32.1761
0.363636E+07	36.9675
0.373737E+07	42.1254
0.383838E+07	47.6409
0.393939E+07	53.5025
0.404040E+07	59.6965
0.414141E+07	66.2069
0.424242E+07	73.0159
0.434343E+07	80.1040
0.444444E+07	87.4506
0.454545E+07	95.0336
0.464646E+07	102.830
0.474747E+07	110.816
0.484848E+07	118.968
0.494949E+07	127.261
0.505050E+07	135.670
0.515151E+07	144.170
0.525253E+07	152.737
0.535354E+07	161.346
0.545455E+07	169.974
0.555556E+07	178.595
0.565657E+07	187.188
0.575758E+07	195.730
0.585859E+07	204.199
0.595960E+07	212.575
0.606061E+07	220.837
0.616162E+07	228.967
0.626263E+07	236.947
0.636364E+07	244.760
0.646465E+07	252.389
0.656566E+07	259.821
0.666667E+07	267.041
0.676768E+07	274.038
0.686869E+07	280.798
0.696970E+07	287.312
0.707071E+07	293.571
0.717172E+07	299.566
0.727273E+07	305.290
0.737374E+07	310.738
0.747475E+07	315.902
0.757576E+07	320.781
0.767677E+07	325.369
0.777778E+07	329.665
0.787879E+07	333.667
0.797980E+07	337.375
0.808081E+07	340.788
0.818182E+07	343.907
0.828283E+07	346.734
0.838384E+07	349.271
0.848485E+07	351.521
0.858586E+07	353.487
0.868687E+07	355.173
0.878788E+07	356.583
0.888889E+07	357.723
0.898990E+07	358.597
0.909091E+07	359.212
0.919192E+07	359.572
0.929293E+07	359.685
0.939394E+07	359.557
0.949495E+07	359.194
0.959596E+07	358.605
0.969697E+07	357.795
0.979798E+07	356.773
0.989899E+07	355.545
0.100000E+08	354.120

OLD PLANT (CPC) LANDFILL AREA

PESTAN RUNS
WITH DECAY

```
-----------------------------------------------
|                  PESTAN                     |
|              version 4.0, 1992.             |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: W/DECAY BENZENE LANDFILL PLBEN1.INP

Solubility (mg/l) .....:	0.17910E+04
Recharge rate (cm/hr).....:	0.65800E-03
Sorption constant (cc/g).....:	0.70000E+00
Saturated water content .....:	0.40000E+00
Solid-phase decay (/hr) .....:	0.00000E+00
Liquid-phase decay (/hr) .....:	0.36000E-04 ✓
Curve coefficient .....:	0.50000E+01
Bulk density (g/cc).....:	0.15900E+01
Dispersion coefficient (cm^2/hr).....:	0.18200E+00
Saturated hydraulic conductivity ....:	0.36000E+00
Minimum depth (cm).....:	0.00000E+00
Maximum depth (cm).....:	0.68300E+03
Minimum time (day).....:	0.00000E+00
Maximum time (day).....:	0.50000E+06

For application 1 the active ingredient (ai) applied is 0.520E+05 ✓ kg ai/ha,
and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content .....:	0.246E+00
Pore water velocity [cm/hr] .....:	0.267E-02
Pollutant velocity [cm/hr] .....:	0.484E-03
Length of pollutant slug [cm] .....:	0.214E+03
Mass decayed prior to recharge [kg] .....:	0.000E+00

W/DECAY BENZENE LANDFILL PLBEN1

DAYS	UG/L		
0.100000E-29	0.000000		
5050.50	0.000000		
10101.0	1.41644		
15151.5	88.4368		
20202.0	453.354	262626.	0.741142E-15
25252.5	838.205	267677.	0.272522E-15
30303.0	918.799	272727.	0.100171E-15
35353.5	741.680	277778.	0.368064E-16
40404.0	492.580	282828.	0.135190E-16
45454.5	286.642	287879.	0.496335E-17
50505.0	151.891	292929.	0.182181E-17
55555.6	75.1408	297980.	0.668920E-18
60606.1	35.2930	303030.	0.245356E-18
65656.6	15.9255	308081.	0.900425E-19
70707.1	6.96273	313131.	0.329899E-19
75757.6	2.96810	318182.	0.120997E-19
80808.1	1.23949	323232.	0.443774E-20
85858.6	0.508931	328283.	0.162353E-20
90909.1	0.206042	333333.	0.595826E-21
95959.6	0.824346E-01	338384.	0.218616E-21
101010.	0.326516E-01	343434.	0.800401E-22
106061.	0.128225E-01	348485.	0.293673E-22
111111.	0.499848E-02	353535.	0.107148E-22
116162.	0.193609E-02	358586.	0.394576E-23
121212.	0.745745E-03	363636.	0.143574E-23
126263.	0.285849E-03	368687.	0.527373E-24
131313.	0.109098E-03	373737.	0.193434E-24
136364.	0.414803E-04	378788.	0.707526E-25
141414.	0.157182E-04	383838.	0.261001E-25
146465.	0.593818E-05	388889.	0.950911E-26
151515.	0.223735E-05	393939.	0.343273E-26
156566.	0.840936E-06	398990.	0.171662E-26
161616.	0.315388E-06	404040.	0.615626E-27
166667.	0.118051E-06	409091.	0.229946E-27
171717.	0.441082E-07	414141.	0.819449E-28
176768.	0.164538E-07	419192.	0.304091E-28
181818.	0.612870E-08	424242.	0.107273E-28
186869.	0.227975E-08	429293.	0.000000
191919.	0.846967E-09	434343.	0.000000
196970.	0.314310E-09	439394.	0.000000
202020.	0.116518E-09	444444.	0.000000
207071.	0.431540E-10	449495.	0.000000
212121.	0.159684E-10	454545.	0.000000
217172.	0.590403E-11	459596.	0.000000
222222.	0.218124E-11	464646.	0.000000
227273.	0.805307E-12	469697.	0.000000
232323.	0.297130E-12	474747.	0.000000
237374.	0.109562E-12	479798.	0.000000
242424.	0.403757E-13	484848.	0.000000
247475.	0.148720E-13	489899.	0.000000
252525.	0.547552E-14	494949.	0.000000
257576.	0.201482E-14	500000.	0.000000

4 9 0629

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-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
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Title: W/DECAY CHLOROBENZENE LANDFILL PLCHB1

Solubility (mg/l)	0.47170E+03
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.18800E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05 ✓
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.40000E+06

For application 1 the active ingredient (ai) applied is 0.930E+04 ✓ kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.203E-03
Length of pollutant slug [cm]	0.609E+02
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY CHLOROBENZENE LANDFILL PLCHB1

DAYS	UG/L
0.100000E-29	0.000000
4040.40	0.000000
8080.81	0.000000
12121.2	0.000000
16161.6	0.000000
20202.0	0.000000
24242.4	1.61043
28282.8	12.1656
32323.2	53.9852
36363.6	167.984
40404.0	407.503
44444.4	824.645
48484.8	1456.66
52525.3	2317.57
56565.7	3396.61
60606.1	4661.79
64646.5	6066.36
68686.9	7555.73
72727.3	9073.89
76767.7	10568.2
80808.1	11992.6
84848.5	13309.7
88888.9	14490.8
92929.3	15516.4
96969.7	16374.9
101010.	17061.8
105051.	17578.5
109091.	17930.9
113131.	18128.3
117172.	18182.6 √
121212.	18107.3
125253.	17916.6
129293.	17625.0
133333.	17246.9
137374.	16796.1
141414.	16285.8
145455.	15727.8
149495.	15133.4
153535.	14512.4
157576.	13873.8
161616.	13225.5
165657.	12574.1
169697.	11925.6
173737.	11284.9
177778.	10656.1
181818.	10042.5
185859.	9446.98
189899.	8871.58
193939.	8317.91
197980.	7787.13
202020.	7280.01
206061.	6796.95
210101.	6338.11
214141.	5903.37
218182.	5492.43
222222.	5104.82
226263.	4739.95
230303.	4397.10
234343.	4075.50
238384.	3774.32
242424.	3492.66
246465.	3229.64
250505.	2984.34
254545.	2755.82
258586.	2543.19
262626.	2345.56
266667.	2162.04
270707.	1991.80
274747.	1834.01
278788.	1687.88
282828.	1552.66
286869.	1427.63
290909.	1312.10
294950.	1205.42
298990.	1106.98
303030.	1016.20
307071.	932.520
311111.	855.437
315152.	784.463
319192.	719.153
323232.	659.076
327273.	603.844
331313.	553.083
335354.	506.452
339394.	463.630
343434.	424.327
347475.	388.260
351515.	355.176
355556.	324.840
359596.	297.030
363636.	271.545
367677.	248.198
371717.	226.815
375758.	207.237
379798.	189.312
383838.	172.911
387879.	157.903
391919.	144.174
395960.	131.619
400000.	120.139

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-----------------------------------------------
|                  PESTAN                     |
|              version 4.0, 1992.             |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
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Title: WITH DECAY 1,2 dichlorobenzene. LANDFILL PL12D1

Solubility (mg/l)	0.15600E+03
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.86100E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+07

For application 1 the active ingredient (ai) applied is 0.100E+09 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.472E-04
Length of pollutant slug [cm]	0.460E+06
Mass decayed prior to recharge [kg]	0.000E+00

WITH DECAY 1,2 DICHLORO LANDFILL PL12D1

DAYS	UG/L		
0.100000E-29	0.000000		
10101.0	0.000000		
20202.0	0.000000		
30303.0	0.000000		
40404.0	0.000000	525253.	28977.5
50505.0	0.000000	535354.	29817.1
60606.1	0.000000	545455.	30618.5
70707.1	0.000000	555556.	31381.1
80808.1	0.000000	565657.	32104.4
90909.1	0.657520E-01	575758.	32788.2
101010.	0.360766	585859.	33432.3
111111.	1.41142	595960.	34036.9
121212.	4.39746	606061.	34602.2
131313.	11.4606	616162.	35128.6
141414.	25.9705	626263.	35616.6
151515.	52.6152	636364.	36066.8
161616.	97.3164	646465.	36479.9
171717.	166.970	656566.	36856.7
181818.	269.073	666667.	37197.9
191919.	411.285	676768.	37504.6
202020.	601.004	686869.	37777.7
212121.	844.986	696970.	38018.2
222222.	1149.01	707071.	38227.0
232323.	1517.69	717172.	38405.3
242424.	1954.31	727273.	38554.0
252525.	2460.77	737374.	38674.4
262626.	3037.60	747475.	38767.4
272727.	3684.06	757576.	38834.1
282828.	4398.19	767677.	38875.6
292929.	5177.01	777778.	38893.0 ✓
303030.	6016.61	787879.	38887.4
313131.	6912.38	797980.	38859.7
323232.	7859.08	808081.	38811.1
333333.	8851.08	818182.	38742.4
343434.	9882.46	828283.	38654.7
353535.	10947.1	838384.	38549.0
363636.	12038.8	848485.	38426.3
373737.	13151.6	858586.	38287.3
383838.	14279.3	868687.	38133.0
393939.	15416.3	878788.	37964.3
404040.	16557.1	888889.	37782.1
414141.	17696.3	898990.	37587.0
424242.	18829.0	909091.	37380.0
434343.	19950.8	919192.	37161.7
444444.	21057.3	929293.	36932.9
454545.	22144.8	939394.	36694.3
464646.	23209.8	949495.	36446.5
474747.	24249.2	959596.	36190.3
484848.	25260.2	969697.	35926.2
494949.	26240.4	979798.	35654.8
505051.	27187.9	989899.	35376.7
515152.	28100.7	0.100000E+07	35092.5

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|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
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Title: W/DECAY 1,3 dichlorobenzene. LANDFILL PL13D1

Solubility (mg/l)	0.11100E+03
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.64600E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.13000E+07

For application 1 the active ingredient (ai) applied is 0.100E+09 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.626E-04
Length of pollutant slug [cm]	0.857E+06
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY 1,3 DICHLORO LANDFILL PL1301

DAYS	UG/L
0.100000E-29	0.000000
13131.3	0.000000
26262.6	0.000000
39393.9	0.000000
52525.3	0.000000
65656.6	0.000000
78787.9	0.416300
91919.2	3.32277
105051.	15.5990
118182.	51.5302
131313.	132.966
144444.	286.575
157576.	539.482
170707.	914.999
183838.	1429.61
196970.	2091.48
210101.	2900.35
223232.	3848.47
236364.	4922.07
249495.	6103.01
262626.	7370.44
275758.	8702.23
288889.	10076.2
302020.	11471.0
315152.	12866.9
328283.	14245.9
341414.	15592.4
354545.	16893.0
367677.	18136.6
380808.	19314.3
393939.	20419.3
407071.	21446.5
420202.	22392.6
433333.	23255.8
446465.	24035.3
459596.	24731.7
472727.	25346.3
485859.	25881.1
498990.	26338.8
512121.	26722.5
525253.	27035.5
538384.	27281.6
551515.	27464.6
564647.	27588.3
577778.	27656.8
590909.	27673.8
604040.	27643.3
617172.	27569.0
630303.	27454.4
643434.	27303.2
656566.	27118.5
669697.	26903.6
682828.	26661.4
695960.	26394.8
709091.	26106.5
722222.	25798.9
735354.	25474.3
748485.	25135.0
761616.	24782.8
774748.	24419.7
787879.	24047.4
801010.	23667.5
814141.	23281.3
827273.	22890.3
840404.	22495.6
853535.	22098.4
866667.	21699.6
879798.	21300.2
892929.	20901.0
906061.	20502.7
919192.	20106.0
932323.	19711.5
945455.	19319.8
958586.	18931.3
971717.	18546.4
984849.	18165.6
997980.	17789.1
0.101111E+07	17417.2
0.102424E+07	17050.2
0.103737E+07	16688.3
0.105051E+07	16331.7
0.106364E+07	15980.5
0.107677E+07	15634.8
0.108990E+07	15294.8
0.110303E+07	14960.6
0.111616E+07	14632.1
0.112929E+07	14309.4
0.114242E+07	13992.6
0.115556E+07	13681.6
0.116869E+07	13376.5
0.118182E+07	13077.3
0.119495E+07	12783.9
0.120808E+07	12496.2
0.122121E+07	12214.4
0.123434E+07	11938.2
0.124747E+07	11667.7
0.126061E+07	11402.7
0.127374E+07	11143.3
0.128687E+07	10889.3
0.130000E+07	10640.7

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|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
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| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
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| Ada, OK 74820                                |
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Title: W/DECAY, 1,4 dichlorobenzene. LANDFILL PL14D1

Solubility (mg/l)	0.87000E+02
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.43100E+01
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.40000E+06

For application 1 the active ingredient (ai) applied is 0.200E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.927E-04
Length of pollutant slug [cm]	0.324E+03
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY 1,4 DICHLORO LANDFILL PL14D1

DAYS	UG/L
0.100000E-29	0.000000
4040.40	0.000000
8080.81	0.000000
12121.2	0.000000
16161.6	0.000000
20202.0	0.000000
24242.4	0.000000
28282.8	0.000000
32323.2	0.000000
36363.6	0.000000
40404.0	0.000000
44444.4	0.000000
48484.8	0.797508E-01
52525.3	0.272758
56565.7	0.780521
60606.1	1.93923
64646.5	4.28873
68686.9	8.62381
72727.3	16.0163
76767.7	27.8182
80808.1	45.6393
84848.5	71.3049
88888.9	106.765
92929.3	154.099
96969.7	215.351
101010.	292.506
105051.	387.407
109091.	501.702
113131.	636.785
117172.	793.769
121212.	973.451
125253.	1176.31
129293.	1402.49
133333.	1651.81
137374.	1923.79
141414.	2217.63
145455.	2532.29
149495.	2866.47
153535.	3218.67
157576.	3587.20
161616.	3970.23
165657.	4365.80
169697.	4771.87
173737.	5186.36
177778.	5607.13
181818.	6032.07
185859.	6459.06
189899.	6886.06
193939.	7311.05
197980.	7732.11
202020.	8147.40
206061.	8555.20
210101.	8953.87
214141.	9341.92
218182.	9717.96
222222.	10080.7
226263.	10429.1
230303.	10762.1
234343.	11078.9
238384.	11378.6
242424.	11660.7
246465.	11924.7
250505.	12170.1
254545.	12396.8
258586.	12604.4
262626.	12792.9
266667.	12962.4
270707.	13112.8
274747.	13244.4
278788.	13357.4
282828.	13452.1
286869.	13528.8
290909.	13588.0
294950.	13630.1
298990.	13655.6
303030.	13665.0 √
307071.	13658.9
311111.	13637.9
315152.	13602.5
319192.	13553.4
323232.	13491.2
327273.	13416.6
331313.	13330.2
335354.	13232.6
339394.	13124.4
343434.	13006.4
347475.	12879.2
351515.	12743.3
355556.	12599.4
359596.	12448.2
363636.	12290.0
367677.	12125.7
371717.	11955.6
375758.	11780.4
379798.	11600.5
383838.	11416.6
387879.	11229.0
391919.	11038.2
395960.	10844.6
400000.	10648.8

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|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
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| Ada, OK 74820                               |
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Title: W/DECAY 1,2,4-Trichlorobenzene. LANDFILL PL1241

Solubility (mg/l)	0.48800E+02
Recharge rate (cm/hr).....	0.65800E-03
Sorption constant (cc/g).....	0.48690E+02
Saturated water content	0.40000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.50000E+01
Bulk density (g/cc).....	0.15900E+01
Dispersion coefficient (cm^2/hr).....	0.18200E+00
Saturated hydraulic conductivity	0.36000E+00
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.68300E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.13000E+08

For application 1 the active ingredient (ai) applied is 0.100E+09 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.246E+00
Pore water velocity [cm/hr]	0.267E-02
Pollutant velocity [cm/hr]	0.847E-05
Length of pollutant slug [cm]	0.264E+06
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY 124TRICHLORO LANDFILL PL1241

DAYS	UG/L
0.100000E-29	0.000000
131313.	0.000000
262626.	0.000000
393939.	0.000000
525253.	0.383914E-01
656566.	0.960563
787879.	8.10287
919192.	36.6453
0.105050E+07	112.077
0.118182E+07	263.891
0.131313E+07	517.138
0.144444E+07	886.485
0.157576E+07	1374.25
0.170707E+07	1971.60
0.183838E+07	2661.41
0.196970E+07	3421.59
0.210101E+07	4228.04
0.223232E+07	5056.97
0.236364E+07	5886.49
0.249495E+07	6697.58
0.262626E+07	7474.52
0.275758E+07	8204.95
0.288889E+07	8879.73
0.302020E+07	9492.62
0.315151E+07	10039.9
0.328283E+07	10520.0
0.341414E+07	10933.0
0.354545E+07	11280.4
0.367677E+07	11564.6
0.380808E+07	11788.9
0.393939E+07	11957.2
0.407071E+07	12073.3
0.420202E+07	12141.7
0.433333E+07	12166.5
0.446465E+07	12152.0
0.459596E+07	12102.3
0.472727E+07	12021.4
0.485859E+07	11912.8
0.498990E+07	11780.1
0.512121E+07	11626.5
0.525252E+07	11454.9
0.538384E+07	11268.2
0.551515E+07	11068.7
0.564646E+07	10858.6
0.577778E+07	10640.1
0.590909E+07	10414.9
0.604040E+07	10184.7
0.617172E+07	9950.76
0.630303E+07	9714.49
0.643434E+07	9476.98
0.656566E+07	9239.19
0.669697E+07	9001.99
0.682828E+07	8766.11
0.695960E+07	8532.20
0.709091E+07	8300.80
0.722222E+07	8072.38
0.735353E+07	7847.32
0.748485E+07	7625.97
0.761616E+07	7408.58
0.774747E+07	7195.38
0.787879E+07	6986.53
0.801010E+07	6782.19
0.814141E+07	6582.43
0.827273E+07	6387.34
0.840404E+07	6196.95
0.853535E+07	6011.29
0.866667E+07	5830.36
0.879798E+07	5654.13
0.892929E+07	5482.58
0.906061E+07	5315.66
0.919192E+07	5153.32
0.932323E+07	4995.49
0.945454E+07	4842.10
0.958586E+07	4693.08
0.971717E+07	4548.35
0.984848E+07	4407.80
0.997980E+07	4271.37
0.101111E+08	4138.95
0.102424E+08	4010.46
0.103737E+08	3885.79
0.105050E+08	3764.86
0.106364E+08	3647.57
0.107677E+08	3533.82
0.108990E+08	3423.53
0.110303E+08	3316.59
0.111616E+08	3212.92
0.112929E+08	3112.43
0.114242E+08	3015.02
0.115556E+08	2920.61
0.116869E+08	2829.11
0.118182E+08	2740.44
0.119495E+08	2654.51
0.120808E+08	2571.25
0.122121E+08	2490.58
0.123434E+08	2412.41
0.124747E+08	2336.68
0.126061E+08	2263.30
0.127374E+08	2192.21
0.128687E+08	2123.35
0.130000E+08	2056.63

FORMER CPC PLANT AREA

PESTAN RUNS
NO DECAY

4 9 0635

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-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
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| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
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Title: BASE CASE, BENZENE PLANT AREA FILE= PPBENB.INP

Solubility (mg/l)	0.17910E+04
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.70000E+00
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00 √
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+06

For application 1 the active ingredient (ai) applied is 0.230E+02 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.694E-03
Length of pollutant slug [cm]	0.960E-01
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, BENZENE, PLANT AREA FILE = PPBENB

DAYS	UG/L		
0.100000E-29	0.000000		
1010.10	0.000000		
2020.20	0.000000		
3030.30	0.000000		
4040.40	0.000000	52525.3	127.889
5050.50	0.000000	53535.4	120.950
6060.61	0.106752	54545.5	114.225
7070.71	0.480384	55555.6	107.819
8080.81	1.70803	56565.7	101.628
9090.91	4.64371	57575.8	95.8098
10101.0	9.98130	58585.9	90.1520
11111.1	18.5215	59596.0	84.9212
12121.2	30.4243	60606.1	79.8504
13131.3	45.5297	61616.2	75.0466
14141.4	63.6241	62626.3	70.4029
15151.5	83.9070	63636.4	66.1328
16161.6	105.631	64646.5	62.0762
17171.7	128.156	65656.6	58.1798
18181.8	150.520	66666.7	54.6036
19191.9	172.298	67676.8	51.0808
20202.0	192.634	68686.9	47.8249
21212.1	211.582	69697.0	44.7291
22222.2	228.396	70707.1	41.9535
23232.3	243.021	71717.2	39.1780
24242.4	255.564	72727.3	36.6693
25252.5	265.732	73737.4	34.2674
26262.6	273.659	74747.5	32.0256
27272.7	279.450	75757.6	29.8905
28282.8	283.186	76767.7	27.9156
29292.9	285.041	77777.8	26.1008
30303.0	285.161	78787.9	24.3394
31313.1	283.733	79798.0	22.7382
32323.2	280.931	80808.1	21.1903
33333.3	276.896	81818.2	19.7491
34343.4	271.817	82828.3	18.4147
35353.5	265.839	83838.4	17.1871
36363.6	259.100	84848.5	16.0128
37373.7	251.761	85858.6	14.8919
38383.8	243.955	86868.7	13.9311
39393.9	235.762	87878.8	12.9704
40404.0	227.302	88888.9	12.0630
41414.1	218.601	89899.0	11.2090
42424.2	209.874	90909.1	10.4617
43434.3	201.067	91919.2	9.71442
44444.4	192.287	92929.3	9.07391
45454.5	183.613	93939.4	8.38003
46464.6	175.020	94949.5	7.84627
47474.7	166.640	95959.6	7.25913
48484.8	158.420	96969.7	6.77875
49494.9	150.413	97979.8	6.29836
50505.1	142.674	98989.9	5.87136
51515.2	135.148	100000.	5.44435

```
-----------------------------------------------
|                  PESTAN                     |
|              version 4.0, 1992.             |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, CHLOROBENZENE PLANT AREA. FILE PPCHBB.INP

Solubility (mg/l) .....:	0.47170E+03
Recharge rate (cm/hr).....:	0.92800E-03
Sorption constant (cc/g).....:	0.18800E+01
Saturated water content .....:	0.35000E+00
Solid-phase decay (/hr) .....:	0.00000E+00
Liquid-phase decay (/hr) .....:	0.00000E+00 ✓
Curve coefficient .....:	0.40000E+01
Bulk density (g/cc).....:	0.17200E+01
Dispersion coefficient (cm^2/hr).....:	0.38500E+00
Saturated hydraulic conductivity ....:	0.38100E+02
Minimum depth (cm).....:	0.00000E+00
Maximum depth (cm).....:	0.55000E+03
Minimum time (day).....:	0.00000E+00
Maximum time (day).....:	0.10000E+06

For application 1 the active ingredient (ai) applied is 0.115E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content .....:	0.133E+00
Pore water velocity [cm/hr] .....:	0.696E-02
Pollutant velocity [cm/hr] .....:	0.276E-03
Length of pollutant slug [cm] .....:	0.724E+01
Mass decayed prior to recharge [kg] .....:	0.000E+00

BASE CASE, CHLOROBENZENE, PLANT AREA FILE= PPCHBB

DAYS	UG/L
0.100000E-29	0.000000
1010.10	0.000000
2020.20	0.000000
3030.30	0.000000
4040.40	0.000000
5050.50	0.000000
6060.61	0.000000
7070.71	0.000000
8080.81	0.000000
9090.91	0.000000
10101.0	0.000000
11111.1	0.000000
12121.2	0.000000
13131.3	0.154635
14141.4	0.492021
15151.5	1.20897
16161.6	2.71315
17171.7	5.46847
18181.8	10.1638
19191.9	17.6003
20202.0	28.7200
21212.1	44.5490
22222.2	66.1417
23232.3	94.5384
24242.4	130.751
25252.5	175.609
26262.6	229.858
27272.7	294.060
28282.8	368.594
29292.9	453.658
30303.0	549.237
31313.1	655.176
32323.2	771.152
33333.3	896.660
34343.4	1031.11
35353.5	1173.74
36363.6	1323.79
37373.7	1480.37
38383.8	1642.56
39393.9	1809.39
40404.0	1979.94
41414.1	2153.24
42424.2	2328.32
43434.3	2504.30
44444.4	2680.29
45454.5	2855.43
46464.6	3028.95
47474.7	3200.11
48484.8	3368.18
49494.9	3532.60
50505.1	3692.79
51515.2	3848.18
52525.3	3998.38
53535.4	4142.95
54545.5	4281.57
55555.6	4413.92
56565.7	4539.81
57575.8	4658.99
58585.9	4771.34
59596.0	4876.73
60606.1	4975.12
61616.2	5066.47
62626.3	5150.77
63636.4	5228.02
64646.5	5298.31
65656.6	5361.69
66666.7	5418.29
67676.8	5468.22
68686.9	5511.62
69697.0	5548.62
70707.1	5579.42
71717.2	5604.17
72727.3	5623.08
73737.4	5636.31
74747.5	5644.08
75757.6	5646.60
76767.7	5644.07
77777.8	5636.70
78787.9	5624.70
79798.0	5608.28
80808.1	5587.67
81818.2	5563.05
82828.3	5534.65
83838.4	5502.65
84848.5	5467.25
85858.6	5428.65
86868.7	5387.07
87878.8	5342.68
88888.9	5295.68
89899.0	5246.23
90909.1	5194.52
91919.2	5140.70
92929.3	5084.95
93939.4	5027.43
94949.5	4968.28
95959.6	4907.65
96969.7	4845.68
97979.8	4782.50
98989.9	4718.27
100000.	4653.09

```
-----------------------------------------------
|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac)|
| Center for Subsurface Modeling Support       |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: BASE CASE, 1,2-DICHLOROBENZENE PLANT AREA FILE = PP12DB.INP

Solubility (mg/l)	0.15600E+03
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.86100E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.322E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.621E-04
Length of pollutant slug [cm]	0.138E+03
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, CHLOROBENZENE, PLANT AREA. FILE PP12DB

DAYS	UG/L
0.100000E-29	0.000000
5555.56	0.000000
11111.1	0.000000
16666.7	0.000000
22222.2	0.000000
27777.8	0.000000
33333.3	0.000000
38888.9	0.000000
44444.4	0.000000
50000.0	0.000000
55555.6	0.836849E-01
61111.1	0.376582
66666.7	1.33896
72222.2	3.91924
77777.8	9.83763
83333.3	21.7069
88888.9	43.4557
94444.4	80.0167
100000.	137.415
105556.	222.448
111111.	342.406
116667.	504.699
122222.	716.459
127778.	984.242
133333.	1313.67
138889.	1709.28
144444.	2174.28
150000.	2710.53
155556.	3318.50
161111.	3997.28
166667.	4744.70
172222.	5557.43
177778.	6431.10
183333.	7360.50
188889.	8339.72
194444.	9362.29
200000.	10421.4
205556.	11509.9
211111.	12620.7
216667.	13746.6
222222.	14880.6
227778.	16015.9
233333.	17145.9
238889.	18264.5
244444.	19365.9
250000.	20444.8
255556.	21496.3
261111.	22515.9
266667.	23499.7
272222.	24444.3
277778.	25346.7
283333.	26204.2
288889.	27014.8
294444.	27776.8
300000.	28488.9
305556.	29150.0
311111.	29759.7
316667.	30317.6
322222.	30823.7
327778.	31278.3
333333.	31681.9
338889.	32035.2
344444.	32339.2
350000.	32594.8
355556.	32803.4
361111.	32966.3
366667.	33084.8
372222.	33160.7
377778.	33195.4
383333.	33190.6
388889.	33148.1
394444.	33069.6
400000.	32956.8
405556.	32811.6
411111.	32635.6
416667.	32430.7
422222.	32198.6
427778.	31941.0
433333.	31659.5
438889.	31355.9
444444.	31031.7
450000.	30688.6
455556.	30327.9
461111.	29951.3
466667.	29560.1
472222.	29155.7
477778.	28739.5
483333.	28312.6
488889.	27876.4
494444.	27431.9
500000.	26980.4
505556.	26522.8
511111.	26060.1
516667.	25593.3
522222.	25123.4
527778.	24651.1
533333.	24177.2
538889.	23702.6
544444.	23227.9
550000.	22753.8

```
-----------------------------------------------
|                   PESTAN                    |
|              version 4.0, 1992.             |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, 1,3-DICHLOROBENZENE PLANT AREA

Solubility (mg/l)	0.11100E+03
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.64600E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00 √
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.252E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00 √
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.825E-04
Length of pollutant slug [cm]	0.202E+03
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, 1,3-DICHLOROBENZENE, PLANT AREA FILE =PP13DB.BTC

DAYS	UG/L
0.100000E-29	0.000000
5555.56	0.000000
11111.1	0.000000
16666.7	0.000000
22222.2	0.000000
27777.8	0.000000
33333.3	0.000000
38888.9	0.000000
44444.4	0.158787
50000.0	0.909716
55555.6	3.68848
61111.1	11.5981
66666.7	30.0934
72222.2	67.2462
77777.8	133.771
83333.3	242.259
88888.9	406.398
94444.4	639.917
100000.	955.585
105556.	1364.34
111111.	1874.62
116667.	2491.93
122222.	3218.65
127778.	4054.05
133333.	4994.40
138889.	6033.34
144444.	7162.24
150000.	8370.58
155556.	9646.46
161111.	10977.0
166667.	12348.8
172222.	13748.1
177778.	15161.6
183333.	16576.2
188889.	17979.4
194444.	19359.7
200000.	20706.3
205556.	22009.8
211111.	23261.5
216667.	24454.2
222222.	25581.5
227778.	26638.3
233333.	27620.3
238889.	28524.6
244444.	29348.8
250000.	30091.6
255556.	30752.5
261111.	31331.5
266667.	31829.4
272222.	32247.6
277778.	32587.9
283333.	32852.4
288889.	33043.8
294444.	33164.8
300000.	33218.6 ✓
305556.	33208.4
311111.	33137.7
316667.	33009.8
322222.	32828.4
327778.	32597.0
333333.	32319.1
338889.	31998.3
344444.	31638.1
350000.	31241.7
355556.	30812.5
361111.	30353.7
366667.	29868.3
372222.	29359.4
377778.	28829.7
383333.	28281.8
388889.	27718.5
394444.	27142.0
400000.	26554.7
405556.	25958.8
411111.	25356.1
416667.	24748.6
422222.	24138.1
427778.	23526.2
433333.	22914.3
438889.	22303.9
444444.	21696.1
450000.	21092.3
455556.	20493.4
461111.	19900.5
466667.	19314.3
472222.	18735.6
477778.	18165.2
483333.	17603.7
488889.	17051.6
494444.	16509.3
500000.	15977.4
505556.	15456.1
511111.	14945.7
516667.	14446.5
522222.	13958.6
527778.	13482.3
533333.	13017.6
538889.	12564.5
544444.	12123.2
550000.	11693.6

```
-----------------------------------------------
|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support       |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: BASE CASE, 1,4-DICHLOROBENZENE PLANT AREA FILE = PP14DB

Solubility (mg/l)	0.87000E+02
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.43100E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.195E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.123E-03
Length of pollutant slug [cm]	0.297E+02
Mass decayed prior to recharge [kg]	0.000E+00

BASE CASE, 1,4DICHLOROBENZENE PLANT AREA FILE=PP14DB

DAYS	UG/L
0.100000E-29	0.000000
5555.56	0.000000
11111.1	0.000000
16666.7	0.000000
22222.2	0.000000
27777.8	0.388920E-01
33333.3	0.477076
38888.9	3.26434
44444.4	13.4748
50000.0	39.7010
55555.6	92.4386
61111.1	181.385
66666.7	313.146
72222.2	490.003
77777.8	709.865
83333.3	967.022
88888.9	1253.25
94444.4	1559.02
100000.	1874.46
105556.	2190.18
111111.	2497.77
116667.	2790.14
122222.	3061.58
127778.	3307.83
133333.	3525.94
138889.	3714.13
144444.	3871.69
150000.	3998.70
155556.	4095.94
161111.	4164.71
166667.	4206.70
172222.	4223.86 ✓
177778.	4218.32
183333.	4192.28
188889.	4147.96
194444.	4087.53
200000.	4013.11
205556.	3926.73
211111.	3830.29
216667.	3725.54
222222.	3614.11
227778.	3497.47
233333.	3376.97
238889.	3253.80
244444.	3129.04
250000.	3003.63
255556.	2878.38
261111.	2754.02
266667.	2631.17
272222.	2510.34
277778.	2391.98
283333.	2276.44
288889.	2164.03
294444.	2054.98
300000.	1949.45
305556.	1847.60
311111.	1749.51
316667.	1655.22
322222.	1564.78
327778.	1478.15
333333.	1395.33
338889.	1316.26
344444.	1240.87
350000.	1169.09
355556.	1100.82
361111.	1035.97
366667.	974.427
372222.	916.086
377778.	860.828
383333.	808.537
388889.	759.100
394444.	712.391
400000.	668.290
405556.	626.685
411111.	587.459
416667.	550.499
422222.	515.695
427778.	482.938
433333.	452.128
438889.	423.163
444444.	395.936
450000.	370.369
455556.	346.365
461111.	323.833
466667.	302.697
472222.	282.877
477778.	264.297
483333.	246.887
488889.	230.573
494444.	215.299
500000.	200.999
505556.	187.615
511111.	175.089
516667.	163.375
522222.	152.420
527778.	142.176
533333.	132.601
538889.	123.653
544444.	115.294
550000.	107.482

```
-----------------------------------------------
|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support       |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: BASE CASE, 1,2,4-TRICHLOROBENZENE PLANT AREA FILE PP124B.INP

Solubility (mg/l) .....:	0.48800E+02
Recharge rate (cm/hr).....:	0.92800E-03
Sorption constant (cc/g).....:	0.48690E+02
Saturated water content .....:	0.35000E+00
Solid-phase decay (/hr) .....:	0.00000E+00
Liquid-phase decay (/hr) .....:	0.00000E+00
Curve coefficient .....:	0.40000E+01
Bulk density (g/cc).....:	0.17200E+01
Dispersion coefficient (cm^2/hr).....:	0.38500E+00
Saturated hydraulic conductivity ....:	0.38100E+02
Minimum depth (cm).....:	0.00000E+00
Maximum depth (cm).....:	0.55000E+03
Minimum time (day).....:	0.00000E+00
Maximum time (day).....:	0.50000E+07

For application 1 the active ingredient (ai) applied is 0.201E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content .....:	0.133E+00
Pore water velocity [cm/hr] .....:	0.696E-02
Pollutant velocity [cm/hr] .....:	0.111E-04
Length of pollutant slug [cm] .....:	0.491E+02
Mass decayed prior to recharge [kg] .....:	0.000E+00

BASE CASE 1,2,4-TRICHLOROBENZENE PLANT AREA FILE PP124B

DAYS	UG/L
0.100000E-29	0.000000
50505.1	0.000000
101010.	0.000000
151515.	0.000000
202020.	0.000000
252525.	0.000000
303030.	0.000000
353535.	0.184703
404040.	1.01805
454545.	4.08964
505051.	12.2602
555556.	29.7124
606061.	61.3810
656566.	112.138
707071.	186.012
757576.	285.613
808081.	411.884
858586.	564.093
909091.	740.049
959596.	936.407
0.101010E+07	1149.05
0.106061E+07	1373.40
0.111111E+07	1604.77
0.116162E+07	1838.58
0.121212E+07	2070.56
0.126263E+07	2296.84
0.131313E+07	2514.09
0.136364E+07	2719.52
0.141414E+07	2910.86
0.146465E+07	3086.39
0.151515E+07	3244.87
0.156566E+07	3385.51
0.161616E+07	3507.90
0.166667E+07	3611.99
0.171717E+07	3697.99
0.176768E+07	3766.38
0.181818E+07	3817.79
0.186869E+07	3853.03
0.191919E+07	3873.02
0.196970E+07	3878.74
0.202020E+07	3871.22
0.207071E+07	3851.55
0.212121E+07	3820.79
0.217172E+07	3779.99
0.222222E+07	3730.20
0.227273E+07	3672.41
0.232323E+07	3607.61
0.237374E+07	3536.70
0.242424E+07	3460.56
0.247475E+07	3379.98
0.252525E+07	3295.73
0.257576E+07	3208.51
0.262626E+07	3118.96
0.267677E+07	3027.68
0.272727E+07	2935.20
0.277778E+07	2842.01
0.282828E+07	2748.55
0.287879E+07	2655.22
0.292929E+07	2562.38
0.297980E+07	2470.32
0.303030E+07	2379.34
0.308081E+07	2289.66
0.313131E+07	2201.50
0.318182E+07	2115.02
0.323232E+07	2030.40
0.328283E+07	1947.73
0.333333E+07	1867.14
0.338384E+07	1788.71
0.343434E+07	1712.49
0.348485E+07	1638.53
0.353535E+07	1566.86
0.358586E+07	1497.52
0.363636E+07	1430.49
0.368687E+07	1365.78
0.373737E+07	1303.37
0.378788E+07	1243.24
0.383838E+07	1185.36
0.388889E+07	1129.70
0.393939E+07	1076.22
0.398990E+07	1024.88
0.404040E+07	975.615
0.409091E+07	928.392
0.414141E+07	883.152
0.419192E+07	839.834
0.424242E+07	798.392
0.429293E+07	758.761
0.434343E+07	720.887
0.439394E+07	684.707
0.444444E+07	650.166
0.449495E+07	617.204
0.454545E+07	585.767
0.459596E+07	555.794
0.464646E+07	527.231
0.469697E+07	500.023
0.474747E+07	474.112
0.479798E+07	449.452
0.484848E+07	425.984
0.489899E+07	403.662
0.494949E+07	382.437
0.500000E+07	362.262

FORMER CPC PLANT AREA

PESTAN RUNS
WITH DECAY

```
-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
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```

4 9 0642

Title: W/DECAY , BENZENE PLANT AREA FILE = PPBEN1

Solubility (mg/l)	0.17910E+04
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.70000E+00
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.36000E-04
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+06

For application 1 the active ingredient (ai) applied is 0.190E+03 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.694E-03
Length of pollutant slug [cm]	0.793E+00
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY BENZENE PLANT AREA FILE = PPBEN1

DAYS	UG/L
0.100000E-29	0.000000
1010.10	0.000000
2020.20	0.000000
3030.30	0.000000
4040.40	0.000000
5050.50	0.345547E-01
6060.61	0.380120
7070.71	2.06172
8080.81	6.94776
9090.91	17.2527
10101.0	34.3382
11111.1	58.3423
12121.2	87.9603
13131.3	120.977
14141.4	154.930
15151.5	187.398
16161.6	216.410
17171.7	240.628
18181.8	259.232
19191.9	271.994
20202.0	279.032
21212.1	280.854
22222.2	278.049
23232.3	271.358
24242.4	261.555
25252.5	249.366
26262.6	235.463
27272.7	220.442
28282.8	204.819
29292.9	189.012
30303.0	173.367
31313.1	158.149
32323.2	143.555
33333.3	129.724
34343.4	116.747
35353.5	104.680
36363.6	93.5412
37373.7	83.3288
38383.8	74.0212
39393.9	65.5790
40404.0	57.9606
41414.1	51.1117
42424.2	44.9801
43434.3	39.5078
44444.4	34.6396
45454.5	30.3222
46464.6	26.4998
47474.7	23.1271
48484.8	20.1570
49494.9	17.5453
50505.1	15.2557
51515.2	13.2493
52525.3	11.4944
53535.4	9.96230
54545.5	8.62662
55555.6	7.46399
56565.7	6.45279
57575.8	5.57440
58585.9	4.81169
59596.0	4.15061
60606.1	3.57784
61616.2	3.08256
62626.3	2.65396
63636.4	2.28406
64646.5	1.96431
65656.6	1.68853
66666.7	1.45108
67676.8	1.24619
68686.9	1.06983
69697.0	0.918040
70707.1	0.787630
71717.2	0.675242
72727.3	0.578862
73737.4	0.496001
74747.5	0.424982
75757.6	0.363922
76767.7	0.311452
77777.8	0.266583
78787.9	0.228115
79798.0	0.195149
80808.1	0.166854
81818.2	0.142663
82828.3	0.121943
83838.4	0.104232
84848.5	0.890203E-01
85858.6	0.760470E-01
86868.7	0.649792E-01
87878.8	0.554762E-01
88888.9	0.473588E-01
89899.0	0.404178E-01
90909.1	0.345175E-01
91919.2	0.294367E-01
92929.3	0.251239E-01
93939.4	0.214074E-01
94949.5	0.182710E-01
95959.6	0.155775E-01
96969.7	0.132943E-01
97979.8	0.113298E-01
98989.9	0.965337E-02
100000.	0.823602E-02

4 9 0643

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-----------------------------------------------
|                  PESTAN                     |
|              version 4.0, 1992.             |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: W/DECAY CHLOROBENZENE PLANT AREA FILE = PPCHB1

Solubility (mg/l)	0.47170E+03
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.18800E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.38600E-05 ✓
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+06

For application 1 the active ingredient (ai) applied is 0.150E+04 ✓ kg ai/ha,
and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.276E-03
Length of pollutant slug [cm]	0.944E+01
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY CHLOROBENZENE PLANT AREA FILE = PPCHB1

DAYS	UG/L		
0.100000E-29	0.000000		
1010.10	0.000000		
2020.20	0.000000		
3030.30	0.000000		
4040.40	0.000000	52525.3	4276.28
5050.50	0.000000	53535.4	4415.84
6060.61	0.000000	54545.5	4548.02
7070.71	0.000000	55555.6	4672.57
8080.81	0.000000	56565.7	4789.33
9090.91	0.000000	57575.8	4898.17
10101.0	0.000000	58585.9	4998.98
11111.1	0.000000	59596.0	5091.73
12121.2	0.000000	60606.1	5176.46
13131.3	0.187558	61616.2	5253.18
14141.4	0.573940	62626.3	5321.99
15151.5	1.43620	63636.4	5382.99
16161.6	3.20625	64646.5	5436.30
17171.7	6.46799	65656.6	5482.08
18181.8	11.9807	66666.7	5520.52
19191.9	20.7152	67676.8	5551.84
20202.0	33.7449	68686.9	5576.22
21212.1	52.2576	69697.0	5593.89
22222.2	77.4228	70707.1	5605.10
23232.3	110.431	71717.2 ✓	5610.08 ✓
24242.4	152.365	72727.3	5609.11
25252.5	204.150	73737.4	5602.41
26262.6	266.555	74747.5	5590.25
27272.7	340.134	75757.6	5572.90
28282.8	425.206	76767.7	5550.62
29292.9	521.891	77777.8	5523.65
30303.0	630.095	78787.9	5492.28
31313.1	749.499	79798.0	5456.74
32323.2	879.612	80808.1	5417.29
33333.3	1019.75	81818.2	5374.17
34343.4	1169.14	82828.3	5327.63
35353.5	1326.86	83838.4	5277.89
36363.6	1491.88	84848.5	5225.17
37373.7	1663.17	85858.6	5169.71
38383.8	1839.62	86868.7	5111.72
39393.9	2020.09	87878.8	5051.42
40404.0	2203.47	88888.9	4989.01
41414.1	2388.63	89899.0	4924.68
42424.2	2574.52	90909.1	4858.62
43434.3	2760.12	91919.2	4790.99
44444.4	2944.41	92929.3	4721.99
45454.5	3126.51	93939.4	4651.76
46464.6	3305.53	94949.5	4580.47
47474.7	3480.70	95959.6	4508.27
48484.8	3651.30	96969.7	4435.30
49494.9	3816.70	97979.8	4361.68
50505.1	3976.32	98989.9	4287.56
51515.2	4129.67	100000.	4213.07

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-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: W/LIQUID PHASE DECAY 1,2-DICHLOROBENZENE

Solubility (mg/l)	0.15600E+03
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.86100E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.432E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.621E-04
Length of pollutant slug [cm]	0.185E+03
Mass decayed prior to recharge [kg]	0.000E+00

W/LIQUID PHASE DECAY 1,2 DICHLOROBENZENE, FILE = PP12D1

DAYS	UG/L		
0.100000E-29	0.000000		
5555.56	0.000000		
11111.1	0.000000		
16666.7	0.000000		
22222.2	0.000000	288889.	26986.8
27777.8	0.000000	294444.	27769.3
33333.3	0.000000	300000.	28500.3
38888.9	0.000000	305556.	29178.8
44444.4	0.000000	311111.	29803.8
50000.0	0.000000	316667.	30374.8
55555.6	0.805607E-01	322222.	30891.8
61111.1	0.361146	327778.	31354.8
66666.7	1.27920	333333.	31764.2
72222.2	3.73010	338889.	32120.7
77777.8	9.32731	344444.	32425.2
83333.3	20.6125	350000.	32678.8
88888.9	41.2129	355556.	32882.6
94444.4	75.7065	361111.	33038.0
100000.	129.908	366667.	33146.7
105556.	210.226	372222.	33210.1
111111.	323.624	377778. √	33230.0 √
116667.	477.243	383333.	33208.2
122222.	678.054	388889.	33146.5
127778.	932.567	394444.	33046.8
133333.	1246.50	400000.	32910.9
138889.	1624.60	405556.	32740.8
144444.	2070.43	411111.	32538.4
150000.	2586.31	416667.	32305.6
155556.	3173.25	422222.	32044.3
161111.	3830.92	427778.	31756.4
166667.	4557.77	433333.	31443.6
172222.	5351.06	438889.	31107.9
177778.	6206.98	444444.	30750.9
183333.	7120.86	450000.	30374.4
188889.	8087.18	455556.	29980.1
194444.	9099.85	461111.	29569.5
200000.	10152.3	466667.	29144.3
205556.	11237.5	472222.	28705.8
211111.	12348.6	477778.	28255.6
216667.	13478.1	483333.	27795.1
222222.	14619.1	488889.	27325.5
227778.	15764.5	494444.	26848.1
233333.	16907.6	500000.	26364.2
238889.	18041.8	505556.	25874.8
244444.	19161.1	511111.	25381.1
250000.	20259.7	516667.	24884.0
255556.	21332.4	522222.	24384.6
261111.	22374.3	527778.	23883.8
266667.	23381.1	533333.	23382.3
272222.	24348.9	538889.	22881.1
277778.	25274.4	544444.	22380.9
283333.	26154.5	550000.	21882.3

4 9 0645

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-----------------------------------------------
|                  PESTAN                      |
|              version 4.0, 1992.              |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
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| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: WITH LIQUID PHASE DECAY, 1,3-DICHLOROBENZENE PP13D1

Solubility (mg/l) .....:	0.11100E+03
Recharge rate (cm/hr).....:	0.92800E-03
Sorption constant (cc/g).....:	0.64600E+01
Saturated water content .....:	0.35000E+00
Solid-phase decay (/hr) .....:	0.00000E+00
Liquid-phase decay (/hr) .....:	0.32000E-05 ✓
Curve coefficient .....:	0.40000E+01
Bulk density (g/cc).....:	0.17200E+01
Dispersion coefficient (cm^2/hr).....:	0.38500E+00
Saturated hydraulic conductivity ....:	0.38100E+02
Minimum depth (cm).....:	0.00000E+00
Maximum depth (cm).....:	0.55000E+03
Minimum time (day).....:	0.00000E+00
Maximum time (day).....:	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.354E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content .....:	0.133E+00
Pore water velocity [cm/hr] .....:	0.696E-02
Pollutant velocity [cm/hr] .....:	0.825E-04
Length of pollutant slug [cm] .....:	0.284E+03
Mass decayed prior to recharge [kg] .....:	0.000E+00

W/LIQUID PHASE DECAY, 1,3-DICHLOROBENZENE PP13D1

DAYS	UG/L
0.100000E-29	0.000000
5555.56	0.000000
11111.1	0.000000
16666.7	0.000000
22222.2	0.000000
27777.8	0.000000
33333.3	0.000000
38888.9	0.000000
44444.4	0.152492
50000.0	0.869247
55555.6	3.50663
61111.1	10.9706
66666.7	28.3218
72222.2	63.0364
77777.8	124.870
83333.3	225.246
88888.9	376.570
94444.4	591.233
100000.	880.805
105556.	1255.34
111111.	1722.78
116667.	2288.67
122222.	2955.93
127778.	3724.84
133333.	4593.19
138889.	5556.40
144444.	6607.88
150000.	7739.28
155556.	8940.82
161111.	10201.7
166667.	11510.2
172222.	12854.5
177778.	14222.3
183333.	15601.4
188889.	16980.2
194444.	18347.4
200000.	19692.4
205556.	21005.2
211111.	22277.0
216667.	23499.6
222222.	24666.0
227778.	25770.0
233333.	26806.4
238889.	27770.9
244444.	28660.3
250000.	29472.0
255556.	30204.4
261111.	30856.6
266667.	31428.4
272222.	31920.1
277778.	32332.8
283333.	32667.8
288889.	32927.2
294444.	33113.1
300000.	33228.3
305556.	33275.4
311111.	33257.8
316667.	33178.5
322222.	33041.0
327778.	32848.7
333333.	32605.1
338889.	32313.9
344444.	31978.4
350000.	31602.2
355556.	31188.8
361111.	30741.4
366667.	30263.4
372222.	29757.9
377778.	29228.0
383333.	28676.6
388889.	28106.6
394444.	27520.6
400000.	26921.1
405556.	26310.6
411111.	25691.2
416667.	25065.3
422222.	24434.6
427778.	23801.1
433333.	23166.5
438889.	22532.5
444444.	21900.4
450000.	21271.6
455556.	20647.4
461111.	20028.8
466667.	19417.0
472222.	18812.8
477778.	18217.1
483333.	17630.5
488889.	17053.8
494444.	16487.4
500000.	15932.0
505556.	15387.8
511111.	14855.3
516667.	14334.8
522222.	13826.5
527778.	13330.6
533333.	12847.1
538889.	12376.3
544444.	11918.2
550000.	11472.7

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-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
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4 9 0646

Title: W/LIQUID PHASE DECAY, 1,4-DICHLOROBENZENE

Solubility (mg/l)	0.87000E+02
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.43100E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.250E+04 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.123E-03
Length of pollutant slug [cm]	0.381E+02
Mass decayed prior to recharge [kg]	0.000E+00

W/LIQUID PHASE DECAY, 1,4 DICHLOROBENZENE, PLANT AREA FILE PP14D1.BTC

DAYS	UG/L		
0.100000E-29	0.000000		
5555.56	0.000000		
11111.1	0.000000		
16666.7	0.000000		
22222.2	0.000000	288889.	1898.99
27777.8	0.374543E-01	294444.	1790.64
33333.3	0.508033	300000.	1686.75
38888.9	3.51724	305556.	1587.36
44444.4	14.6322	311111.	1492.47
50000.0	43.3347	316667.	1402.04
55555.6	101.219	322222.	1316.03
61111.1	198.942	327778.	1234.34
66666.7	343.596	333333.	1156.88
72222.2	537.322	338889.	1083.54
77777.8	777.290	344444.	1014.18
83333.3	1056.60	350000.	948.679
88888.9	1365.61	355556.	886.881
94444.4	1693.31	361111.	828.646
100000.	2028.50	366667.	773.821
105556.	2360.66	372222.	722.258
111111.	2680.54	377778.	673.802
116667.	2980.51	383333.	628.310
122222.	3254.63	388889.	585.631
127778.	3498.63	394444.	545.623
133333.	3709.76	400000.	508.144
138889.	3886.62	405556.	473.059
144444.	4028.96	411111.	440.234
150000.	4137.43	416667.	409.542
155556.	4213.39	422222.	380.863
161111.	4258.75	427778.	354.080
166667.	4275.78	433333.	329.079
172222.	4266.97	438889.	305.754
177778.	4234.96	444444.	283.997
183333.	4182.42	450000.	263.720
188889.	4111.97	455556.	244.828
194444.	4026.11	461111.	227.232
200000.	3927.27	466667.	210.848
205556.	3817.70	472222.	195.602
211111.	3699.49	477778.	181.418
216667.	3574.53	483333.	168.225
222222.	3444.54	488889.	155.960
227778.	3311.07	494444.	144.561
233333.	3175.47	500000.	133.970
238889.	3038.95	505556.	124.132
244444.	2902.56	511111.	114.995
250000.	2767.20	516667.	106.513
255556.	2633.64	522222.	98.6412
261111.	2502.51	527778.	91.3353
266667.	2374.36	533333.	84.5588
272222.	2249.62	538889.	78.2721
277778.	2128.65	544444.	72.4443
283333.	2011.70	550000.	67.0389

```
-----------------------------------------------
|                  PESTAN                     |
|             version 4.0, 1992.              |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
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4 9 0647

Title: W/DECAY 1,2,4-TRICHLOROBENZENE PLANT AREA PP1241

Solubility (mg/l)	0.48800E+02
Recharge rate (cm/hr).....	0.92800E-03
Sorption constant (cc/g).....	0.48690E+02
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.32000E-05
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38500E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.50000E+07

For application 1 the active ingredient (ai) applied is 0.260E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.696E-02
Pollutant velocity [cm/hr]	0.111E-04
Length of pollutant slug [cm]	0.635E+02
Mass decayed prior to recharge [kg]	0.000E+00

W/DECAY 1,2,4 TRICHLOROBENZENE PLANT AREA PP1241

DAYS	UG/L		
0.100000E-29	0.000000		
50505.1	0.000000		
101010.	0.000000		
151515.	0.000000		
202020.	0.000000	0.262626E+07	2959.00
252525.	0.000000	0.267677E+07	2857.79
303030.	0.000000	0.272727E+07	2756.31
353535.	0.176906	0.277778E+07	2655.04
404040.	1.03830	0.282828E+07	2554.41
454545.	4.20611	0.287879E+07	2454.79
505051.	12.7118	0.292929E+07	2356.52
555556.	31.0215	0.297980E+07	2259.87
606061.	64.4538	0.303030E+07	2165.08
656566.	118.306	0.308081E+07	2072.37
707071.	196.977	0.313131E+07	1981.90
757576.	303.325	0.318182E+07	1893.81
808081.	438.349	0.323232E+07	1808.22
858586.	601.191	0.328283E+07	1725.19
909091.	789.353	0.333333E+07	1644.81
959596.	999.046	0.338384E+07	1567.10
0.101010E+07	1225.62	0.343434E+07	1492.09
0.106061E+07	1463.92	0.348485E+07	1419.80
0.111111E+07	1708.70	0.353535E+07	1350.21
0.116162E+07	1954.84	0.358586E+07	1283.31
0.121212E+07	2197.62	0.363636E+07	1219.07
0.126263E+07	2432.80	0.368687E+07	1157.44
0.131313E+07	2656.76	0.373737E+07	1098.38
0.136364E+07	2866.51	0.378788E+07	1041.85
0.141414E+07	3059.70	0.383838E+07	987.774
0.146465E+07	3234.57	0.388889E+07	936.100
0.151515E+07	3389.94	0.393939E+07	886.760
0.156566E+07	3525.12	0.398990E+07	839.683
0.161616E+07	3639.88	0.404040E+07	794.801
0.166667E+07	3734.33	0.409091E+07	752.040
0.171717E+07	3808.92	0.414141E+07	711.327
0.176768E+07	3864.34	0.419192E+07	672.589
0.181818E+07	3901.50	0.424242E+07	635.752
0.186869E+07	3921.42	0.429293E+07	600.743
0.191919E+07 ✓	3925.27 ✓	0.434343E+07	567.490
0.196970E+07	3914.27	0.439394E+07	535.920
0.202020E+07	3889.66	0.444444E+07	505.962
0.207071E+07	3852.72	0.449495E+07	477.551
0.212121E+07	3804.70	0.454545E+07	450.617
0.217172E+07	3746.83	0.459596E+07	425.095
0.222222E+07	3680.30	0.464646E+07	400.920
0.227273E+07	3606.24	0.469697E+07	378.031
0.232323E+07	3525.73	0.474747E+07	356.368
0.237374E+07	3439.77	0.479798E+07	335.873
0.242424E+07	3349.33	0.484848E+07	316.488
0.247475E+07	3255.26	0.489899E+07	298.162
0.252525E+07	3158.37	0.494949E+07	280.841
0.257576E+07	3059.39	0.500000E+07	264.477

ATTACHMENT E

RECALCULATION OF THE POTENTIAL SOIL ACTION LEVELS

ATTACHMENT E

RECALCULATION OF THE POTENTIAL SOIL ACTION LEVELS

The calculations presented in this attachment were performed using the corrected value of the area west of the former CPC plant area, or 15,000 ft^2 (as opposed to 27,500 ft^2 used originally in the Potential Soil Action Levels report, PSALs). The area west of the former CPC plant area shown on Figure 2-2 of this FS report. The penetration depth (H) was calculated from Equation 2-9[1] , using the same values except for the following changes:

α_V = the vertical dispersivity in the Alluvial Aquifer, calculated using 1/100 of the horizontal length L_b (230/100 = 2.30 ft).

L_b = horizontal length of the plume at the bottom of the unsaturated zone (230 ft).

I = vertical recharge rate (3.19 in/yr, from the updated HELP model calculations presented in Appendix E of this FS report).

Using the values presented on Table 3-4 of the PSALs except for those specified above, the penetration depth (H) was calculated as 33 ft.

Using this new value for the penetration depth, the concentration reduction factor (CRF_2) was calculated from Equation 2-10 using the same parameters listed on Table 3-4 with the following exceptions:

A_1 = the width of the source area (perpendicular to the groundwater flow direction, or 150 ft) times the penetration depth (H) calculated above, for an area of 4,950 ft^2.

---

[1] All the referenced equations and tables are from the text of Appendix F of this FS report.

A_2 = the map area of the former CPC plant, or 15,000 ft^2 .

I = vertical recharge rate (3.19 in/yr, from the updated HELP model calculations presented in Appendix E of this FS report).

The resulting concentration factor was 544 (dimensionless). From Equation 2-12, the CRF_2 was multiplied by the MCL ($=C_{ALL}$) of the soil action level constituents to obtain the target concentration in the aqueous phase at the source (C_{TARGET}). The results are summarized in the table below.

CHEMICAL	MCL mg/l	C_{TARGET} mg/l	AQUEOUS SOLUBILITY[1] mg/l
1,2-Dichlorobenzene	0.6	326.4	156.0
1,3-Dichlorobenzene	0.6	326.4	111.0
1,4-Dichlorobenzene	0.075	40.80	87.0
1,2,4-Trichlorobenzene	0.07	38.08	48.8
Chlorobenzene	0.1	54.4	471.7
Benzene	0.005	2.720	1791.0

1 From Table 3-5 of this Appendix.

1,2-Dichlorobenzene and 1,3-dichlorobenzene presented a C_{TARGET} value greater than the aqueous solubility. The PESTAN model assumes that the chemical leaches at its solubility, and therefore it will never yield results higher than the solubility, and therefore no further analysis was conducted for these two parameters. PESTAN without degradation was used for the four remaining parameters, and the results are summarized in the table below, including the calculated potential soil action level (PSAL) values. The PESTAN input and output printouts are included in this Attachment.

CHEMICAL	PESTAN input kg/ha	PSAL (without degradation) mg/kg
1,4-Dichlorobenzene	22,500	429
1,2,4-Trichlorobenzene	318,000	6,062
Chlorobenzene	11,400	217
Benzene	219	4.17

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-----------------------------------------------
|                  PESTAN                      |
|             version 4.0, 1992.               |
|                                              |
| Developed by :                               |
|                                              |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac)
| Center for Subsurface Modeling Support       |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency         |
| P.O. Box 1198                                |
| Ada, OK 74820                                |
-----------------------------------------------
```

Title: BASE CASE, BENZENE OCTOBER 1993 FILE: PPBENB2.INP

Solubility (mg/l)	0.17910E+04
Recharge rate (cm/hr).....	0.92500E-03
Sorption constant (cc/g).....	0.70000E+00
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38400E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+06

For application 1 the active ingredient (ai) applied is 0.219E+03 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.694E-02
Pollutant velocity [cm/hr]	0.692E-03
Length of pollutant slug [cm]	0.914E+00
Mass decayed prior to recharge [kg]	0.000E+00

FILE= PPBENB2.BTC BENZENE
OCTOBER 1993

DAYS	UG/L
0.100000E-29	0.000000
1010.10	0.000000
2020.20	0.000000
3030.30	0.000000
4040.40	0.000000
5050.50	0.533760E-01
6060.61	0.693887
7070.71	4.16332
8080.81	15.5858
9090.91	42.4339
10101.0	92.3938
11111.1	171.604
12121.2	282.839
13131.3	425.246
14141.4	595.035
15151.5	786.228
16161.6	991.832
17171.7	1204.43
18181.8	1417.03
19191.9	1623.43
20202.0	1818.57
21212.1	1998.34
22222.2	2159.91
23232.3	2301.30
24242.4	2421.45
25252.5	2520.01
26262.6	2597.43
27272.7	2654.31
28282.8	2691.91
29292.9	2711.45
30303.0	2714.51 ✓
31313.1	2702.67
32323.2	2677.56
33333.3	2640.76
34343.4	2593.80
35353.5	2538.21
36363.6	2475.38
37373.7	2406.62
38383.8	2333.01
39393.9	2255.77
40404.0	2175.76
41414.1	2093.91
42424.2	2010.91
43434.3	1927.59
44444.4	1844.35
45454.5	1761.73
46464.6	1680.38
47474.7	1600.32
48484.8	1522.12
49494.9	1445.90
50505.1	1371.82
51515.2	1300.13
52525.3	1230.90
53535.4	1164.18
54545.5	1100.13
55555.6	1038.64
56565.7	979.823
57575.8	923.618
58585.9	870.028
59596.0	819.001
60606.1	770.375
61616.2	724.258
62626.3	680.490
63636.4	639.017
64646.5	599.732
65656.6	562.529
66666.7	527.515
67676.8	494.368
68686.9	463.090
69697.0	433.680
70707.1	405.924
71717.2	379.877
72727.3	355.270
73737.4	332.212
74747.5	310.488
75757.6	290.152
76767.7	271.043
77777.8	253.109
78787.9	236.349
79798.0	220.603
80808.1	205.871
81818.2	192.047
82828.3	179.130
83838.4	167.013
84848.5	155.698
85858.6	145.183
86868.7	135.308
87878.8	126.074
88888.9	117.427
89899.0	109.421
90909.1	101.841
91919.2	94.8491
92929.3	88.2838
93939.4	82.1990
94949.5	76.4877
95959.6	71.2035
96969.7	66.2396
97979.8	61.5959
98989.9	57.3258
100000.	53.3226

4 9 0652

```
-----------------------------------------------
|                PESTAN                       |
|            version 4.0, 1992.               |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac)
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, 1,2,4-TRICHLOROBENZENE OCTOBER 1993 FILE PP124B2.INP

Solubility (mg/l)	0.48800E+02
Recharge rate (cm/hr).....	0.92500E-03
Sorption constant (cc/g).....	0.48690E+02
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38400E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.50000E+07

For application 1 the active ingredient (ai) applied is 0.318E+06 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.694E-02
Pollutant velocity [cm/hr]	0.110E-04
Length of pollutant slug [cm]	0.777E+03
Mass decayed prior to recharge [kg]	0.000E+00

FILE PP12482.BTC 1,2,4-TRICHLOROBENZENE
OCTOBER 1993

DAYS	UG/L		
0.100000E-29	0.000000	0.252525E+07	32237.4
50505.1	0.000000	0.257576E+07	32933.6
101010.	0.000000	0.262626E+07	33586.7
151515.	0.000000	0.267677E+07	34196.0
202020.	0.000000	0.272727E+07	34760.8
252525.	0.000000	0.277778E+07	35280.8
303030.	0.000000	0.282828E+07	35755.4
353535.	0.175977	0.287879E+07	36184.6
404040.	1.12858	0.292929E+07	36568.1
454545.	4.76446	0.297980E+07	36905.9
505051.	15.0540	0.303030E+07	37198.0
555556.	38.5098	0.308081E+07	37444.8
606061.	84.0427	0.313131E+07	37646.4
656566.	162.274	0.318182E+07	37803.3
707071.	284.538	0.323232E+07	37916.1
757576.	461.846	0.328283E+07	37985.4
808081.	703.980	0.333333E+07	38012.0 ✓
858586.	1018.86	0.338384E+07	37996.6
909091.	1412.17	0.343434E+07	37940.3
959596.	1887.25	0.348485E+07	37844.1
0.101010E+07	2445.13	0.353535E+07	37709.2
0.106061E+07	3084.75	0.358586E+07	37536.7
0.111111E+07	3803.23	0.363636E+07	37328.0
0.116162E+07	4596.22	0.368687E+07	37084.4
0.121212E+07	5458.18	0.373737E+07	36807.3
0.126263E+07	6382.73	0.378788E+07	36498.1
0.131313E+07	7362.93	0.383838E+07	36158.5
0.136364E+07	8391.47	0.388889E+07	35790.0
0.141414E+07	9461.00	0.393939E+07	35394.1
0.146465E+07	10564.2	0.398990E+07	34972.4
0.151515E+07	11693.9	0.404040E+07	34526.6
0.156566E+07	12843.3	0.409091E+07	34058.3
0.161616E+07	14005.8	0.414141E+07	33569.1
0.166667E+07	15175.6	0.419192E+07	33060.6
0.171717E+07	16346.8	0.424242E+07	32534.5
0.176768E+07	17514.4	0.429293E+07	31992.2
0.181818E+07	18673.5	0.434343E+07	31435.5
0.186869E+07	19820.0	0.439394E+07	30865.9
0.191919E+07	20950.0	0.444444E+07	30284.8
0.196970E+07	22059.8	0.449495E+07	29693.7
0.202020E+07	23146.4	0.454545E+07	29094.1
0.207071E+07	24207.1	0.459596E+07	28487.3
0.212121E+07	25239.1	0.464646E+07	27874.7
0.217172E+07	26240.2	0.469697E+07	27257.6
0.222222E+07	27208.5	0.474747E+07	26637.2
0.227273E+07	28142.1	0.479798E+07	26014.7
0.232323E+07	29039.3	0.484848E+07	25391.2
0.237374E+07	29898.7	0.489899E+07	24767.9
0.242424E+07	30719.0	0.494949E+07	24145.7
0.247475E+07	31498.9	0.500000E+07	23525.7

```
-----------------------------------------------
|                PESTAN                       |
|            version 4.0, 1992.               |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, 1,4-DICHLOROBENZENE OCTOBER 1993 FILE: PP14DB2.INP

Solubility (mg/l)	0.87000E+02
Recharge rate (cm/hr).....	0.92500E-03
Sorption constant (cc/g).....	0.43100E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38400E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.55000E+06

For application 1 the active ingredient (ai) applied is 0.225E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.694E-02
Pollutant velocity [cm/hr]	0.123E-03
Length of pollutant slug [cm]	0.343E+03
Mass decayed prior to recharge [kg]	0.000E+00

FILE: PP14DB2.BTC

1,4-DICHLOROBENZENE
OCTOBER 1993

DAYS	UG/L
0.100000E-29	0.000000
5555.56	0.000000
11111.1	0.000000
16666.7	0.000000
22222.2	0.000000
27777.8	0.362992E-01
33333.3	0.622272
38888.9	4.68779
44444.4	21.2973
50000.0	68.8933
55555.6	175.626
61111.1	376.340
66666.7	707.679
72222.2	1203.33
77777.8	1890.05
83333.3	2785.48
88888.9	3897.22
94444.4	5223.06
100000.	6751.90
105556.	8465.10
111111.	10338.1
116667.	12341.9
122222.	14444.7
127778.	16613.5
133333.	18814.8
138889.	21016.2
144444.	23187.0
150000.	25299.1
155556.	27327.0
161111.	29248.6
166667.	31045.3
172222.	32701.6
177778.	34205.8
183333.	35549.0
188889.	36725.8
194444.	37733.2
200000.	38571.0
205556.	39240.9
211111.	39746.7
216667.	40093.9
222222.	40289.2
227778.	40340.4 ✓
233333.	40256.1
238889.	40045.5
244444.	39718.3
250000.	39284.3
255556.	38753.4
261111.	38135.3
266667.	37439.8
272222.	36676.3
277778.	35853.7
283333.	34980.6
288889.	34065.3
294444.	33115.3
300000.	32138.0
305556.	31139.9
311111.	30127.1
316667.	29105.5
322222.	28080.0
327778.	27055.3
333333.	26035.6
338889.	25024.7
344444.	24025.9
350000.	23042.0
355556.	22075.5
361111.	21128.8
366667.	20203.5
372222.	19301.3
377778.	18423.4
383333.	17570.9
388889.	16744.4
394444.	15944.7
400000.	15172.0
405556.	14426.6
411111.	13708.5
416667.	13017.7
422222.	12354.0
427778.	11717.1
433333.	11106.6
438889.	10522.0
444444.	9962.80
450000.	9428.46
455556.	8918.32
461111.	8431.72
466667.	7967.96
472222.	7526.34
477778.	7106.11
483333.	6706.54
488889.	6326.87
494444.	5966.37
500000.	5624.28
505556.	5299.86
511111.	4992.40
516667.	4701.16
522222.	4425.44
527778.	4164.56
533333.	3917.83
538889.	3684.62
544444.	3464.27
550000.	3256.18

```
-----------------------------------------------
|                PESTAN                       |
|            version 4.0, 1992.               |
|                                             |
| Developed by :                              |
|                                             |
| Varadhan Ravi and Jeffrey A. Johnson (Dynamac) |
| Center for Subsurface Modeling Support      |
| Robert S. Kerr Environmental Research Laboratory|
| U.S. Environmental Protection Agency        |
| P.O. Box 1198                               |
| Ada, OK 74820                               |
-----------------------------------------------
```

Title: BASE CASE, CHLOROBENZENE OCTOBER 1993 RUN, FILE PPCHBB2.INP

Solubility (mg/l)	0.47170E+03
Recharge rate (cm/hr).....	0.92500E-03
Sorption constant (cc/g).....	0.18800E+01
Saturated water content	0.35000E+00
Solid-phase decay (/hr)	0.00000E+00
Liquid-phase decay (/hr)	0.00000E+00
Curve coefficient	0.40000E+01
Bulk density (g/cc).....	0.17200E+01
Dispersion coefficient (cm^2/hr).....	0.38400E+00
Saturated hydraulic conductivity	0.38100E+02
Minimum depth (cm).....	0.00000E+00
Maximum depth (cm).....	0.55000E+03
Minimum time (day).....	0.00000E+00
Maximum time (day).....	0.10000E+06

For application 1 the active ingredient (ai) applied is 0.114E+05 kg ai/ha, and has been applied 0.100E+01 days prior to recharge

++

Results

Projected water content	0.133E+00
Pore water velocity [cm/hr]	0.694E-02
Pollutant velocity [cm/hr]	0.275E-03
Length of pollutant slug [cm]	0.721E+02
Mass decayed prior to recharge [kg]	0.000E+00

FILE PPCHBB2.BTC
OCTOBER 1993

TIME (D)	CONC (UG/L)
0.100000E-29	0.000000
1010.10	0.000000
2020.20	0.000000
3030.30	0.000000
4040.40	0.000000
5050.50	0.000000
6060.61	0.000000
7070.71	0.000000
8080.81	0.000000
9090.91	0.000000
10101.0	0.000000
11111.1	0.000000
12121.2	0.000000
13131.3	0.520137
14141.4	1.61664
15151.5	4.37196
16161.6	9.93883
17171.7	21.1288
18181.8	41.2033
19191.9	74.6467
20202.0	127.110
21212.1	205.173
22222.2	316.187
23232.3	468.039
24242.4	668.770
25252.5	926.322
26262.6	1248.17
27272.7	1641.10
28282.8	2110.94
29292.9	2662.43
30303.0	3299.02
31313.1	4022.87
32323.2	4834.83
33333.3	5734.45
34343.4	6720.03
35353.5	7788.71
36363.6	8936.61
37373.7	10158.9
38383.8	11450.1
39393.9	12803.8
40404.0	14213.5
41414.1	15671.9
42424.2	17171.7
43434.3	18705.3
44444.4	20265.3
45454.5	21844.1
46464.6	23434.3
47474.7	25028.8
48484.8	26620.7
49494.9	28203.3
50505.1	29770.5
51515.2	31316.4
52525.3	32835.5
53535.4	34322.8
54545.5	35773.7
55555.6	37184.0
56565.7	38550.0
57575.8	39868.2
58585.9	41135.8
59596.0	42350.3
60606.1	43509.5
61616.2	44611.6
62626.3	45655.2
63636.4	46639.2
64646.5	47562.8
65656.6	48425.5
66666.7	49227.0
67676.8	49967.5
68686.9	50647.0
69697.0	51266.1
70707.1	51825.4
71717.2	52325.7
72727.3	52767.9
73737.4	53153.3
74747.5	53482.9
75757.6	53758.1
76767.7	53980.4
77777.8	54151.3
78787.9	54272.2
79798.0	54344.9
80808.1	54371.0 ✓
81818.2	54352.3
82828.3	54290.4
83838.4	54187.0
84848.5	54044.0
85858.6	53863.0
86868.7	53645.9
87878.8	53394.3
88888.9	53110.0
89899.0	52794.7
90909.1	52450.0
91919.2	52077.6
92929.3	51679.2
93939.4	51256.3
94949.5	50810.4
95959.6	50343.1
96969.7	49855.9
97979.8	49350.1
98989.9	48827.3
100000.	48288.6

Appendix G

4 9 0656

APPENDIX G

COST ESTIMATES

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Table G-3	Results of Cost Sensitivity Analysis—Soil and Sediment Alternatives

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Attachment G-1	Cost Tables

APPENDIX G
COST ESTIMATES

1.0 COST TABLES

Attachment G-1 includes cost tables for the major components of each alternative. These cost tables provide detail on the individual cost items (e.g., clearing and grubbing, transportation, etc.) within these major components. A list of the cost tables is presented in Table G-1. Table G-2 references the cost tables to the associated remedial alternatives that were evaluated in Section 4.0 of this FS.

2.0 COST ESTIMATE ELEMENTS

2.1 Capital Costs

Direct capital costs: Include expenditures incurred for equipment, materials, and labor necessary for installation or construction of remedial actions. Direct capital costs considered include but are not limited to remedial action construction, component equipment, land and site development, buildings and services, transportation and disposal costs.

Indirect capital costs: Include expenditures for engineering, permitting, legal, and other services that are incurred not as part of actual remedial actions but are ancillary to direct or construction costs and are required to complete the implementation of remedial alternatives. Indirect capital costs include but are not limited to engineering services, construction services, permitting and legal.

2.2 Operation and Maintenance Costs

Annual post-construction/installation costs necessary to ensure continued effectiveness of a remedial action. The O&M costs include but are not limited to costs for continuous monitoring and routine maintenance.

2.3 Present Worth Analysis

Is a method of evaluating and comparing costs that occur over different time periods by discounting all future expenditures to the present year. Present worth analysis allows costs for different remedial action alternatives to be compared on the basis of a single figure for each alternative by discounting all costs to a common base year. This single figure — the present worth of or value of a project — represents the amount of money, which, if invested in the initial year of the remedial action and disbursed as needed, would be sufficient to cover all the costs associated with a remedial action alternative.

2.4 Assumptions

- Capital costs occur in Year 0.
- Discount rate will be 5 percent before taxes and after inflation.
- Costs are in 1993 dollars.
- O&M costs occur throughout the life of the remedial alternative.
- The period of performance of a remedial action is less than or equal to 30 years (for calculating present worth). No salvage value will be credited at the end of the life of the alternative.
- Unlisted items include those cost items that will be incurred, but because of the level of detail in the estimate they were not itemized. Under construction/capital cost item, unlisted costs may include but not be limited to those costs such as insurance and bonding; support services such as utility connections, buildings; additional site preparation, site restoration; monitoring costs such as ambient air monitoring during a remedial action; cost for disposal of small amounts of residuals, etc., associated with a remedial action; and other items. Unlisted costs were typically based on either 15, 20 or 25 percent of the direct capital cost of the listed items. An exception was that of the off-site disposal component, where less than 5 percent was used. The percentage for

unlisted items was selected based on the complexity of the technology and how well the costs items could be defined. For example, incineration would have a higher unlisted items percentage than excavation, because incineration would take more auxiliary and support equipment. Percentages for unlisted items under O&M are similar to those under construction items.

- Engineering services costs include but are not limited to the following: additional site characterization, design and process development (bench and/or pilot scale studies), preparation of specifications and requests for proposals and bid documents, drafting, administration and supervision, project and cost engineering. Engineering services costs are based on a percent of total direct capital cost typically in the range of 10 to 25 percent. Nevertheless, certain remedial actions might require a higher or a lower percentage outside of this range.

  Engineering services costs vary among remedial alternatives and among alternative components. For example, for two different remedial actions such as off-site RCRA disposal and on-site thermal treatment that are considered for the same amount of soil or sediment volume, it is obvious that the engineering services cost would vary considerably. Similarly, for the same remedial action such as on-site incineration, engineering services costs might vary among operable units, though not significantly, based on the scope and complexity of the project being considered for such operable units. Taking into consideration these factors and the uncertainties associated with the current level of project scope, wherever appropriate, different percentages were used for different remedial alternative components.

- Construction services costs include but are not limited to the supervision and oversight services provided during construction phase of a remedial action to ensure that work is carried out in accordance with the specifications and in compliance with appropriate regulatory requirements. Construction services costs are based on a percent of the total direct capital cost typically in the range of 10 to 20 percent. Similar to the explanation provided under engineering services costs, varying percentages were used for different remedial alternative

components. Construction services costs are sensitive to the type and duration of a particular remedial action.

- Permitting and legal costs include but are not limited to the expenses for legal fees and administrative and technical personnel necessary to obtain licenses and permits. Construction permits and temporary or long-term operating permits, such as building, electrical connection and water supply permits may be required from Federal, state and local jurisdictions to complete a remedial action. Similarly, legal advice may be necessary to obtain licenses or negotiate construction and operating contracts. Permitting and legal costs also include the expenses that may be incurred in obtaining permits as mandated by pertinent environmental regulations. Permitting and legal services costs are based on a percent of the total direct capital cost typically in the range of 1 to 5 percent. There might be exceptions to this range for certain remedial actions. For example, independent of the size of a particular remedial project, the expense incurred in obtaining permits such as NPDES, Section 404 permits, etc., might be fixed.

- Contingency allowances are added to capital costs to take into consideration assumptions and uncertainties associated with the current project scope and for unforeseen circumstances which result in additional costs. Contingency is based on a percentage of the subtotal of costs including direct capital, engineering services, construction services, and permitting and legal. A typical value was assumed to be 30 percent. For certain alternatives with greater uncertainty, a percentage higher than 30 was used. An explanation is provided in Section 4.0 of this FS for those components of the alternatives for which the contingency exceeded 30 percent.

- Health and safety multipliers were used primarily for alternatives involving such construction activities as excavation. Since the raw costs for such activities are based on non-hazardous waste scenarios, a level of safety (LOS) multiplier was used based on one of the four assumed levels of hazard — Levels A, B, C, and D. Where there was an uncertainty as to whether an alternative involved a particular level, a combination of levels, e.g., D/C was used. In addition to the

four levels of safety, another level of safety — mD, modified Level D — was also used.

The cost multipliers for the various levels of safety were based on a combination of information from the EPA guidance documents and best professional judgment. Based on the EPA guidance document it is evident that LOS multipliers vary among various safety levels and among various actions within a particular safety level. For example, for the same Level C of safety, the LOS multiplier for excavation would be different from that of drum processing.

In the cost tables, a blank space is left under the safety level column for construction items not needing a level of safety or for which a level of safety designation is not appropriate, or if the unit price is based on a particular level of safety. For OU-1 soils and OU-2 sediments a level of safety of "C" was considered in the unit prices for the above-ground or ex-situ treatment technologies. For unit prices for in-situ technologies in OU-1, Level D was considered. For dredging in OU-2 Basin alternatives, Level D was considered.

The following EPA guidance documents were used as a basis for preparing the cost estimates. The actual unit prices for the various cost items were based on information obtained from vendors/equipment manufacturers, construction companies, past experience, actual costs incurred at the facility for some construction related activities, estimates for similar sites, construction cost estimating guides, remedial contractors, published EPA literature and on-line bulletin board systems, and expert judgement. The estimates from vendors and contractors were used as a prime basis for costing purposes.

1. Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA, Interim Final, EPA/540/G-89/004, October 1988.

2. Remedial Action Costing Procedures Manual, EPA/600/8-87/049, October 1987.

3. Costs of Remedial Actions at Uncontrolled Hazardous Waste Sites - Worker Health and Safety Considerations, EPA/600/2-86/037, March 1986.

4. Compendium of Costs of Remedial Technologies at Hazardous Waste Sites, EPA/600/2-87/087, October 1987.

3.0 OTHER COMMENTS AND OBSERVATIONS

- Unit prices involving such construction activities as excavation, transportation, disposal, and other handling of soils and sediments were all based on in-place or bank cubic yards.

- A conversion factor of 1.35 was used to convert volume of soil/sediment/debris from a volume (in cubic yards) to weight (in tons) measurement. This factor is based on an assumed bulk density of 100 lbs/cf.

- The following is a list of abbreviations that were used in the cost tables under "units":

  LF - Linear Foot
  LS - Lump Sum
  EA - Each
  MH - Man Hours
  LB - Pounds
  QTR - Quarter
  SY - Square Yards
  CY- Cubic Yards
  SF - Square Feet
  TN - Tons
  MO - Month

- Typically, the cost estimates were prepared to provide a desired level of accuracy of -30 percent to +50 percent for the cost estimates provided in this FS report. The following is stated from Page 6-12 of the RI/FS guidance

document (Reference number 1) - "Site characterization and treatability investigation information should permit the user to refine cost estimates for remedial action alternatives. It is important to consider the accuracy of costs developed for alternatives in the FS. Typically, these "study estimate" costs made during the FS are expected to provide an accuracy of +50 percent to -30 percent and are prepared using data available from the RI. It should be indicated when it is not realistic to achieve this level of accuracy." The need for additional site characterization was identified for the alternatives presented in Section 4.0 of this FS. A treatability study work plan was submitted to EPA on October 16, 1992. The costs presented in this FS would be refined in the design phase with further site characterization and treatability studies, as appropriate.

4.0 SENSITIVITY ANALYSIS

A sensitivity analysis was performed for the soil and sediment alternatives that would be sensitive to volume changes and the results of the analysis are summarized in Table G-3. As shown in Table G-3, two scenarios were selected for OU-1 soils in the old plant (CPC) landfill and OU-2 sediments. Scenario 1 is where changes in costs were analyzed based on volumes which were 0.5 times that of the original estimated volumes. In the second scenario, changes in costs were analyzed based on volumes which were 1.5 times that of the original estimated volumes. For Basin Sediment Alternative C and Wastewater Ditch Sediment Alternative C1, which involve backfilling, three different scenarios — 1.5, 2.0 and 3.0 times the original estimated amounts of backfilling — were evaluated. Other variables were kept constant for this sensitivity analysis.

TABLES

TABLE G-1

SUMMARY OF COST TABLES

COST TABLE No.	MEDIUM	ALTERNATIVE COMPONENT
1	OU-1 GROUNDWATER	VERTICAL WELL WITH TREATMENT SYSTEM
2	OU-1 GROUNDWATER	HORIZONTAL WELL WITH TREATMENT SYSTEM
3	OU-1 SOILS (Old Plant Landfill Drainage Ditch)	EXCAVATION/BACKFILL
4	OU-1 SOILS (CPC Landfill)	MULTIMEDIA CAP
5	OU-1 SOILS (CPC Landfill)	IN SITU S/S 0 TO 23 FT
6	OU-1 SOILS (CPC Landfill)	CLAY CAP
7	OU-1 SOILS (CPC Landfill)	EXCAVATION BACKFILL (S/S MATERIAL)
8	OU-1 SOILS (CPC Landfill)	EX-SITU STABILIZATION/SOLIDIFICATION
9	OU-1 SOILS (CPC Landfill)	IN SITU S/S 15 TO 23 FT
10	OU-1 SOILS (CPC Landfill)	EXCAVATION BACKFILL (IMPORTED MATERIAL)
11	OU-1 SOILS (CPC Landfill)	OFF-SITE DISPOSAL (RCRA)
12	OU-1 SOILS (CPC Landfill)	EXCAVATION BACKFILL (THERMALLY TREATED MATERIAL)
13	OU-1 SOILS (CPC Landfill)	ON-SITE THERMAL TREATMENT
14	OU-1 SOILS (West of Former CPC Plant)	CLAY CAP
15	OU-1 SOILS (West of Former CPC Plant)	IN SITU S/S 0 TO 14 FT
16	OU-1 SOILS (West of Former CPC Plant)	EXCAVATION/BACKFILL OF S/S MATERIAL
17	OU-1 SOILS (West of Former CPC Plant)	EX-SITU STABILIZATION/SOLIDIFICATION
18	OU-1 SOILS (West of Former CPC Plant)	EXCAVATION/BACKFILL (IMPORTED MATERIAL)
19	OU-1 SOILS (West of Former CPC Plant)	OFF-SITE DISPOSAL (RCRA)
20	OU-1 SOILS (West of Former CPC Plant)	EXCAVATION/ BACKFILL (THERMALLY TREATED MATERIAL)
21	OU-1 SOILS (West of Former CPC Plant)	ON-SITE THERMAL TREATMENT
22	OU-1 SOILS (Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area	INSTITUTIONAL ACTIONS - ALTERNATIVE B1
23	OU-1 SOILS (Sanitary Landfills, Lime Ponds, Mercury Cell Plant and Well Sand Residue Area	EXPANDED INSTITUTIONAL ACTIONS - ALTERNATIVE B2
24	OU- 1 SOILS (Lime Ponds)	MULTIMEDIA CAP
25	OU-1 SOILS (Sanitary Landfill)	CLAY CAP
26	OU-1 SOILS (Well Sand)	LOAD/TRANSPORT
27	OU-1 BASIN SEDIMENTS	INSTITUTIONAL ACTIONS
28	OU-2 BASIN SEDIMENTS	BACKFILLING
29	OU-2 BASIN SEDIMENTS	DREDGING/COVERING (CAD)
30	OU-2 BASIN SEDIMENTS	DREDGING (UPLAND)
31	OU-2 BASIN SEDIMENTS	TEMPORARY HOLDING POND
32	OU-2 BASIN SEDIMENTS	MECHANICAL DEWATERING
33	OU-2 BASIN SEDIMENTS	ON-SITE DISPOSAL
34	OU-2 BASIN SEDIMENTS	CONFINED DISPOSAL FACILITY
35	OU-2 BASIN SEDIMENTS	IN SITU S/S AND CAPPING
36	OU-2 DITCH SEDIMENTS	PROCESS WATER DIVERSION
37	OU-2 DITCH SEDIMENTS	BACKFILLING
38	OU-2 DITCH SEDIMENTS	EXCAVATION
39	OU-2 DITCH SEDIMENTS	OFF-SITE DISPOSAL (RCRA)
40	OU-2 DITCH SEDIMENTS	ON-SITE THERMAL TREATMENT
41	OU-2 DITCH SEDIMENTS	ON-SITE DISPOSAL

TABLE G-2

COST TABLES ASSOCIATED WITH ALTERNATIVES

MEDIUM	ALTERNATIVE	ALTERNATIVE COMPONENT	COST TABLE No.
OU-1 SOILS Area West of Former CPC Plant	ALTERNATIVE C	CLAY CAP	14
OU-1 SOILS Area West of Former CPC Plant	ALTERNATIVE D	IN SITU S/S (0 TO 14 FT)	15
		CLAY CAP	14
OU-1 SOILS Area West of Former CPC Plant	ALTERNATIVE E	EXCAVATION/BACKFILL	16
		IN SITU S/S (0 TO 14 FT)	17
		CLAY CAP	14
OU-1 SOILS Area West of Former CPC Plant	ALTERNATIVE F	EXCAVATION/BACKFILL	18
		OFF-SITE RECRA DISPOSAL (0 TO 15 FT)	19
		CLAY CAP	14
OU-1 SOILS Area West of Former CPC Plant	ALTERNATIVE G	EXCAVATION/BACKFILL	20
		ON-SITE THERMAL TREATMENT (0 TO 15 FT)	21
		CLAY CAP	14
OU-1 SOILS - Sanitary Landfills, Lime Ponds, Mercury Cell Plant, and Well Sand Residue Area	ALTERNATIVE B1	INSTITUTIONAL ACTIONS	22
OU-1 SOILS - Sanitary Landfills, Lime Ponds, Mercury Cell Plant, and Well Sand Residue Area	ALTERNATIVE B2	EXPANDED INSTITUTIONAL ACTIONS	23
OU-1 SOILS - Sanitary Landfills, and Well Sand Residue Area	ALTERNATIVE C1	SANITARY LANDFILLS (CLAY CAP)	25
		LIME PONDS (MULTIMEDIA CAP)	24
		INSTITUTIONAL ACTIONS	22
OU-1 SOILS - Sanitary Landfills, and Well Sand Residue Area	ALTERNATIVE C2	SANITARY LANDFILLS (CLAY CAP)	25
		LIME PONDS (MULTIMEDIA CAP)	24
		WELL SAND RESIDUE AREA (CONSOLIDATION)	26
		INSTITUTIONAL ACTIONS	22
OU-1 BASIN SEDIMENTS	ALTERNATIVE B	INSTITUTIONAL ACTIONS	27
OU-1 BASIN SEDIMENTS	ALTERNATIVE C	BACKFILLING	28
OU-1 BASIN SEDIMENTS	ALTERNATIVE D	DREDGING CAPPING (CAD)	29

TABLE G-2

COST TABLES ASSOCIATED WITH ALTERNATIVES

MEDIUM	ALTERNATIVE	ALTERNATIVE COMPONENT	COST TABLE No.
OU-1 BASIN SEDIMENTS	ALTERNATIVE E1	DREDGING (UPLAND)	30
		TEMPORARY HOLDING POND	31
		MECHANICAL DEWATERING	32
		ON SITE DISPOSAL	33
OU-1 BASIN SEDIMENTS	ALTERNATIVE E2	DREDGING (UPLAND)	30
		CONFINED DISPOSAL FACILITY	34
		IN SITU S/S AND CAPPING	35
OU-1 DITCH SEDIMENTS	ALTERNATIVE C1	PROCESS WATER DIVERSION	36
		BACKFILLING	37
OU-1 DITCH SEDIMENTS	ALTERNATIVE E	PROCESS WATER DIVERSION	36
		EXCAVATION	38
		OFF-SITE DISPOSAL (RCRA)	39
OU-1 DITCH SEDIMENTS	ALTERNATIVE G1	PROCESS WATER DIVERSION	36
		EXCAVATION	38
		ON-SITE THERMAL TREATMENT	40
		ON-SITE DISPOSAL	41

TABLE G-2

COST TABLES ASSOCIATED WITH ALTERNATIVES

MEDIUM	ALTERNATIVE	ALTERNATIVE COMPONENT	COST TABLE No.
OU-1 GROUNDWATER	ALTERNATIVE C1	VERTICAL WELL WITH TREATMENT SYSTEM # 1	1
		VERTICAL WELL WITH TREATMENT SYSTEM # 2	1
OU-1 GROUNDWATER	ALTERNATIVE C3	VERTICAL WELL WITH TREATMENT SYSTEM	1
		HORIZONTAL WELL WITH TREATMENT SYSTEM	2
OU-1 SOILS Old Plant (CPC) Landfill	ALTERNATIVE C	EXCAVATION/TRANSPORT (D DITCH SOILS)	3
		MULTIMEDIA CAP	4
OU-1 SOILS Old Plant (CPC) Landfill	ALTERNATIVE D	EXCAVATION/TRANSPORT (D DITCH SOILS)	3
		IN SITU S/S (0 TO 23 FT)	5
		CLAY CAP	6
OU-1 SOILS Old Plant (CPC) Landfill	ALTERNATIVE E	EXCAVATION/TRANSPORT (D DITCH SOILS)	3
		EXCAVATION/BACKFILL	7
		EX SITU (0 TO 15 FT)	8
		IN SITU S/S (15 TO 23 FT)	9
		CLAY CAP	6
OU-1 SOILS Old Plant (CPC) Landfill	ALTERNATIVE F	EXCAVATION/TRANSPORT (D DITCH SOILS)	3
		EXCAVATION/BACKFILL	10
		OFF-SITE RCRA DISPOSAL (0 TO 15 FT)	11
		IN SITU S/S (15 TO 23 FT)	9
		CLAY CAP	6
OU-1 SOILS Old Plant (CPC) Landfill	ALTERNATIVE G1	EXCAVATION/TRANSPORT (D DITCH SOILS)	3
		EXCAVATION/BACKFILL (0 TO 15 FT)	12
		ON SITE THERMAL TREATMENT	13
		IN SITU S/S (15 TO 23 FT)	9
		CLAY CAP	6

TABLE G-3

RESULTS OF COST SENSITIVITY ANALYSIS SOIL AND SEDIMENT ALTERNATIVES

Alternative[1]	Original Present Worth $1,000	Change[2] $1,000	Change[3] $1,000	Change[4] $1,000	Change[5] $1,000
OU-1 Soil Alternative D Old Plant (CPC) Landfill	$16,155	-6,980	+6,982	--	--
OU-1 Soil Alternative E Old Plant (CPC) Landfill	$30,089	-12,693	+12,699	--	--
OU-1 Soil Alternative F Old Plant (CPC) Landfill	$73,347	-35,697	+35,695	--	--
OU-1 Soil Alternative G1 Old Plant (CPC) Landfill	$108,908	-51,360	+51,366	--	--
OU-2 Basin Sediment[6] Alternative C	$13,871	--	+16,936	+13,871	+27,742
OU-2 Basin Sediment Alternative D	$14,983	-3,746	+3,746	--	--
OU-2 Basin Sediment Alternative E1	$57,491	-27,596	+27,596	--	--
OU-2 Basin Sediment Alternative E2	$51,968	-21,827	+25,984	--	--
OU-2 Wastewater Ditch[6] Sediment Alternative C1	$4,592	--	+872	+2,663	+6,291
OU-2 Wastewater Ditch Sediment Alternative E	$40,793	-15,909	+19,581	--	--
OU-2 Wastewater Ditch Sediment Alternative G1	$85,530	-36,778	+41,910	--	--

NOTES:

1. Alternatives sensitive to volume changes.
2. Change based on 0.5 times the original estimated volume.
3. Change based on 1.5 times the original estimated volume.
4. Change based on 2.0 times the original estimated volume of backfill.
5. Change based on 3.0 times the original estimated volume of backfill.
6. Sensitivity analysis conducted for volume of backfill.

ATTACHMENT G-1

COST TABLES

TABLE 1

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: VERTICAL WELL W/ TREATMENT SYSTEM						MEDIUM	OU-1 Groundwater	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Well installation	1	1	EA	$17,000	$17,000	C	1.5	$25,500
2. Disposal of well cuttings	2	1	LS	$1,200	$1,200		1	$1,200
3. Submersible well pump	3	1	EA	$8,000	$8,000		1	$8,000
4. Air stripping tower with pump	3	1	EA	$38,000	$38,000		1	$38,000
5. pH adjustment	3	1	EA	$7,000	$7,000		1	$7,000
6. GAC unit	3	1	EA	$50,000	$50,000		1	$50,000
7. Piping, fittings, instrumentation	1	1	EA	$37,000	$37,000		1	$37,000
8. Excavation, grading, foundation	1	1	LS	$30,000	$30,000		1	$30,000
9. Electrical hookup	1	1	LS	$50,000	$50,000		1	$50,000
10. Treatment system startup	1	200	MH	$45	$9,000		1	$9,000
11. Unlisted items		1	LS		$51,000		1	$51,000
TOTAL DIRECT COST								$306,700
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					35			$107,345
CONSTRUCTION SERVICES COST					20			$61,340
PERMITTING AND LEGAL SERVICES COST					5			$15,335
SUBTOTAL								$490,720
CONTINGENCY ALLOWANCE					30			$147,216
TOTAL TECHNOLOGY CAPITAL COST								$638,000

* Sources of unit costs are provided at the end of the cost tables.

4 9 0668

TABLE 1

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: VERTICAL WELL W/ TREATMENT SYSTEM						MEDIUM	OU-1 Groundwater	
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Caustic addition	3	5200	Gallons	$1	$5,200		1	$5,200
2. GAC disposal/replacement	1	20000	LB	$1.50	$30,000		1	$30,000
3. Sampling and analysis (MW's)	1	4	QTR	$1,000	$4,000		1	$4,000
4. Sampling and analysis (TT syste	1	4	QTR	$1,250	$5,000		1	$5,000
5. Electricity	1	12	MO	$1,000	$12,000		1	$12,000
6. Equipment repair & replacement	1	1	LS	$6,000	$6,000		1	$6,000
7. Personnel to maintain system	1	1	LS	$10,000	$10,000		1	$10,000
8. Unlisted items		1	LS		$14,000			$14,000
TOTAL TECHNOLOGY O&M YEARLY COST								$86,200
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$1,325,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$1,963,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 2

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: HORIZONTAL WELL W/ TREATMENT SYSTEM						MEDIUM	OU-1 Groundwater	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Well installation	4	1000	LF	$150	$150,000	C	1.5	$225,000
2. Mobilization/demobilization (we	4	1	LS	$10,000	$10,000		1	$10,000
3. Disposal of well cuttings	2	1	LS	$45,000	$45,000		1	$45,000
4. Submersible well pump	3	1	EA	$8,000	$8,000		1	$8,000
5. Air stripping tower with pump	3	1	EA	$38,000	$38,000		1	$38,000
6. pH adjustment	3	1	EA	$7,000	$7,000		1	$7,000
7. GAC unit	3	1	EA	$50,000	$50,000		1	$50,000
8. Piping, fittings, instrumentation	1	1	EA	$37,000	$37,000		1	$37,000
9. Excavation, grading, foundation	1	1	LS	$30,000	$30,000		1	$30,000
10. Electrical hookup	1	1	LS	$50,000	$50,000		1	$50,000
11. Treatment system startup	1	300	MH	$45	$13,500		1	$13,500
12. Unlisted items		1	LS		$103,000			$103,000
TOTAL DIRECT COST								$616,500
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					35			$215,775
CONSTRUCTION SERVICES COST					20			$123,300
PERMITTING AND LEGAL SERVICES COST					5			$30,825
SUBTOTAL								$986,400
CONTINGENCY ALLOWANCE					30			$295,920
TOTAL TECHNOLOGY CAPITAL COST								$1,282,000

* Sources of unit costs are provided at the end of the cost tables.

4 9 0669

TABLE 2

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: HORIZONTAL WELL W/ TREATMENT SYSTEM						MEDIUM	OU-1 Groundwater	
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Caustic addition	3	5200	Gallons	$1	$5,200		1	$5,200
2. GAC disposal/replacement	1	20000	LB	$1.50	$30,000		1	$30,000
3. Sampling and analysis (MW's)	1	4	QTR	$1,000	$4,000		1	$4,000
4. Sampling and analysis (TT syste	1	4	QTR	$1,250	$5,000		1	$5,000
5. Electricity	1	12	MO	$1,000	$12,000		1	$12,000
6. Equipment repair & replacement	1	1	LS	$6,000	$6,000		1	$6,000
7. Personnel to maintain system	1	1	LS	$10,000	$10,000		1	$10,000
8. Unlisted items		1	LS		$14,000			$14,000
TOTAL TECHNOLOGY O&M YEARLY COST								$86,200
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$1,325,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$2,607,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 3

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: EXCAVATION/BACKFILL MEDIUM: OU-1 Soils (Old Plant Landfill Drainage Ditch)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation	14	1,000	CY	$8.00	$8,000	C/B	1.3	$10,400
2. Backfill	7	1,000	CY	$8.00	$8,000	mD	1.3	$10,400
3. Transportation to Landfill	13	1,000	CY	$6.00	$6,000		1	$6,000
4. Unlisted items		1	LS		$7,000			$7,000
TOTAL DIRECT COST								$33,800

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$6,760
CONSTRUCTION SERVICES COST	10	$3,380
PERMITTING AND LEGAL SERVICES COST	2	$676
SUBTOTAL		$44,616
CONTINGENCY ALLOWANCE	30	$13,385
TOTAL TECHNOLOGY CAPITAL COST		$58,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0	D	1	$0
2.					$0	D	1	$0
3.					$0	D	1	$0
4.					$0	D	1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$58,000**

*Sources of unit costs are provided at the end of the cost tables.

4 9 0670

TABLE 4

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: MULTIMEDIA CAP MEDIUM OU-1 Soils (CPC Landfill)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$20,000	$20,000	D	1	$20,000
2. Clearing and grubbing	6	3	Acres	$555	$1,665	D	1	$1,665
3. Grading	6	14,500	SY	$1.50	$21,750	D	1	$21,750
4. Clay liner - 2 ft thick	7	9,000	CY	$20	$180,000	D	1	$180,000
5. 60 mil HDPE FML (installed)	8	120,000	SF	$0.65	$78,000	D	1	$78,000
6. Composite geonet (installed)	8	120,000	SF	$0.95	$114,000	D	1	$114,000
7. Compacted native soil - 1 ft.	7	4,500	CY	$20	$90,000	D	1	$90,000
8. Topsoil - 1ft	7	4,500	CY	$12.50	$56,250	D	1	$56,250
9. Seeding	7	3	Acres	$1,800	$5,400	D	1	$5,400
10. Demolition of existing ditch	9	1	LS	$10,000	$10,000	D	1	$10,000
11. New perimeter ditch (installed)	7	1400	LF	$40	$56,000	D	1	$56,000
12. Monitoring well installation	1	1	LS	$38,000	$38,000	C	1.5	$57,000
13. Unlisted items		1	LS		$138,000			$138,000
TOTAL DIRECT COST								$828,100

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	15	$124,215
CONSTRUCTION SERVICES COST	30	$248,430
PERMITTING AND LEGAL SERVICES COST	10	$82,810
SUBTOTAL		$1,283,555
CONTINGENCY ALLOWANCE	30	$385,067
TOTAL TECHNOLOGY CAPITAL COST		$1,669,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EA	$310	$7,440	D	1	$7,440
2. Monitoring and reporting	1	1	LS	$11,000	$11,000		1	$11,000
3. Repairs and maintenance	10	1	LS	$5,000	$5,000	D	1	$5,000
4. Unlisted items		1	LS		$5,000			$5,000
TOTAL TECHNOLOGY O&M YEARLY COST								$28,400
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$437,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$2,106,000**

* Sources of unit costs are provided at the end of the cost tables.

TABLE 5

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: IN SITU S/S 0 TO 23 FT MEDIUM OU-1 Soils (CPC Landfill)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$10,000	$10,000	D	1	$10,000
2. Mobilization/demobilization	12	1	LS	$120,000	$120,000	D	1	$120,000
3. Solidification (to 23' bls) w/H&S*	12	105,000	CY	$30	$3,150,000		1	$3,150,000
4. Reagent (20%addition by weight)	12	28,400	TN	$65	$1,846,000		1	$1,846,000
5. Analytical testing	13	1	LS	$120,000	$120,000		1	$120,000
6. Unlisted items		1	LS		$1,049,000			$1,049,000
TOTAL DIRECT COST								$6,295,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COS	COST
ENGINEERING SERVICES COST	20	$1,259,000
CONSTRUCTION SERVICES COST	15	$944,250
PERMITTING AND LEGAL SERVICES COST	2	$125,900
SUBTOTAL		$8,624,150
CONTINGENCY ALLOWANCE	70	$6,036,905
TOTAL TECHNOLOGY CAPITAL COST		$14,661,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$14,661,000**

* Sources of unit costs are provided at the end of the cost tables.

** Includes material from old plnt landfill drainage ditch

4 9 0672

TABLE 6

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			CLAY CAP			MEDIUM	OU-1 Soils (CPC Landfill)	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$12,000	$12,000	D	1	$12,000
2. Clearing and grubbing	6	3.00	Acres	$555	$1,665	D	1	$1,665
3. Grading	6	14,500	SY	$2	$21,750	D	1	$21,750
4. Clay liner - 2 ft thick	7	9,000	CY	$20	$180,000	D	1	$180,000
5. Topsoil - 1'	7	4,500	CY	$13	$56,250	D	1	$56,250
6. Seeding	7	3.00	Acres	$1,800	$5,400	D	1	$5,400
7. Demolition of existing ditch	9	1	LS	$10,000	$10,000	D	1	$10,000
8. New perimeter ditch (installed)	7	1400	LF	$40	$56,000	D	1	$56,000
9. Monitoring well installation	1	1	LS	$38,000	$38,000	C	1.5	$57,000
10. Unlisted items					$80,000			$80,000
TOTAL DIRECT COST								$480,100
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$96,020
CONSTRUCTION SERVICES COST					30			$144,030
PERMITTING AND LEGAL SERVICES COST					10			$48,010
SUBTOTAL								$768,160
CONTINGENCY ALLOWANCE					30			$230,448
TOTAL TECHNOLOGY CAPITAL COST								$999,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EA	$310	$7,440	D	1	$7,440
2. Monitoring and reporting	1	1	LS	$11,000	$11,000		1	$11,000
3. Repairs and maintenance	10	1	LS	$5,000	$5,000	D	1	$5,000
4. Unlisted items		1	LS		$5,000			$5,000
TOTAL TECHNOLOGY O&M YEARLY COST								$28,400
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$437,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$1,436,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 7

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			EXCAVATION/BACKFILL			MEDIUM	OU-1 Soils (CPC Landfill)	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation (to 15' bls)	14	67,000	CY	$8.00	$536,000	C/B	3.5	$1,876,000
2. Backfill (solidified soil)**	6	76,200	CY	$4.65	$354,330	mD	1.3	$460,629
3. Offsite disposal of debris	2	6,075	TN	$560	$3,402,000		1	$3,402,000
4. Shoring during excavation	6	7,500	SF	$20	$150,000	C/B	2.5	$375,000
5. Unlisted items		1	LS		$1,528,000			$1,528,000
TOTAL DIRECT COST								$7,641,600
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$1,528,320
CONSTRUCTION SERVICES COST					10			$764,160
PERMITTING AND LEGAL SERVICES COST					2			$152,832
SUBTOTAL								$10,086,912
CONTINGENCY ALLOWANCE					70			$7,060,838
TOTAL TECHNOLOGY CAPITAL COST								$17,148,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0	D	1	$0
2.					$0	D	1	$0
3.					$0	D	1	$0
4.					$0	D	1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$17,148,000

*Sources of unit costs are provided at the end of the cost tables.

** Includes material from old plant landfill drainage ditch.

4 9 0674

TABLE 8

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: Ex-Situ Stabilization/Solidification **MEDIUM OU-1 Soils (CPC Landfill)**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$20,000	$20,000	D	1	$20,000
2. Mobilization/demobilization	12	1	LS	$135,000	$135,000	D	1	$135,000
3. Temporary storage	15	1	LS	$500,000	$500,000		1	$500,000
4. Solidification (to 15 feet bls)**	12	63,500	CY	$15	$952,500		1	$952,500
5. Reagent (20% addition by weight)	12	12,700	TN	$65	$825,500		1	$825,500
6. Haul soil to storage/treatment area	13	63,500	CY	$6.00	$381,000		1	$381,000
7. Haul treated soil to landfill**	13	76,200	CY	$6.00	$457,200		1	$457,200
8. Analytical	13	1	LS	$100,000	$100,000		1	$100,000
9. Unlisted items		1	LS		$843,000			$843,000
TOTAL DIRECT COST								$4,214,200

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COS	COST
ENGINEERING SERVICES COST	15	$632,130
CONSTRUCTION SERVICES COST	20	$842,840
PERMITTING AND LEGAL SERVICES COST	3	$126,426
SUBTOTAL		$5,815,596
CONTINGENCY ALLOWANCE	30	$1,744,679
TOTAL TECHNOLOGY CAPITAL COST		$7,560,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$7,560,000**

*Sources of unit costs are provided at the end of the cost tables.

** Includes material from old plant landfill drainage ditch

TABLE 9

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: IN SITU S/S 15 TO 23 FT **MEDIUM OU-1 Soils (CPC Landfill)**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$10,000	$10,000	D	1	$10,000
2. Mobilization/demobilization	12	1	LS	$120,000	$120,000	D	1	$120,000
3. Solidification (from 15 to 23 ft bls)	12	32,000	CY	$30	$960,000		1	$960,000
4. Reagent (20%addition by weight)	12	8,700	TN	$65	$565,500		1	$565,500
5. Analytical testing	13	1	LS	$75,000	$75,000		1	$75,000
6.					$0		1	$0
7.					$0		1	$0
8.					$0		1	$0
9.					$0		1	$0
10. Unlisted items		1	LS		$346,000			$346,000
TOTAL DIRECT COST								$2,076,500

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COS	COST
ENGINEERING SERVICES COST	25	$519,125
CONSTRUCTION SERVICES COST	15	$311,475
PERMITTING AND LEGAL SERVICES COST	4	$83,060
SUBTOTAL		$2,990,160
CONTINGENCY ALLOWANCE	30	$897,048
TOTAL TECHNOLOGY CAPITAL COST		$3,887,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$3,887,000**

*Sources of unit costs are provided at the end of the cost tables.

4 9 0679

TABLE 10

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: EXCAVATION/BACKFILL MEDIUM OU-1 Soils (CPC Landfill)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation	14	67,000	CY	$8.00	$536,000	C/B	3.5	$1,876,000
2. Backfill (Imported material)	7	67,000	CY	$20.00	$1,340,000	mD	1.3	$1,742,000
3. Offsite disposal of debris	2	6,075	TN	$560	$3,402,000		1	$3,402,000
4. Shoring during excavation	6	7,500	LS	$20	$150,000	C/B	2.5	$375,000
5. Unlisted items		1	LS		$1,849,000			$1,849,000
TOTAL DIRECT COST								$9,244,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$1,848,800
CONSTRUCTION SERVICES COST	10	$924,400
PERMITTING AND LEGAL SERVICES COST	2	$184,880
SUBTOTAL		$12,202,080
CONTINGENCY ALLOWANCE	70	$8,541,456
TOTAL TECHNOLOGY CAPITAL COST		$20,744,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0		1	$0
2.					$0		1	$0
3.					$0		1	$0
4.					$0		1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$20,744,000**

*Sources of unit costs are provided at the end of the cost tables.

4 9 0677

TABLE 11

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: **OFF-SITE DISPOSAL (RCRA)** **MEDIUM** **OU-1 Soils (CPC Landfill)**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Off-site transport of soil**	2	4,550	Trip	$2,895	$13,172,250		1	$13,172,250
2. Direct disposal at the landfill**	2	86,000	TN	$245	$21,070,000		1	$21,070,000
3.					$0		1	$0
4.					$0		1	$0
5.					$0		1	$0
6.					$0		1	$0
7.					$0		1	$0
8.					$0		1	$0
9.					$0		1	$0
10. Unlisted items		1	LS		$685,000			$685,000
TOTAL DIRECT COST								$34,927,300

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	1	$349,273
CONSTRUCTION SERVICES COST	2	$698,546
PERMITTING AND LEGAL SERVICES COST	1	$349,273
SUBTOTAL		$36,324,392
CONTINGENCY ALLOWANCE	30	$10,897,318
TOTAL TECHNOLOGY CAPITAL COST		$47,222,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$47,222,000**

*Sources of unit costs are provided at the end of the cost tables.

** Includes material from old plant landfill drainage ditch.

4 9 0678

TABLE 12

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			EXCAVATION/BACKFILL			MEDIUM OU-1 Soils (CPC Landfill)		
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation	14	67,000	CY	$8.00	$536,000	C/B	3.5	$1,876,000
2. Backfill (thermally treated soil)**	6	63,500	CY	$4.65	$295,275	mD	1.3	$383,858
3. Offsite disposal of debris	2	6,075	TN	$560	$3,402,000		1	$3,402,000
4. Backfill (additional clean soil)	7	3,500	CY	$20	$70,000		1	$70,000
5. Shoring during excavation	6	7,500	SF	$20	$150,000	C/B	2.5	$375,000
6. Unlisted items		1	LS		$1,221,000			$1,221,000
TOTAL DIRECT COST								$7,327,900
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$1,465,580
CONSTRUCTION SERVICES COST					10			$732,790
PERMITTING AND LEGAL SERVICES COST					2			$146,558
SUBTOTAL								$9,672,828
CONTINGENCY ALLOWANCE					70			$6,770,980
TOTAL TECHNOLOGY CAPITAL COST								$16,444,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			
2.					$0			
3.					$0			
4.					$0			
5.								
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH								
(5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$16,444,000

*Sources of unit costs are provided at the end of the cost tables.

** Includes material from old plant landfill drainage ditch.

4 9 0679

TABLE 13

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: ON-SITE THERMAL TREATMENT **MEDIUM OU-1 Soils (CPC Landfill)**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$20,000	$20,000	D	1	$20,000
2. Mobilization/demobilization	16	1	LS	$1,000,000	$1,000,000	D	1	$1,000,000
3. Temporary storage	15	1	LS	$500,000	$500,000		1	$500,000
4. Incineration (H&S cost included)**	16	86,000	TN	$450	$38,700,000		1	$38,700,000
5. Haul soil to storage/treatment area**	13	63,500	CY	$6.00	$381,000		1	$381,000
6. Haul treated soil to landfill**	13	63,500	CY	$6.00	$381,000		1	$381,000
7. Analytical	17	1	LS	$500,000	$500,000		1	$500,000
8. Offsite transport of residual sludge	2	15	Trip	$835	$12,525		1	$12,525
9. Disposal of residual sludge	2	300	TN	$375	$112,500		1	$112,500
10. Unlisted items		1	LS		$6,241,000			$6,241,000
TOTAL DIRECT COST								$47,848,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$9,569,600
CONSTRUCTION SERVICES COST	15	$7,177,200
PERMITTING AND LEGAL SERVICES COST	5	$2,392,400
SUBTOTAL		$66,987,200
CONTINGENCY ALLOWANCE	30	$20,096,160
TOTAL TECHNOLOGY CAPITAL COST		$87,083,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$87,083,000**

*Sources of unit costs are provided at the end of the cost tables.

** Includes material from old plant landfill drainage ditch.

TABLE 14

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:		CLAY CAP		MEDIUM:	OU-1 Soils (West of Former CPC Plant)			
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	26	1	LS	$6,000	$6,000	D	1	$6,000
2. Clearing and grubbing	6	0.00	Acres	$555	$0	D	1	$0
3. Grading	6	1,700	SY	$2	$2,550	D	1	$2,550
4. Clay liner - 2 ft thick	7	1,200	CY	$20	$24,000	D	1	$24,000
5. Topsoil - 1' to 1.5'	7	900	CY	$13	$11,250	D	1	$11,250
6. Seeding	7	3.00	Acres	$1,800	$5,400	D	1	$5,400
7.Perimeter Ditch	7	500	LF	$40	$20,000	D	1	$20,000
8.		0		$0	$0			
9.		0		$0	$0			
10. Unlisted items					$14,000			$14,000
TOTAL DIRECT COST								$83,200
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$16,640
CONSTRUCTION SERVICES COST					30			$24,960
PERMITTING AND LEGAL SERVICES COST					10			$8,320
SUBTOTAL								$133,120
CONTINGENCY ALLOWANCE					30			$39,936
TOTAL TECHNOLOGY CAPITAL COST								$173,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EA	$310	$7,440	D	1	$7,440
2. Monitoring and reporting	1	1	LS	$2,000	$2,000		1	$2,000
3. Repairs and maintenance	10	1	LS	$2,000	$2,000	D	1	$2,000
4. Unlisted items		1	LS		$2,000			$2,000
TOTAL TECHNOLOGY O&M YEARLY COST								$13,400
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$206,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$379,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 15

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: IN SITU S/S 0 TO 14 FT MEDIUM: OU-1 Soils (West of Former CPC PLant)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$5,000	$5,000	D	1	$5,000
2. Mobilization/demobilization	12	1	LS	$55,000	$55,000	D	1	$55,000
3. Solidification (to 14' bls) w/H&S	12	8,000	CY	$30	$240,000		1	$240,000
4. Reagent (20%addition by weight)	12	2,200	TN	$65	$143,000		1	$143,000
5. Analytical testing	13	1	LS	$10,000	$10,000		1	$10,000
6. Unlisted items		1	LS		$68,000			$68,000
TOTAL DIRECT COST								$521,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$104,200
CONSTRUCTION SERVICES COST	15	$78,150
PERMITTING AND LEGAL SERVICES COST	2	$10,420
SUBTOTAL		$713,770
CONTINGENCY ALLOWANCE	30	$214,131
TOTAL TECHNOLOGY CAPITAL COST		$928,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$928,000**

* Sources of unit costs are provided at the end of the cost tables.

4 9 0682

TABLE 16

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: EXCAVATION/BACKFILL OF S/S MATERIAL MEDIUM: OU-1 Soils (West of Former CPC Plant)								
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation (to 14' bls)	14	8,000	CY	$8.00	$64,000	C/B	3.5	$224,000
2. Backfill (solidified soil)	6	9,600	CY	$4.65	$44,640	mD	1.3	$58,032
3. Shoring	6	4,000	SF	$20	$80,000	mD	1.3	$104,000
4.								
5. Unlisted items		1	LS		$97,000			$97,000
TOTAL DIRECT COST								$483,000
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$96,600
CONSTRUCTION SERVICES COST					10			$48,300
PERMITTING AND LEGAL SERVICES COST					2			$9,660
SUBTOTAL								$637,560
CONTINGENCY ALLOWANCE					30			$191,268
TOTAL TECHNOLOGY CAPITAL COST								$829,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0	D	1	$0
2.					$0	D	1	$0
3.					$0	D	1	$0
4.					$0	D	1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$829,000

*Sources of unit costs are provided at the end of the cost tables.

4 9 0683

TABLE 17

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: EXSITU S/S **MEDIUM: OU-1 Soils (West of Former CPC Plant)**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$5,000	$5,000	D	1	$5,000
2. Mobilization/demobilization	12	1	LS	$50,000	$50,000	D	1	$50,000
3. Temporary storage	15	1	LS	$75,000	$75,000		1	$75,000
4. Solidification (to 14 feet bls)	12	8,000	CY	$15	$120,000		1	$120,000
5. Reagent (20% addition by weight)	12	2,200	TN	$65	$143,000		1	$143,000
6. Haul soil to storage/treatment area	13	8,000	CY	$6.00	$48,000		1	$48,000
7. Haul treated soil to landfill	13	9,600	CY	$6.00	$57,600		1	$57,600
8. Analytical	13	1	LS	$10,000	$10,000		1	$10,000
9. Unlisted items		1	LS		$127,000			$127,000
TOTAL DIRECT COST								$635,600

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COS	COST
ENGINEERING SERVICES COST	15	$95,340
CONSTRUCTION SERVICES COST	20	$127,120
PERMITTING AND LEGAL SERVICES COST	3	$19,068
SUBTOTAL		$877,128
CONTINGENCY ALLOWANCE	30	$263,138
TOTAL TECHNOLOGY CAPITAL COST		$1,140,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$1,140,000**

*Sources of unit costs are provided at the end of the cost tables.

TABLE 18

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: EXCAV./BACKFILL OF IMPORTED MATERIAL MEDIUM: OU-1 Soils (West of Former CPC Plant)								
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation	14	8,000	CY	$8.00	$64,000	C/B	3.5	$224,000
2. Backfill (Imported material)	7	8,000	CY	$20.00	$160,000	mD	1.3	$208,000
3. Shoring	6	4,000	SF	$20	$80,000	mD	1.3	$104,000
4.								
5. Unlisted items		1	LS		$134,000			$134,000
TOTAL DIRECT COST								$670,000
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$134,000
CONSTRUCTION SERVICES COST					10			$67,000
PERMITTING AND LEGAL SERVICES COST					2			$13,400
SUBTOTAL								$884,400
CONTINGENCY ALLOWANCE					30			$265,320
TOTAL TECHNOLOGY CAPITAL COST								$1,150,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0		1	$0
2.					$0		1	$0
3.					$0		1	$0
4.					$0		1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$1,150,000

*Sources of unit costs are provided at the end of the cost tables.

TABLE 19

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: OFF-SITE (RCRA) DISPOSAL **MEDIUM: OU-1 Soils (West of Former CPC Plant)**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Off-site transport of soil	2	580	Trip	$2,895	$1,679,100		1	$1,679,100
2. Direct disposal at the landfill	2	11,000	TN	$245	$2,695,000		1	$2,695,000
3.					$0		1	$0
4.					$0		1	$0
5.					$0		1	$0
6.					$0		1	$0
7.					$0		1	$0
8.					$0		1	$0
9.					$0		1	$0
10. Unlisted items		1	LS		$87,000			$87,000
TOTAL DIRECT COST								$4,461,100

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	1	$44,611
CONSTRUCTION SERVICES COST	2	$89,222
PERMITTING AND LEGAL SERVICES COST	1	$44,611
SUBTOTAL		$4,639,544
CONTINGENCY ALLOWANCE	30	$1,391,863
TOTAL TECHNOLOGY CAPITAL COST		$6,031,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$6,031,000**

*Sources of unit costs are provided at the end of the cost tables.

TABLE 20

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: EXCAV./BACKFILL OF THERMALLY TREATED SOIL MEDIUM: OU-1 Soils (West of Former CPC Plant)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Excavation	14	8,000	CY	$8.00	$64,000	C/B	3.5	$224,000
2. Backfill (thermally treated soil)	6	8,000	CY	$4.65	$37,200	mD	1.3	$48,360
3. Shoring	6	4,000	SF	$20	$80,000	mD	1.3	$104,000
4.								
5.								
6. Unlisted items		1	LS		$75,000			$75,000
TOTAL DIRECT COST								$451,400

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$90,280
CONSTRUCTION SERVICES COST	10	$45,140
PERMITTING AND LEGAL SERVICES COST	2	$9,028
SUBTOTAL		$595,848
CONTINGENCY ALLOWANCE	30	$178,754
TOTAL TECHNOLOGY CAPITAL COST		$775,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			
2.					$0			
3.					$0			
4.					$0			
5.								
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$775,000**

*Sources of unit costs are provided at the end of the cost tables.

4 9 0687

TABLE 21

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: ON-SITE THERMAL TREATME MEDIUM: OU-1 Soils (West of Former CPC Plant)

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$5,000	$5,000	D	1	$5,000
2. Mobilization/demobilization	16	1	LS	$1,000,000	$1,000,000	D	1	$1,000,000
3. Temporary storage	15	1	LS	$75,000	$75,000		1	$75,000
4. Incineration (H&S cost included)	16	11,000	TN	$450	$4,950,000		1	$4,950,000
5. Haul soil to storage/treatment area	13	8,000	CY	$6.00	$48,000		1	$48,000
6. Haul treated soil to landfill	13	8,000	CY	$6.00	$48,000		1	$48,000
7. Analytical	17	1	LS	$75,000	$75,000		1	$75,000
8. Offsite transport of residual sludge	2	3	Trip	$835	$2,505		1	$2,505
9. Disposal of residual sludge	2	50	TN	$375	$18,750		1	$18,750
10. Unlisted items		1	LS		$933,000			$933,000
TOTAL DIRECT COST								$7,155,300

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$1,431,060
CONSTRUCTION SERVICES COST	15	$1,073,295
PERMITTING AND LEGAL SERVICES COST	5	$357,765
SUBTOTAL		$10,017,420
CONTINGENCY ALLOWANCE	30	$3,005,226
TOTAL TECHNOLOGY CAPITAL COST		$13,023,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$13,023,000**

*Sources of unit costs are provided at the end of the cost tables.

4 9 0688

TABLE 22

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: INSTITUTIONAL ACTIONS FOR ALTERNATIVE B1

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Monitoring Well Installation	1	6	EACH	$12,500	$75,000	mD	1.3	$97,500
2.								
3.								
4.								
5.								
6.								
7. Unlisted items		1	LS		$20,000		1	$20,000
TOTAL DIRECT COST								$117,500

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	35	$41,125
CONSTRUCTION SERVICES COST	20	$23,500
PERMITTING AND LEGAL SERVICES COST	5	$5,875
SUBTOTAL		$188,000
CONTINGENCY ALLOWANCE	30	$56,400
TOTAL TECHNOLOGY CAPITAL COST		$244,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EACH	$1,600	$38,400	D	1	$38,400
2. Monitoring and Reporting	1	1	LS	$30,000	$30,000	D	1	$30,000
3. Sampling/Analytical	1	32	EACH	$750	$24,000	D	1	$24,000
4. Repairs and Maineneance	1	1		$50,000	$50,000	D	1	$50,000
		0		$0	$0		1	$0
Unlisted items		1	LS		$28,000			$28,000
TOTAL TECHNOLOGY O&M YEARLY COST								$170,400
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$2,619,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$2,863,000**

* Sources of unit costs are provided at the end of the cost tables.

TABLE 23

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: INSTITUTIONAL ACTIONS FOR ALTERNATIVE B2

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Monitoring Well Installation	1	13	EACH	$12,500	$162,500	mD	1.3	$211,250
2.								
3.								
4.								
5.								
6.								
7. Unlisted items		1	LS		$42,000		1	$42,000
TOTAL DIRECT COST								$253,300

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	35	$88,655
CONSTRUCTION SERVICES COST	20	$50,660
PERMITTING AND LEGAL SERVICES COST	5	$12,665
SUBTOTAL		$405,280
CONTINGENCY ALLOWANCE	30	$121,584
TOTAL TECHNOLOGY CAPITAL COST		$527,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EACH	$1,600	$38,400	D	1	$38,400
2. Monitoring and Reporting	1	1	LS	$35,000	$35,000	D	1	$35,000
3. Sampling/Analytical	1	68	EACH	$750	$51,000	D	1	$51,000
4. Repairs and Maineneance	1	1		$50,000	$50,000	D	1	$50,000
		0		$0	$0		1	$0
Unlisted items		1	LS		$35,000			$35,000
TOTAL TECHNOLOGY O&M YEARLY COST								$209,400
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$3,219,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$3,746,000**

* Sources of unit costs are provided at the end of the cost tables.

TABLE 24

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: MULTIMEDIA CAP LIME PONDS

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/Demobilization	5	1	LS	$20,000	$20,000	D	1	$20,000
2. Clearing and grubbing	6	1.6	ACRES	$550.00	$880	D	1	$880
3. Grading	6	8000	SY	$1.50	$12,000	D	1	$12,000
4. Clay Liner - 2 ft thick	7	5200	CY	$20	$104,000	D	1	$104,000
5. Composite geonet - installed	8	70000	SF	$0.95	$66,500	D	1	$66,500
6. Compacted natural soil - 1 ft	7	2600	CY	$20	$52,000	D	1	$52,000
7. Synthetic Liner - 40 ml	8	70000	SF	$0.55	$38,500	D	1	$38,500
8. Topsoil - 1 ft	7	2600	CY	$12.50	$32,500	D	1	$32,500
9. Seeding	7	1.6	ACRES	$1,800	$2,880	D	1	$2,880
10. Perimeter Ditch	7	1500	LF	$40	$60,000	D	1	$60,000
11. Unlisted items		1	LS		$58,000		1	$58,000
TOTAL DIRECT COST								$447,300

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	35	$156,555
CONSTRUCTION SERVICES COST	20	$89,460
PERMITTING AND LEGAL SERVICES COST	5	$22,365
SUBTOTAL		$715,680
CONTINGENCY ALLOWANCE	30	$214,704
TOTAL TECHNOLOGY CAPITAL COST		$930,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
		0		$0	$0		1	$0
Unlisted items		1	LS		$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$930,000**

* Sources of unit costs are provided at the end of the cost tables.

TABLE 25

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: CLAY CAP **SANITARY LANDFILL**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/Demobilization	5	1	LS	$50,000	$50,000	D	1	$50,000
2. Clearing and grubbing	6	12	ACRES	$550	$6,600	D	1	$6,600
3. Grading	6	58000	SY	$1.50	$87,000	D	1	$87,000
4. Clay Liner - 2 ft thick	7	38000	CY	$20	$760,000	D	1	$760,000
5. Topsoil - 1 ft	7	19000	CY	$12.50	$237,500	D	1	$237,500
6. Seeding	7	12	ACRES	$1,800	$21,600	D	1	$21,600
7. Perimeter Ditch	7	1000	LF	$40	$40,000	D	1	$40,000
8. Unlisted items		1	LS		$241,000		1	$241,000
TOTAL DIRECT COST								$1,443,700

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	35	$505,295
CONSTRUCTION SERVICES COST	20	$288,740
PERMITTING AND LEGAL SERVICES COST	5	$72,185
SUBTOTAL		$2,309,920
CONTINGENCY ALLOWANCE	30	$692,976
TOTAL TECHNOLOGY CAPITAL COST		$3,003,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
		0		$0	$0		1	$0
		0		$0	$0		1	$0
		0		$0	$0		1	$0
Unlisted items		1	LS		$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$3,003,000**

* Sources of unit costs are provided at the end of the cost tables.

TABLE 26

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION: LOAD/TRANSPORT						WELL SAND		
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Load and Haul Well Sand	13	15,000	CY	$7.00	$105,000	mD	1.3	$136,500
2.								
3. Unlisted items		1	LS		$34,000			$34,000
TOTAL DIRECT COST								$170,500
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COS			COST
ENGINEERING SERVICES COST					5			$8,525
CONSTRUCTION SERVICES COST					15			$25,575
PERMITTING AND LEGAL SERVICES COST					3			$5,115
SUBTOTAL								$209,715
CONTINGENCY ALLOWANCE					30			$62,915
TOTAL TECHNOLOGY CAPITAL COST								$273,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$273,000

*Sources of unit costs are provided at the end of the cost tables.

49 0693

TABLE 27

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			INSTITUTIONAL ACTIONS			MEDIUM	OU-1 Basin Sediments	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Construction of a fence	6	1	LS	$100,000	$100,000		1	$100,000
2.					$0		1	$0
3.					$0		1	$0
4.					$0		1	$0
5.					$0		1	$0
6. Unlisted Items		1	LS		$20,000			$20,000
TOTAL DIRECT COST								$120,000
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					15			$18,000
CONSTRUCTION SERVICES COST					15			$18,000
PERMITTING AND LEGAL SERVICES COST					5			$6,000
SUBTOTAL								$162,000
CONTINGENCY ALLOWANCE					30			$48,600
TOTAL TECHNOLOGY CAPITAL COST								$211,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Patrolling of the basin - labor	18	1	LS	$35,000	$35,000		1	$35,000
2. Analytical (sediment and fish)	1	1	LS	$100,000	$100,000		1	$100,000
3. Sedimentation Studies	1	1	LS	$20,000	$20,000		1	$20,000
4.					$0			
5. Unlisted Items		1	LS		$23,000			$23,000
TOTAL TECHNOLOGY O&M YEARLY COST								$178,000
TOTAL TECHNOLOGY O&M PRESENT WORTH								
(5% & 30 Years)								$2,736,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$2,947,000

*Sources of unit costs are provided at the end of the cost tables.

4 9 0694

TABLE 28

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: BACKFILLING MEDIUM OU-2 Basin Sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	20	1	LS	$30,000	$30,000	D	1	$30,000
2. Clearing and grubbing	6	45	Acres	$3,900	$175,500	D	1	$175,500
3. Access roads	6	60,000	SY	$12.00	$720,000	D	1	$720,000
4. Excavating, hauling, dumping	6	1,000,000	CY	$4	$4,000,000	D	1	$4,000,000
5. Backfill/Placement (by 4 dozers)	6	1,000,000	CY	$0.50	$500,000	D	1	$500,000
6. Revegetation	6	120	Acres	$1,000	$120,000	D	1	$120,000
7. Unlisted items		1	LS		$832,000			$832,000
TOTAL DIRECT COST								$6,377,500

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	20	$1,275,500
CONSTRUCTION SERVICES COST	10	$637,750
PERMITTING AND LEGAL SERVICES COST	15	$956,625
SUBTOTAL		$9,247,375
CONTINGENCY ALLOWANCE	50	$4,623,688
TOTAL TECHNOLOGY CAPITAL COST		$13,871,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0		1	$0
2.					$0		1	$0
3.					$0		1	$0
4.					$0		1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$13,871,000**

*Sources of unit costs are provided at the end of the cost tables.

TABLE 29

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: DREDGING/COVERING (CAD) MEDIUM OU-2 Basin sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	19	1	LS	$400,000	$400,000		1	$400,000
2. Dredging (sediment)	19	240,000	CY	$10	$2,400,000		1	$2,400,000
3. Dredging (cap material)	19	150,000	CY	$10	$1,500,000		1	$1,500,000
4. Analytical (before dredging)	1	1	LS	$100,000	$100,000		1	$100,000
5. Analytical (after capping)	1	1	LS	$25,000	$25,000		1	$25,000
6.					$0		1	$0
7.					$0		1	$0
8.					$0		1	$0
9. Unlisted items		1	LS		$664,000			$664,000
TOTAL DIRECT COST								$5,089,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	40	$2,035,600
CONSTRUCTION SERVICES COST	20	$1,017,800
PERMITTING AND LEGAL SERVICES COST	20	$1,017,800
SUBTOTAL		$9,160,200
CONTINGENCY ALLOWANCE	50	$4,580,100
TOTAL TECHNOLOGY CAPITAL COST		$13,740,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Bathymetry	1	2	EA	$20,000	$40,000		1	$40,000
2. Analytical (sediment and fish)	1	1	LS	$100,000	$100,000		1	$100,000
3.					$0		1	$0
4.					$0		1	$0
5. Unlisted		1	LS		$21,000			$21,000
TOTAL TECHNOLOGY O&M YEARLY COST								$161,000
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 10 Years)								$1,243,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$14,983,000**

* Sources of unit costs are provided at the end of the cost tables.

TABLE 30

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: DREDGING (UPLAND) MEDIUM OU-2 Basin sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	19	1	LS	$500,000	$500,000	D	1	$500,000
2. Dredging (in-place sediment)	19	340,000	CY	$13	$4,420,000	D	1	$4,420,000
3. Analytical testing	1	1	LS	$150,000	$150,000		1	$150,000
4.					$0		1	$0
5.					$0		1	$0
6.					$0		1	$0
7.					$0		1	$0
8.					$0		1	$0
9. Unlisted items		1	LS		$761,000			$761,000
TOTAL DIRECT COST								$5,831,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	30	$1,749,300
CONSTRUCTION SERVICES COST	20	$1,166,200
PERMITTING AND LEGAL SERVICES COST	20	$1,166,200
SUBTOTAL		$9,912,700
CONTINGENCY ALLOWANCE	50	$4,956,350
TOTAL TECHNOLOGY CAPITAL COST		$14,869,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$14,869,000**

* Sources of unit costs are provided at the end of the cost tables.

4 9 0697

TABLE 31

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: TEMPORARY HOLDING POND MEDIUM OU-2 Basin sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	20	1	LS	$10,000	$10,000	D	1	$10,000
2. Clearing and grubbing	6	0.60	Acres	$3,900	$2,340	D	1	$2,340
3. Excavate pond	6	6,700	CY	$4.00	$26,800	D	1	$26,800
4. Grading	6	3,000	SY	$2.00	$6,000	D	1	$6,000
5. Recompacted clay liner - 2ft	7	2,100	CY	$8.00	$16,800	D	1	$16,800
6. Backfill	7	6,700	CY	$8.00	$53,600	D	1	$53,600
7. Topsoil (cap)	7	1,000	CY	$12.50	$12,500	D	1	$12,500
8. Seeding (cap)	7	0.6	Acres	$1,800	$1,080	D	1	$1,080
9. Unlisted items		1	LS		$19,000			$19,000
TOTAL DIRECT COST								$148,100

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	25	$37,025
CONSTRUCTION SERVICES COST	25	$37,025
PERMITTING AND LEGAL SERVICES COST	5	$7,405
SUBTOTAL		$229,555
CONTINGENCY ALLOWANCE	30	$68,867
TOTAL TECHNOLOGY CAPITAL COST		$298,000

OPERATION AND MAINTENANCE (O&M) ITEMS		QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0		1	$0
2.					$0		1	$0
3.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$298,000**

*** Sources of unit costs are provided at the end of the cost tables.**

4 9 0698

TABLE 32

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:				MECHANICAL DEWATERING		MEDIUM	OU-2 Basin sediments	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$150,000	$150,000	D	1	$150,000
2. Mobilization/demobilization	21	1	LS	$100,000	$100,000	D	1	$100,000
3. Filter press (4 presses)	21	210	DAY	$10,000	$2,100,000	D	1	$2,100,000
4. Mix tanks (4 tanks)	21	7	MO	$14,000	$98,000	D	1	$98,000
5. Small dredge (operated)	21	210	DAY	$1,800	$378,000	D	1	$378,000
6. Oversight/support personnel	21	7	MO	$180,200	$1,261,400		1	$1,261,400
7. Polymer addition	21	1	LS	$5,500,000	$5,500,000		1	$5,500,000
8. Onsite transport of tractors	21	7	MO	$31,200	$218,400		1	$218,400
10. Unlisted items		1	LS		$1,961,000			$1,961,000
TOTAL DIRECT COST								$11,766,800
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					10			$1,176,680
CONSTRUCTION SERVICES COST					10			$1,176,680
PERMITTING AND LEGAL SERVICES COST					5			$588,340
SUBTOTAL								$14,708,500
CONTINGENCY ALLOWANCE					50			$7,354,250
TOTAL TECHNOLOGY CAPITAL COST								$22,063,000
OPERATION AND MAINTENANCE (O&M) ITEMS		QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$22,063,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 33

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: ON-SITE DISPOSAL MEDIUM OU-2 Basin sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$200,000	$200,000	D	1	$200,000
2. Clearing and grubbing	6	30	Acres	$3,900	$117,000	D	1	$117,000
3. Grading	6	135,000	SY	$2.00	$270,000	D	1	$270,000
4. Access roads	6	1	LS	$100,000	$100,000	D	1	$100,000
5. Excavate landfill	6	410,000	CY	$4.00	$1,640,000	D	1	$1,640,000
6. Recompacted clay liner - 2ft	7	100,000	CY	$8.00	$800,000	D	1	$800,000
7. Hauling of waste to landfill	13	410,000	CY	$6.00	$2,460,000		1	$2,460,000
8. Placement and compaction (wast	6	410,000	CY	$4.65	$1,906,500	mD	1.3	$2,478,450
9. Cap (2' - compacted soil)	7	90,000	CY	$8.00	$720,000	D	1	$720,000
10. Topsoil	7	45,000	CY	$12.50	$562,500	D	1	$562,500
11. Seeding	7	30	Acres	$1,800	$54,000	D	1	$54,000
12. Monitoring well installation	1	1	LS	$50,000	$50,000		1	$50,000
13. Miscellaneous items		1	LS		$1,418,000			$1,418,000
TOTAL DIRECT COST								$10,870,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	10	$1,087,000
CONSTRUCTION SERVICES COST	15	$1,630,500
PERMITTING AND LEGAL SERVICES COST	5	$543,500
SUBTOTAL		$14,131,000
CONTINGENCY ALLOWANCE	30	$4,239,300
TOTAL TECHNOLOGY CAPITAL COST		$18,370,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	24	24	EA	$3,000	$72,000		1	$72,000
2. Monitoring and reporting	1	1	LS	$20,000	$20,000		1	$20,000
3. Repairs and maintenance	1	1	LS	$20,000	$20,000		1	$20,000
4. Unlisted items	1	1	LS		$11,000			$11,000
TOTAL TECHNOLOGY O&M YEARLY COST								$123,000
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$1,891,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$20,261,000**

*Sources of unit costs are provided at the end of the cost tables.

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TABLE 34

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			CONFINED DISPOSAL FACILIT			MEDIUM	OU-2 Basin sediments	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$200,000	$200,000	D	1	$200,000
2. Clearing and grubbing	6	35	Acres	$3,900	$136,500	D	1	$136,500
3. Grading	6	135,000	SY	$2.00	$270,000	D	1	$270,000
4. Access roads	6	1	LS	$100,000	$100,000	D	1	$100,000
5. Excavate CDF	6	510,000	CY	$4.00	$2,040,000	D	1	$2,040,000
6. Recompacted clay liner - 2ft	7	125,000	CY	$8.00	$1,000,000	D	1	$1,000,000
7. Berm construction	7	18,000	CY	$8.00	$144,000	D	1	$144,000
8. Operation of CDF until closure	22	1	LS	$1,000,000	$1,000,000	D	1	$1,000,000
9. Unlisted items		1	LS		$1,223,000			$1,223,000
TOTAL DIRECT COST								$6,113,500
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$1,222,700
CONSTRUCTION SERVICES COST					15			$917,025
PERMITTING AND LEGAL SERVICES COST					5			$305,675
SUBTOTAL								$8,558,900
CONTINGENCY ALLOWANCE					50			$4,279,450
TOTAL TECHNOLOGY CAPITAL COST								$12,838,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0		1	$0
2.					$0		1	$0
3.					$0		1	$0
4.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0
TECHNOLOGY OR PROCESS OPTION TOTAL -								$12,838,000

* Sources of unit costs are provided at the end of the cost tables.

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TABLE 35

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOL. OR PROCESS OPTION: **IN SITU S/S AND CAPPING** **MEDIUM OU-2 Basin sediments**

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$200,000	$200,000	D	1	$200,000
2. In-situ S/S	23	250,000	CY	$15	$3,750,000	D	1	$3,750,000
3. Reagent addition (20% by weigh	23	67,500	TN	$65	$4,387,500		1	$4,387,500
4. Cap - (2' compacted soil)	7	125,000	CY	$8.00	$1,000,000	D	1	$1,000,000
5. Topsoil	7	62,500	CY	$12.50	$781,250	D	1	$781,250
6. Seeding	7	35	Acres	$1,800	$63,000	D	1	$63,000
7. Monitoring well installation	1	1	LS	$50,000	$50,000		1	$50,000
8. Unlisted items		1	LS		$1,535,000			$1,535,000
TOTAL DIRECT COST								$11,766,800

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	10	$1,176,680
CONSTRUCTION SERVICES COST	10	$1,176,680
PERMITTING AND LEGAL SERVICES COST	5	$588,340
SUBTOTAL		$14,708,500
CONTINGENCY ALLOWANCE	50	$7,354,250
TOTAL TECHNOLOGY CAPITAL COST		$22,063,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EA	$3,750	$90,000	D	1	$90,000
2. Monitoring and reporting	1	1	LS	$20,000	$20,000		1	$20,000
3. Repairs and maintenance	10	1	LS	$20,000	$20,000	D	1	$20,000
4. Unlisted items		1	LS		$13,000			$13,000
TOTAL TECHNOLOGY O&M YEARLY COST								$143,000
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$2,198,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$24,261,000**

* Sources of unit costs are provided at the end of the cost tables.

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TABLE 36

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: PROCESS WATER DIVERSION MEDIUM OU-2 Ditch sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
Process water diversion								
1. Mobilization/demobilization	20	1	LS	$30,000	$30,000	D	1	$30,000
2. Site preparation	6	7	Acres	$3,900	$27,300	D	1	$27,300
3. Pump (two - one standby)	6	7	MO	$10,000	$70,000		1	$70,000
4. Pump instrumentation	24	1	LS	$10,000	$10,000		1	$10,000
5. Oversight	18	850	Hr	$50	$42,500	D	1	$42,500
6. Lift station	6	1	LS	$10,000	$10,000		1	$10,000
7. Pipe installation	6	6,000	LF	$25	$150,000	D	1	$150,000
8. Electricity	25	7	MO	$5,400	$40,230		1	$40,230
9.								
10. Unlisted items		1	LS		$95,000			$95,000
TOTAL DIRECT COST								$475,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	15	$71,250
CONSTRUCTION SERVICES COST	20	$95,000
PERMITTING AND LEGAL SERVICES COST	20	$95,000
SUBTOTAL		$736,250
CONTINGENCY ALLOWANCE	30	$220,875
TOTAL TECHNOLOGY CAPITAL COST		$957,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$957,000**

* Sources of unit costs are provided at the end of the cost tables.

4 9 0703

TABLE 37

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			BACKFILLING			MEDIUM	OU-2 Ditch Sediments	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$30,000	$30,000	D	1	$30,000
2. Clearing and grubbing	6	20	Acres	$3,900	$78,000	D	1	$78,000
3. Access roads	6	28,000	SY	$5.40	$151,200	D	1	$151,200
4. Excavating of new ditch	6	50,000	CY	$4	$200,000	D	1	$200,000
5. Backfilling existing ditch	6	50,000	CY	$5	$232,500	mD	1.3	$302,250
6. Grading	6	70,000	SY	$2	$140,000	D	1	$140,000
7. Seeding	7	20	Acres	$1,800	$36,000	D	1	$36,000
8. Unlisted items		1	LS		$234,000			$234,000
TOTAL DIRECT COST								$1,171,500
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					30			$351,450
CONSTRUCTION SERVICES COST					25			$292,875
PERMITTING AND LEGAL SERVICES COST					30			$351,450
SUBTOTAL								$2,167,275
CONTINGENCY ALLOWANCE					50			$1,083,638
TOTAL TECHNOLOGY CAPITAL COST								$3,251,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Ditch maintenance	10	1	LS	$20,000	$20,000	D	1	$20,000
2.					$0		1	$0
3.					$0		1	$0
4.					$0		1	$0
5. Unlisted items					$5,000			$5,000
TOTAL TECHNOLOGY O&M YEARLY COST								$25,000
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$384,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$3,635,000

* Sources of unit costs are provided at the end of the cost tables.

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TABLE 38

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

TECHNOLOGY OR PROCESS OPTION: EXCAVATION MEDIUM OU-2 Ditch sediments

CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$90,000	$90,000	D	1	$90,000
2. Site development	6	1	LS	$225,000	$225,000	D	1	$225,000
3. Excavation	14	43,000	CY	$8.00	$344,000	mD/C	2	$688,000
4. Grading	6	36,000	SY	$2.00	$72,000	D	1	$72,000
5. Seeding	7	10	Acres	$1,800	$18,000	D	1	$18,000
6. Contaminated debris disposal	2	4,500	TN	$540	$2,430,000		1	$2,430,000
7.					$0		1	$0
8.					$0		1	$0
9. Unlisted items		1	LS		$1,057,000			$1,057,000
TOTAL DIRECT COST								$4,580,000

ADDITIONAL COSTS	PERCENTAGE OF DIRECT COST	COST
ENGINEERING SERVICES COST	10	$458,000
CONSTRUCTION SERVICES COST	15	$687,000
PERMITTING AND LEGAL SERVICES COST	10	$458,000
SUBTOTAL		$6,183,000
CONTINGENCY ALLOWANCE	70	$4,328,100
TOTAL TECHNOLOGY CAPITAL COST		$10,511,000

OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0		1	$0
2.					$0		1	$0
3.					$0		1	$0
4.					$0		1	$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								**$10,511,000**

* Sources of unit costs are provided at the end of the cost tables.

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TABLE 39

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			OFF-SITE DISPOSAL (RCRA)			MEDIUM	OU-2 Ditch sediments	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Off-site transport of soil	2	2,650	Trip	$2,895	$7,671,750		1	$7,671,750
2. Direct disposal at offsite landfill	2	53,000	TN	$245	$12,985,000		1	$12,985,000
3.					$0		1	$0
4.					$0		1	$0
5.					$0		1	$0
6.					$0		1	$0
7.					$0		1	$0
8.					$0		1	$0
9.					$0		1	$0
10. Unlisted items		1	LS		$1,033,000			$1,033,000
TOTAL DIRECT COST								$21,689,800
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					1			$216,898
CONSTRUCTION SERVICES COST					2			$433,796
PERMITTING AND LEGAL SERVICES COST					1			$216,898
SUBTOTAL								$22,557,392
CONTINGENCY ALLOWANCE					30			$6,767,218
TOTAL TECHNOLOGY CAPITAL COST								$29,325,000
OPERATION AND MAINTENANCE (O&M) ITEMS		QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$29,325,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 40

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			ON-SITE THERMAL TREATME			MEDIUM	OU-2 Ditch sediments	
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Site preparation	11	1	LS	$100,000	$100,000	D	1	$100,000
2. Mobilization/demobilization	16	1	LS	$1,000,000	$1,000,000	D	1	$1,000,000
3. Temporary storage	15	1	LS	$100,000	$100,000		1	$100,000
4. Incineration (H&S cost included	16	53,000	TN	$575	$30,475,000		1	$30,475,000
5. Haul soil to treatment area	13	39,000	CY	$6.00	$234,000		1	$234,000
6. Haul soil/ash to onsite landfill	13	39,000	CY	$6.00	$234,000		1	$234,000
7. Analytical	17	1	LS	$300,000	$300,000		1	$300,000
8. Offsite transport of residual slud	2	10	Trip	$2,895	$27,503		1	$27,503
9. Disposal of residual sludge	2	190	TN	$365	$69,350		1	$69,350
10. Unlisted items		1	LS		$6,508,000			$6,508,000
TOTAL DIRECT COST								$39,047,900
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					20			$7,809,580
CONSTRUCTION SERVICES COST					15			$5,857,185
PERMITTING AND LEGAL SERVICES COST					5			$1,952,395
SUBTOTAL								$54,667,060
CONTINGENCY ALLOWANCE					30			$16,400,118
TOTAL TECHNOLOGY CAPITAL COST								$71,067,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1.					$0			$0
2.					$0			$0
3.					$0			$0
4.					$0			$0
5.					$0			$0
TOTAL TECHNOLOGY O&M YEARLY COST								$0
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$0.00
TECHNOLOGY OR PROCESS OPTION TOTAL -								$71,067,000

* Sources of unit costs are provided at the end of the cost tables.

TABLE 41

OLIN CHEMICALS - McINTOSH, ALABAMA PLANT SITE FEASIBILITY STUDY COST ESTIMATE								
TECHNOLOGY OR PROCESS OPTION:			ON-SITE DISPOSAL			MEDIUM OU-2 Ditch sediments		
CONSTRUCTION ITEM	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	TOTAL COST
1. Mobilization/demobilization	5	1	LS	$30,000	$30,000	D	1	$30,000
2. Clearing and grubbing	6	6.00	Acres	$3,900	$23,400	D	1	$23,400
3. Excavate landfill	6	39,000	CY	$4.00	$156,000	D	1	$156,000
4. Grading	6	28,000	SY	$2.00	$56,000	D	1	$56,000
5. Recompacted clay liner - 2ft	7	20,000	CY	$8.00	$160,000	D	1	$160,000
6. Placement and compaction (wast	6	39,000	CY	$4.65	$181,350	mD	1.2	$217,620
7. Cap (2' compacted soil)	7	20,000	CY	$8.00	$160,000	D	1	$160,000
8. Topsoil	7	10,000	CY	$12.50	$125,000	D	1	$125,000
9. Seeding	7	6	Acres	$1,800	$10,800	D	1	$10,800
10. Monitoring well installation	1	1	LS	$50,000	$50,000		1	$50,000
11. Unlisted items		1	LS		$148,000			$148,000
TOTAL DIRECT COST								$1,136,800
ADDITIONAL COSTS					PERCENTAGE OF DIRECT COST			COST
ENGINEERING SERVICES COST					15			$170,520
CONSTRUCTION SERVICES COST					25			$284,200
PERMITTING AND LEGAL SERVICES COST					10			$113,680
SUBTOTAL								$1,705,200
CONTINGENCY ALLOWANCE					30			$511,560
TOTAL TECHNOLOGY CAPITAL COST								$2,217,000
OPERATION AND MAINTENANCE (O&M) ITEMS	COST SOURCE*	QUANTITY	UNITS	UNIT PRICE	BASE COST	SAFETY LEVEL	COST FACTOR	YEARLY COST
1. Mowing	7	24	EA	$650	$15,600		1	$15,600
2. Monitoring and reporting	1	1	LS	$20,000	$20,000		1	$20,000
3. Repairs and maintenance	10	1	LS	$10,000	$10,000		1	$10,000
4. Unlisted items		1	LS		$5,000		1	$5,000
TOTAL TECHNOLOGY O&M YEARLY COST								$50,600
TOTAL TECHNOLOGY O&M PRESENT WORTH (5% & 30 Years)								$778,000
TECHNOLOGY OR PROCESS OPTION TOTAL -								$2,995,000

* Sources of unit costs are provided at the end of the cost tables.

SOURCES OF UNIT COSTS
OLIN CHEMICALS - MCINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE

1. Estimated based on previous work at the site.

2. Estimated based on oral input on transportation/disposal costs from Chemical Waste Management Incorporated (CWM, Inc.).

3. WCC estimate based on vendor estimates for similar sites.

4. Based on estimate from "Eastman Christensen Environmental Systems" in Houston, Texas.

5. Estimated at 2 to 5 percent of other construction item costs excluding "unlisted items" cost.

6. Based on R. S. Mean's site work and construction cost data manual - 1993 (Means manual).

7. Based on Means manual; WCC past and current project experience at similar sites; conversations with contractors.

8. Based on estimates received from several equipment/material vendors for similar projects.

9. Based on estimated labor, time, and materials.

10. Estimated based on best professional judgment.

SOURCES OF UNIT COSTS
OLIN CHEMICALS - MCINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE
(Continued)

11. Estimated based on unit prices in Means manual.

12. Based on oral and written estimates from Geo-Con, Inc., Denton, Texas.

13. Estimated based on input from Geo-Con, Inc.

14. WCC past and current experience at similar sites; dirt contractors.

15. Estimated based on oral input from Geo-Con, Inc.; and OHM, Inc., in Findlay, Ohio.

16. Based on oral estimates from OHM, Inc.

17. Estimated based on oral input from OHM, Inc.

18. Based on assumed labor rate.

19. USACOE literature; oral estimates from Great Lakes Dredge and Dock Company in Metairie, Louisiana; and Ferguson-Harbour, Inc. in Jackson, Mississippi.

SOURCES OF UNIT COSTS
OLIN CHEMICALS - MCINTOSH, ALABAMA PLANT SITE
FEASIBILITY STUDY COST ESTIMATE
(Continued)

20. Based on estimated materials, labor and project duration.

21. Based on input from Laidlaw Environmental Services, Inc. in Houston, Texas.

22. USACOE Literature; best professional judgement.

23. Based on oral estimates from Geo-Con, Inc.; and VFL Technologies Corporation in Malvern, Pennsylvania.

24. Estimate based on review of Means manual and best professional judgment.

25. Based on an assumed unit cost for electricity.

26. Estimated as 10 percent of other construction costs including unlisted items.

NOTE:

USACOE U. S. Army Corps of Engineers, Vicksburg, Mississippi.

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Appendix H

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APPENDIX H

FS RISK CALCULATIONS

Chemical List: Olin McIntosh Landfill

Chemical	Inhalation Slope Factor (mg/kg/day)-1	Inhalation Subchronic RFD mg/kg/day	Inhalation Chronic RFD mg/kg/day	Non-Inhalation Slope Factor (mg/kg/day)-1	Non-Inhalation Subchronic RFD mg/kg/day	Non-Inhalation Chronic RFD mg/kg/day
1,2 dichlorobenzene			4.00E-02			9.00E-02
1,2,4 trichlorobenzene			3.00E-03			1.31E-03
1,2,4,5 Tetrachlorobenzene			3.00E-04			3.00E-04
1,3 dichlorobenzene						
1,4 dichlorobenzene			2.30E-01			7.00E-01
2-methylnaphthalene			4.00E-02			4.00E-02
Acenaphthene			6.00E-02			6.00E-02
Anthracene			3.00E-01			3.00E-01
Aroclor 1254				7.70E+00		
Arsenic	5.00E+01	1.00E+01	8.30E-05	1.75E+00	3.00E-03	3.00E-04
Benzo(a)anthracene	6.10E-01		3.00E-02	7.30E-01		3.00E-02
Benzo(a)pyrene	6.10E+00		3.00E-02	7.30E+00		3.00E-02
Benzo(b)fluoranthene	6.10E-01		3.00E-02	7.30E-01		3.00E-02
Benzo(g,h,i)perylene			3.00E-02			3.00E-02
Benzo(k)fluoranthene	6.10E-01		3.00E-02	7.30E-01		3.00E-02
Bis(2 ethylhexyl)phthalate			2.00E-02	1.40E-02	2.00E-02	2.00E-02
Carbazole						
Chlorobenzene			5.00E-03			2.00E-02
Chromium VI	4.10E+01	5.70E-06	5.70E-07		2.00E-02	5.00E-03
Chrysene	6.10E-02		3.00E-02	7.30E-02		3.00E-02
Copper					3.70E-02	3.70E-02
Dibenzofuran						
Endrin			3.00E-04			3.00E-04
Ethylbenzene			2.90E-01			1.00E-01
Fluoranthene			4.00E-02			4.00E-02
Fluorene			4.00E-02		4.00E-01	4.00E-02
Hexachlorobenzene	1.60E+00		8.00E-04	1.60E+00	8.00E-04	8.00E-04
Indeno(1,2,3-c,d)pyrene	6.10E-01		3.00E-02	7.30E-01		3.00E-02
Mercury		8.60E-05	8.60E-05		3.00E-04	3.00E-04
Naphthalene					4.00E-02	4.00E-03
Nickel (refinery dust)	8.40E-01		2.00E-02		2.00E-02	2.00E-02
Pentachlorobenzene			8.00E-04		8.00E-03	8.00E-04
Pentachloronitrobenzene			3.00E-03			3.00E-03
Phenanthrene			3.00E-02			3.00E-02
Pyrene			3.00E-02		3.00E-01	3.00E-02

Receptor/Pathway Summary: Olin McIntosh Landfill

Receptor / Pathway	Average Exposure			Reasonable Maximum Exposure		
	Cancer Risk	Subchronic H.I.	Chronic H.I.	Cancer Risk	Subchronic H.I.	Chronic H.I.
Hypothetical Child Resident						
-- Dermal Contact with Surface Soil D	0.00E+00		0.00E+00	7.71E-06		6.24E-02
-- Ingestion of surface soil	0.00E+00		0.00E+00	8.58E-05		7.10E-01
-- Inhalation of Soil VOC Inhalation	0.00E+00		0.00E+00	0.00E+00		5.72E+00
-- Inhalation of Soil Particulate Inh	0.00E+00		0.00E+00	6.97E-08		9.13E-03
	0.00E+00		0.00E+00	9.36E-05		6.50E+00
Industrial Worker						
-- Dermal Contact with Surface Soil D	0.00E+00		0.00E+00	2.89E-07		1.87E-03
-- Ingestion of surface soil	0.00E+00		0.00E+00	1.56E-06		1.03E-02
-- Inhalation of Soil VOC Inhalation	0.00E+00		0.00E+00	0.00E+00		7.20E-02
-- Inhalation of Soil Particulate Inh	0.00E+00		0.00E+00	1.10E-09		1.15E-04
	0.00E+00		0.00E+00	1.85E-06		8.43E-02

Hypothetical Child Resident
Dermal Contact with Surface Soil Dermal Absorption
Reasonable Maximum Exposure

Carcinogenic Risk

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Carcinogenic Risk	Total Risk
Aroclor 1254	4.70E-03	9.33E-06	4.39E-08	7.70E+00	3.38E-07	
Arsenic	4.10E-03	9.33E-06	3.83E-08	1.75E+00	6.69E-08	
Benzo(a)anthracene	1.10E-02	9.33E-06	1.03E-07	7.30E-01	7.49E-08	
Benzo(a)pyrene	7.40E-03	9.33E-06	6.90E-08	7.30E+00	5.04E-07	
Benzo(b)fluoranthene	8.10E-03	9.33E-06	7.56E-08	7.30E-01	5.52E-08	
Benzo(k)fluoranthene	1.00E-02	9.33E-06	9.33E-08	7.30E-01	6.81E-08	
Bis(2 ethylhexyl)phthalate	7.70E-03	9.33E-06	7.18E-08	1.40E-02	1.01E-09	
Chrysene	1.30E-02	9.33E-06	1.21E-07	7.30E-02	8.85E-09	
Hexachlorobenzene	4.40E-01	9.33E-06	4.11E-06	1.60E+00	6.57E-06	
Indeno(1,2,3-c,d)pyrene	4.30E-03	9.33E-06	4.01E-08	7.30E-01	2.93E-08	
						7.71E-06

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
1,2 dichlorobenzene	2.40E-02	3.27E-05	7.84E-07	9.00E-02	8.71E-06	
1,2,4 trichlorobenzene	7.40E-02	3.27E-05	2.42E-06	1.31E-03	1.84E-03	
1,2,4,5 Tetrachlorobenzene	6.60E-02	3.27E-05	2.16E-06	3.00E-04	7.18E-03	
1,4 dichlorobenzene	1.80E-02	3.27E-05	5.88E-07	7.00E-01	8.40E-07	
2-methylnaphthalene	2.30E-03	3.27E-05	7.51E-08	4.00E-02	1.88E-06	
Acenaphthene	7.90E-03	3.27E-05	2.58E-07	6.00E-02	4.30E-06	
Anthracene	8.80E-03	3.27E-05	2.87E-07	3.00E-01	9.58E-07	
Arsenic	4.10E-03	3.27E-05	1.34E-07	3.00E-04	4.46E-04	
Benzo(a)anthracene	1.10E-02	3.27E-05	3.59E-07	3.00E-02	1.20E-05	
Benzo(a)pyrene	7.40E-03	3.27E-05	2.42E-07	3.00E-02	8.05E-06	
Benzo(b)fluoranthene	8.10E-03	3.27E-05	2.65E-07	3.00E-02	8.82E-06	
Benzo(g,h,i)perylene	4.50E-03	3.27E-05	1.47E-07	3.00E-02	4.90E-06	
Benzo(k)fluoranthene	1.00E-02	3.27E-05	3.27E-07	3.00E-02	1.09E-05	
Bis(2 ethylhexyl)phthalate	7.70E-03	3.27E-05	2.51E-07	2.00E-02	1.26E-05	
Chlorobenzene	5.70E-02	3.27E-05	1.86E-06	2.00E-02	9.31E-05	
Chromium VI	3.64E-02	3.27E-05	1.19E-06	5.00E-03	2.38E-04	
Chrysene	1.30E-02	3.27E-05	4.25E-07	3.00E-02	1.42E-05	
Copper	1.71E-02	3.27E-05	5.58E-07	3.70E-02	1.51E-05	
Endrin	6.70E-05	3.27E-05	2.19E-09	3.00E-04	7.29E-06	
Ethylbenzene	2.00E-05	3.27E-05	6.53E-10	1.00E-01	6.53E-09	
Fluoranthene	4.00E-02	3.27E-05	1.31E-06	4.00E-02	3.27E-05	
Fluorene	9.00E-03	3.27E-05	2.94E-07	4.00E-02	7.35E-06	
Hexachlorobenzene	4.40E-01	3.27E-05	1.44E-05	8.00E-04	1.80E-02	
Ir (1,2,3-c,d)pyrene	4.30E-03	3.27E-05	1.40E-07	3.00E-02	4.68E-06	
Me. ..y	2.71E-01	3.27E-05	8.85E-06	3.00E-04	2.95E-02	
Naphthalene	6.90E-03	3.27E-05	2.25E-07	4.00E-03	5.63E-05	
Nickel (refinery dust)	7.40E-03	3.27E-05	2.42E-07	2.00E-02	1.21E-05	
Pentachlorobenzene	3.60E-02	3.27E-05	1.18E-06	8.00E-04	1.47E-03	
Pentachloronitrobenzene	3.10E-01	3.27E-05	1.01E-05	3.00E-03	3.37E-03	
Phenanthrene	4.60E-02	3.27E-05	1.50E-06	3.00E-02	5.01E-05	
Pyrene	3.10E-02	3.27E-05	1.01E-06	3.00E-02	3.37E-05	

Hypothetical Child Resident
Ingestion of surface soil
Reasonable Maximum Exposure

Carcinogenic Risk

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Carcinogenic Risk	Total Risk
Aroclor 1254	4.70E-01	9.63E-07	4.52E-07	7.70E+00	3.48E-06	
Arsenic	4.10E+00	9.63E-07	3.95E-06	1.75E+00	6.91E-06	
Benzo(a)anthracene	1.10E+00	9.63E-07	1.06E-06	7.30E-01	7.73E-07	
Benzo(a)pyrene	7.40E-01	9.63E-07	7.12E-07	7.30E+00	5.20E-06	
Benzo(b)fluoranthene	8.10E-01	9.63E-07	7.80E-07	7.30E-01	5.69E-07	
Benzo(k)fluoranthene	1.00E+00	9.63E-07	9.63E-07	7.30E-01	7.03E-07	
Bis(2 ethylhexyl)phthalate	7.70E-01	9.63E-07	7.41E-07	1.40E-02	1.04E-08	
Chrysene	1.30E+00	9.63E-07	1.25E-06	7.30E-02	9.14E-08	
Hexachlorobenzene	4.40E+01	9.63E-07	4.24E-05	1.60E+00	6.78E-05	
Indeno(1,2,3-c,d)pyrene	4.30E-01	9.63E-07	4.14E-07	7.30E-01	3.02E-07	
						8.58E-05

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
1,2 dichlorobenzene	2.40E+00	3.37E-06	8.09E-06	9.00E-02	8.98E-05	
1,2,4 trichlorobenzene	7.40E+00	3.37E-06	2.49E-05	1.31E-03	1.90E-02	
1,2,4,5 Tetrachlorobenzene	6.60E+00	3.37E-06	2.22E-05	3.00E-04	7.41E-02	
1,4 dichlorobenzene	1.80E+00	3.37E-06	6.06E-06	7.00E-01	8.66E-06	
2-methylnaphthalene	2.30E-01	3.37E-06	7.75E-07	4.00E-02	1.94E-05	
Acenaphthene	7.90E-01	3.37E-06	2.66E-06	6.00E-02	4.44E-05	
Anthracene	8.80E-01	3.37E-06	2.96E-06	3.00E-01	9.88E-06	
Arsenic	4.10E+00	3.37E-06	1.38E-05	3.00E-04	4.60E-02	
Benzo(a)anthracene	1.10E+00	3.37E-06	3.71E-06	3.00E-02	1.24E-04	
Benzo(a)pyrene	7.40E-01	3.37E-06	2.49E-06	3.00E-02	8.31E-05	
Benzo(b)fluoranthene	8.10E-01	3.37E-06	2.73E-06	3.00E-02	9.10E-05	
Benzo(g,h,i)perylene	4.50E-01	3.37E-06	1.52E-06	3.00E-02	5.05E-05	
Benzo(k)fluoranthene	1.00E+00	3.37E-06	3.37E-06	3.00E-02	1.12E-04	
Bis(2 ethylhexyl)phthalate	7.70E-01	3.37E-06	2.59E-06	2.00E-02	1.30E-04	
Chlorobenzene	5.70E+00	3.37E-06	1.92E-05	2.00E-02	9.60E-04	
Chromium VI	3.64E+01	3.37E-06	1.23E-04	5.00E-03	2.45E-02	
Chrysene	1.30E+00	3.37E-06	4.38E-06	3.00E-02	1.46E-04	
Copper	1.71E+01	3.37E-06	5.76E-05	3.70E-02	1.56E-03	
Endrin	6.70E-03	3.37E-06	2.26E-08	3.00E-04	7.52E-05	
Ethylbenzene	2.00E-03	3.37E-06	6.74E-09	1.00E-01	6.74E-08	
Fluoranthene	4.00E+00	3.37E-06	1.35E-05	4.00E-02	3.37E-04	
Fluorene	9.00E-01	3.37E-06	3.03E-06	4.00E-02	7.58E-05	
Hexachlorobenzene	4.40E+01	3.37E-06	1.48E-04	8.00E-04	1.85E-01	
Indeno(1,2,3-c,d)pyrene	4.30E-01	3.37E-06	1.45E-06	3.00E-02	4.83E-05	
Mercury	2.71E+01	3.37E-06	9.13E-05	3.00E-04	3.04E-01	
Naphthalene	6.90E-01	3.37E-06	2.32E-06	4.00E-03	5.81E-04	
Nickel (refinery dust)	7.40E+00	3.37E-06	2.49E-05	2.00E-02	1.25E-03	
Pentachlorobenzene	3.60E+00	3.37E-06	1.21E-05	8.00E-04	1.52E-02	
Pentachloronitrobenzene	3.10E+01	3.37E-06	1.04E-04	3.00E-03	3.48E-02	
Phenanthrene	4.60E+00	3.37E-06	1.55E-05	3.00E-02	5.17E-04	
Pyrene	3.10E+00	3.37E-06	1.04E-05	3.00E-02	3.48E-04	

Hypothetical Child Resident
Inhalation of Soil VOC Inhalation
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Chlorobenzene	5.54E-02	5.16E-01	2.86E-02	5.00E-03	5.72E+00	
Ethylbenzene	1.50E-07	5.16E-01	7.74E-08	2.90E-01	2.67E-07	
						5.72E+00

Hypothetical Child Resident
Inhalation of Soil Particulate Inhal.
Reasonable Maximum Exposure

Carcinogenic Risk

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Carcinogenic Risk	Total Risk
Arsenic	8.80E-10	1.48E-01	1.30E-10	5.00E+01	6.49E-09	
Benzo(a)anthracene	2.30E-10	1.48E-01	3.39E-11	6.10E-01	2.07E-11	
Benzo(a)pyrene	1.60E-10	1.48E-01	2.36E-11	6.10E+00	1.44E-10	
Benzo(b)fluoranthene	1.74E-10	1.48E-01	2.57E-11	6.10E-01	1.57E-11	
Benzo(k)fluoranthene	2.10E-10	1.48E-01	3.10E-11	6.10E-01	1.89E-11	
Chromium VI	1.00E-08	1.48E-01	1.48E-09	4.10E+01	6.05E-08	
Chrysene	2.80E-10	1.48E-01	4.13E-11	6.10E-02	2.52E-12	
Hexachlorobenzene	1.00E-08	1.48E-01	1.48E-09	1.60E+00	2.36E-09	
Indeno(1,2,3-c,d)pyrene	9.20E-11	1.48E-01	1.36E-11	6.10E-01	8.28E-12	
Nickel (refinery dust)	1.60E-09	1.48E-01	2.36E-10	8.40E-01	1.98E-10	
						6.97E-08

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
1,2 dichlorobenzene	5.18E-10	5.16E-01	2.67E-10	4.00E-02	6.69E-09	
1,2,4 trichlorobenzene	1.60E-09	5.16E-01	8.26E-10	3.00E-03	2.75E-07	
1,2,4,5 Tetrachlorobenzene	1.40E-09	5.16E-01	7.23E-10	3.00E-04	2.41E-06	
1,4 dichlorobenzene	3.80E-10	5.16E-01	1.96E-10	2.30E-01	8.53E-10	
2-methylnaphthalene	4.90E-11	5.16E-01	2.53E-11	4.00E-02	6.32E-10	
Acenaphthene	1.70E-10	5.16E-01	8.78E-11	6.00E-02	1.46E-09	
Anthracene	1.90E-10	5.16E-01	9.81E-11	3.00E-01	3.27E-10	
Arsenic	8.80E-10	5.16E-01	4.54E-10	8.30E-05	5.47E-06	
Benzo(a)anthracene	2.30E-10	5.16E-01	1.19E-10	3.00E-02	3.96E-09	
Benzo(a)pyrene	1.60E-10	5.16E-01	8.26E-11	3.00E-02	2.75E-09	
Benzo(b)fluoranthene	1.74E-10	5.16E-01	8.98E-11	3.00E-02	2.99E-09	
Benzo(g,h,i)perylene	9.70E-11	5.16E-01	5.01E-11	3.00E-02	1.67E-09	
Benzo(k)fluoranthene	2.10E-10	5.16E-01	1.08E-10	3.00E-02	3.61E-09	
Bis(2 ethylhexyl)phthalate	1.60E-10	5.16E-01	8.26E-11	2.00E-02	4.13E-09	
Chlorobenzene	1.20E-09	5.16E-01	6.20E-10	5.00E-03	1.24E-07	
Chromium VI	1.00E-08	5.16E-01	5.16E-09	5.70E-07	9.06E-03	
Chrysene	2.80E-10	5.16E-01	1.45E-10	3.00E-02	4.82E-09	
Endrin	1.40E-12	5.16E-01	7.23E-13	3.00E-04	2.41E-09	
Ethylbenzene	4.30E-13	5.16E-01	2.22E-13	2.90E-01	7.65E-13	
Fluoranthene	8.60E-10	5.16E-01	4.44E-10	4.00E-02	1.11E-08	
Fluorene	1.90E-10	5.16E-01	9.81E-11	4.00E-02	2.45E-09	
Hexachlorobenzene	1.00E-08	5.16E-01	5.16E-09	8.00E-04	6.45E-06	
Indeno(1,2,3-c,d)pyrene	9.20E-11	5.16E-01	4.75E-11	3.00E-02	1.58E-09	
Mercury	1.00E-08	5.16E-01	5.16E-09	8.60E-05	6.00E-05	
Nickel (refinery dust)	1.60E-09	5.16E-01	8.26E-10	2.00E-02	4.13E-08	
Pentachlorobenzene	7.70E-10	5.16E-01	3.98E-10	8.00E-04	4.97E-07	
Pentachloronitrobenzene	1.00E-08	5.16E-01	5.16E-09	3.00E-03	1.72E-06	
Phenanthrene	9.90E-10	5.16E-01	5.11E-10	3.00E-02	1.70E-08	
Pyrene	6.60E-10	5.16E-01	3.41E-10	3.00E-02	1.14E-08	
						9.13E-03

Industrial Worker
Dermal Contact with Surface Soil Dermal Absorption
Reasonable Maximum Exposure

Carcinogenic Risk

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Carcinogenic Risk	Total Risk
Aroclor 1254	4.70E-03	3.49E-07	1.64E-09	7.70E+00	1.26E-08	
Arsenic	4.10E-03	3.49E-07	1.43E-09	1.75E+00	2.51E-09	
Benzo(a)anthracene	1.10E-02	3.49E-07	3.84E-09	7.30E-01	2.81E-09	
Benzo(a)pyrene	7.40E-03	3.49E-07	2.59E-09	7.30E+00	1.89E-08	
Benzo(b)fluoranthene	8.10E-03	3.49E-07	2.83E-09	7.30E-01	2.07E-09	
Benzo(k)fluoranthene	1.00E-02	3.49E-07	3.49E-09	7.30E-01	2.55E-09	
Bis(2 ethylhexyl)phthalate	7.70E-03	3.49E-07	2.69E-09	1.40E-02	3.77E-11	
Chrysene	1.30E-02	3.49E-07	4.54E-09	7.30E-02	3.32E-10	
Hexachlorobenzene	4.40E-01	3.49E-07	1.54E-07	1.60E+00	2.46E-07	
Indeno(1,2,3-c,d)pyrene	4.30E-03	3.49E-07	1.50E-09	7.30E-01	1.10E-09	
						2.89E-07

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
1,2 dichlorobenzene	2.40E-02	9.78E-07	2.35E-08	9.00E-02	2.61E-07	
1,2,4 trichlorobenzene	7.40E-02	9.78E-07	7.24E-08	1.31E-03	5.53E-05	
1,2,4,5 Tetrachlorobenzene	6.60E-02	9.78E-07	6.46E-08	3.00E-04	2.15E-04	
1,4 dichlorobenzene	1.80E-02	9.78E-07	1.76E-08	7.00E-01	2.52E-08	
2-methylnaphthalene	2.30E-03	9.78E-07	2.25E-09	4.00E-02	5.63E-08	
Acenaphthene	7.90E-03	9.78E-07	7.73E-09	6.00E-02	1.29E-07	
Anthracene	8.80E-03	9.78E-07	8.61E-09	3.00E-01	2.87E-08	
Arsenic	4.10E-03	9.78E-07	4.01E-09	3.00E-04	1.34E-05	
Benzo(a)anthracene	1.10E-02	9.78E-07	1.08E-08	3.00E-02	3.59E-07	
Benzo(a)pyrene	7.40E-03	9.78E-07	7.24E-09	3.00E-02	2.41E-07	
Benzo(b)fluoranthene	8.10E-03	9.78E-07	7.93E-09	3.00E-02	2.64E-07	
Benzo(g,h,i)perylene	4.50E-03	9.78E-07	4.40E-09	3.00E-02	1.47E-07	
Benzo(k)fluoranthene	1.00E-02	9.78E-07	9.78E-09	3.00E-02	3.26E-07	
Bis(2 ethylhexyl)phthalate	7.70E-03	9.78E-07	7.53E-09	2.00E-02	3.77E-07	
Chlorobenzene	5.70E-02	9.78E-07	5.58E-08	2.00E-02	2.79E-06	
Chromium VI	3.64E-02	9.78E-07	3.56E-08	5.00E-03	7.12E-06	
Chrysene	1.30E-02	9.78E-07	1.27E-08	3.00E-02	4.24E-07	
Copper	1.71E-02	9.78E-07	1.67E-08	3.70E-02	4.52E-07	
Endrin	6.70E-05	9.78E-07	6.56E-11	3.00E-04	2.19E-07	
Ethylbenzene	2.00E-05	9.78E-07	1.96E-11	1.00E-01	1.96E-10	
Fluoranthene	4.00E-02	9.78E-07	3.91E-08	4.00E-02	9.78E-07	
Fluorene	9.00E-03	9.78E-07	8.81E-09	4.00E-02	2.20E-07	
Hexachlorobenzene	4.40E-01	9.78E-07	4.31E-07	8.00E-04	5.38E-04	
Ir (1,2,3-c,d)pyrene	4.30E-03	9.78E-07	4.21E-09	3.00E-02	1.40E-07	
Me y	2.71E-01	9.78E-07	2.65E-07	3.00E-04	8.84E-04	
Naphthalene	6.90E-03	9.78E-07	6.75E-09	4.00E-03	1.69E-06	
Nickel (refinery dust)	7.40E-03	9.78E-07	7.24E-09	2.00E-02	3.62E-07	
Pentachlorobenzene	3.60E-02	9.78E-07	3.52E-08	8.00E-04	4.40E-05	
Pentachloronitrobenzene	3.10E-01	9.78E-07	3.03E-07	3.00E-03	1.01E-04	
Phenanthrene	4.60E-02	9.78E-07	4.50E-08	3.00E-02	1.50E-06	
Pyrene	3.10E-02	9.78E-07	3.03E-08	3.00E-02	1.01E-06	

Industrial Worker
Ingestion of surface soil
Reasonable Maximum Exposure

Carcinogenic Risk

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Carcinogenic Risk	Total Risk
Aroclor 1254	4.70E-01	1.75E-08	8.21E-09	7.70E+00	6.32E-08	
Arsenic	4.10E+00	1.75E-08	7.16E-08	1.75E+00	1.25E-07	
Benzo(a)anthracene	1.10E+00	1.75E-08	1.92E-08	7.30E-01	1.40E-08	
Benzo(a)pyrene	7.40E-01	1.75E-08	1.29E-08	7.30E+00	9.44E-08	
Benzo(b)fluoranthene	8.10E-01	1.75E-08	1.42E-08	7.30E-01	1.03E-08	
Benzo(k)fluoranthene	1.00E+00	1.75E-08	1.75E-08	7.30E-01	1.28E-08	
Bis(2 ethylhexyl)phthalate	7.70E-01	1.75E-08	1.35E-08	1.40E-02	1.88E-10	
Chrysene	1.30E+00	1.75E-08	2.27E-08	7.30E-02	1.66E-09	
Hexachlorobenzene	4.40E+01	1.75E-08	7.69E-07	1.60E+00	1.23E-06	
Indeno(1,2,3-c,d)pyrene	4.30E-01	1.75E-08	7.51E-09	7.30E-01	5.48E-09	
						1.56E-06

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
1,2 dichlorobenzene	2.40E+00	4.89E-08	1.17E-07	9.00E-02	1.30E-06	
1,2,4 trichlorobenzene	7.40E+00	4.89E-08	3.62E-07	1.31E-03	2.76E-04	
1,2,4,5 Tetrachlorobenzene	6.60E+00	4.89E-08	3.23E-07	3.00E-04	1.08E-03	
1,4 dichlorobenzene	1.80E+00	4.89E-08	8.81E-08	7.00E-01	1.26E-07	
2-methylnaphthalene	2.30E-01	4.89E-08	1.13E-08	4.00E-02	2.81E-07	
Acenaphthene	7.90E-01	4.89E-08	3.86E-08	6.00E-02	6.44E-07	
Anthracene	8.80E-01	4.89E-08	4.31E-08	3.00E-01	1.44E-07	
Arsenic	4.10E+00	4.89E-08	2.01E-07	3.00E-04	6.69E-04	
Benzo(a)anthracene	1.10E+00	4.89E-08	5.38E-08	3.00E-02	1.79E-06	
Benzo(a)pyrene	7.40E-01	4.89E-08	3.62E-08	3.00E-02	1.21E-06	
Benzo(b)fluoranthene	8.10E-01	4.89E-08	3.96E-08	3.00E-02	1.32E-06	
Benzo(g,h,i)perylene	4.50E-01	4.89E-08	2.20E-08	3.00E-02	7.34E-07	
Benzo(k)fluoranthene	1.00E+00	4.89E-08	4.89E-08	3.00E-02	1.63E-06	
Bis(2 ethylhexyl)phthalate	7.70E-01	4.89E-08	3.77E-08	2.00E-02	1.88E-06	
Chlorobenzene	5.70E+00	4.89E-08	2.79E-07	2.00E-02	1.39E-05	
Chromium VI	3.64E+01	4.89E-08	1.78E-06	5.00E-03	3.56E-04	
Chrysene	1.30E+00	4.89E-08	6.36E-08	3.00E-02	2.12E-06	
Copper	1.71E+01	4.89E-08	8.37E-07	3.70E-02	2.26E-05	
Endrin	6.70E-03	4.89E-08	3.28E-10	3.00E-04	1.09E-06	
Ethylbenzene	2.00E-03	4.89E-08	9.78E-11	1.00E-01	9.78E-10	
Fluoranthene	4.00E+00	4.89E-08	1.96E-07	4.00E-02	4.89E-06	
Fluorene	9.00E-01	4.89E-08	4.40E-08	4.00E-02	1.10E-06	
Hexachlorobenzene	4.40E+01	4.89E-08	2.15E-06	8.00E-04	2.69E-03	
Indeno(1,2,3-c,d)pyrene	4.30E-01	4.89E-08	2.10E-08	3.00E-02	7.01E-07	
Mercury	2.71E+01	4.89E-08	1.33E-06	3.00E-04	4.42E-03	
Naphthalene	6.90E-01	4.89E-08	3.38E-08	4.00E-03	8.44E-06	
Nickel (refinery dust)	7.40E+00	4.89E-08	3.62E-07	2.00E-02	1.81E-05	
Pentachlorobenzene	3.60E+00	4.89E-08	1.76E-07	8.00E-04	2.20E-04	
Pentachloronitrobenzene	3.10E+01	4.89E-08	1.52E-06	3.00E-03	5.06E-04	
Phenanthrene	4.60E+00	4.89E-08	2.25E-07	3.00E-02	7.50E-06	
Pyrene	3.10E+00	4.89E-08	1.52E-07	3.00E-02	5.06E-06	

Industrial Worker
Inhalation of Soil VOC Inhalation
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Chlorobenzene	5.54E-02	6.50E-03	3.60E-04	5.00E-03	7.20E-02	
Ethylbenzene	1.50E-07	6.50E-03	9.75E-10	2.90E-01	3.36E-09	
						7.20E-02

Industrial Worker
Inhalation of Soil Particulate Inhal.
Reasonable Maximum Exposure

Carcinogenic Risk

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Slope Factor (mg/kg/day)-1	Carcinogenic Risk	Total Risk
Arsenic	8.80E-10	2.32E-03	2.04E-12	5.00E+01	1.02E-10	
Benzo(a)anthracene	2.30E-10	2.32E-03	5.34E-13	6.10E-01	3.26E-13	
Benzo(a)pyrene	1.60E-10	2.32E-03	3.71E-13	6.10E+00	2.26E-12	
Benzo(b)fluoranthene	1.74E-10	2.32E-03	4.04E-13	6.10E-01	2.46E-13	
Benzo(k)fluoranthene	2.10E-10	2.32E-03	4.87E-13	6.10E-01	2.97E-13	
Chromium VI	1.00E-08	2.32E-03	2.32E-11	4.10E+01	9.51E-10	
Chrysene	2.80E-10	2.32E-03	6.50E-13	6.10E-02	3.96E-14	
Hexachlorobenzene	1.00E-08	2.32E-03	2.32E-11	1.60E+00	3.71E-11	
Indeno(1,2,3-c,d)pyrene	9.20E-11	2.32E-03	2.13E-13	6.10E-01	1.30E-13	
Nickel (refinery dust)	1.60E-09	2.32E-03	3.71E-12	8.40E-01	3.12E-12	
						1.10E-09

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
1,2 dichlorobenzene	5.18E-10	6.50E-03	3.37E-12	4.00E-02	8.41E-11	
1,2,4 trichlorobenzene	1.60E-09	6.50E-03	1.04E-11	3.00E-03	3.47E-09	
1,2,4,5 Tetrachlorobenzene	1.40E-09	6.50E-03	9.10E-12	3.00E-04	3.03E-08	
1,4 dichlorobenzene	3.80E-10	6.50E-03	2.47E-12	2.30E-01	1.07E-11	
2-methylnaphthalene	4.90E-11	6.50E-03	3.18E-13	4.00E-02	7.96E-12	
Acenaphthene	1.70E-10	6.50E-03	1.10E-12	6.00E-02	1.84E-11	
Anthracene	1.90E-10	6.50E-03	1.23E-12	3.00E-01	4.11E-12	
Arsenic	8.80E-10	6.50E-03	5.72E-12	8.30E-05	6.89E-08	
Benzo(a)anthracene	2.30E-10	6.50E-03	1.49E-12	3.00E-02	4.98E-11	
Benzo(a)pyrene	1.60E-10	6.50E-03	1.04E-12	3.00E-02	3.47E-11	
Benzo(b)fluoranthene	1.74E-10	6.50E-03	1.13E-12	3.00E-02	3.77E-11	
Benzo(g,h,i)perylene	9.70E-11	6.50E-03	6.30E-13	3.00E-02	2.10E-11	
Benzo(k)fluoranthene	2.10E-10	6.50E-03	1.36E-12	3.00E-02	4.55E-11	
Bis(2 ethylhexyl)phthalate	1.60E-10	6.50E-03	1.04E-12	2.00E-02	5.20E-11	
Chlorobenzene	1.20E-09	6.50E-03	7.80E-12	5.00E-03	1.56E-09	
Chromium VI	1.00E-08	6.50E-03	6.50E-11	5.70E-07	1.14E-04	
Chrysene	2.80E-10	6.50E-03	1.82E-12	3.00E-02	6.06E-11	
Endrin	1.40E-12	6.50E-03	9.10E-15	3.00E-04	3.03E-11	
Ethylbenzene	4.30E-13	6.50E-03	2.79E-15	2.90E-01	9.63E-15	
Fluoranthene	8.60E-10	6.50E-03	5.59E-12	4.00E-02	1.40E-10	
Fluorene	1.90E-10	6.50E-03	1.23E-12	4.00E-02	3.09E-11	
Hexachlorobenzene	1.00E-08	6.50E-03	6.50E-11	8.00E-04	8.12E-08	
Indeno(1,2,3-c,d)pyrene	9.20E-11	6.50E-03	5.98E-13	3.00E-02	1.99E-11	
Mercury	1.00E-08	6.50E-03	6.50E-11	8.60E-05	7.55E-07	
Nickel (refinery dust)	1.60E-09	6.50E-03	1.04E-11	2.00E-02	5.20E-10	
Pentachlorobenzene	7.70E-10	6.50E-03	5.00E-12	8.00E-04	6.25E-09	
Pentachloronitrobenzene	1.00E-08	6.50E-03	6.50E-11	3.00E-03	2.17E-08	
Phenanthrene	9.90E-10	6.50E-03	6.43E-12	3.00E-02	2.14E-10	
Pyrene	6.60E-10	6.50E-03	4.29E-12	3.00E-02	1.43E-10	
						1.15E-04

Intake Factor: Olin McIntosh Landfill

Description: Industrial Worker Soil Dermal
Abbreviation: iwsd
Pathway Type: Dermal Contact with Soil

$$\text{Intake Factor} = \frac{(SA \times EF \times ED \times ME \times AF \times AB \times FI \times CF \times SS)}{(BW \times AT)}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
SA	Surface Area(cm2)	0	1000	0	1000
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
AF	Adherence Factor(mg/cm2)	0	1	0	1
AB	Absorption Factor	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
CF	Conversion Factor(kg/mg)	0	.000001	0	.000001
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$3.49E-07 = \frac{(1.00E+03 \times 2.50E+02 \times 2.50E+01 \times 1 \times 1 \times 1 \times 1.00E-01 \times 1.00E-06 \times 1)}{(7.00E+01 \times 2.56E+04)}$$

Non-Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$9.78E-07 = \frac{(1.00E+03 \times 2.50E+02 \times 2.50E+01 \times 1 \times 1 \times 1 \times 1.00E-01 \times 1.00E-06 \times 1)}{(7.00E+01 \times 9.13E+03)}$$

Intake Factor: Olin McIntosh Landfill

Description: Industrial Worker Soil Ingestion
Abbreviation: iwsi
Pathway Type: Ingestion of Soil

$$\text{Intake Factor} = \frac{(\text{IR3} \times \text{EF} \times \text{ED} \times \text{ME} \times \text{FI} \times \text{CF} \times \text{SS})}{(\text{BW} \times \text{AT})}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR3	Ingestion Rate(mg/day)	0	50	0	50
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
CF	Conversion Factor (kg/mg)	0	.000001	0	.000001
SS	Site-specific Factor	0	1	0	1
BW	Body Weight (kg)	0	70	0	70
AT	Averaging Time (dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.75\text{E-08} = \frac{(5.00\text{E+01} \times 2.50\text{E+02} \times 2.50\text{E+01} \times 1 \times 1.00\text{E-01} \times 1.00\text{E-06} \times 1)}{(7.00\text{E+01} \times 2.56\text{E+04})}$$

Non-Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$4.89\text{E-08} = \frac{(5.00\text{E+01} \times 2.50\text{E+02} \times 2.50\text{E+01} \times 1 \times 1.00\text{E-01} \times 1.00\text{E-06} \times 1)}{(7.00\text{E+01} \times 9.13\text{E+03})}$$

Intake Factor: Olin McIntosh Landfill

Description: Industrial Worker Soil VOC Inhalation
Abbreviation: iwsv
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	8	0	8
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$2.32E{-}03 = \frac{(\ 8.30E{-}01 \times 8.00E{+}00 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1 \times 1 \times 1.00E{-}01 \times 1\ )}{(\ 7.00E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$6.50E{-}03 = \frac{(\ 8.30E{-}01 \times 8.00E{+}00 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1 \times 1 \times 1.00E{-}01 \times 1\ )}{(\ 7.00E{+}01 \times 9.13E{+}03\ )}$$

Intake Factor: Olin McIntosh Landfill

Description: Industrial Worker Soil Particulate Inhal
Abbreviation: iwsp
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	8	0	8
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$2.32E{-}03 = \frac{(\ 8.30E{-}01 \times 8.00E{+}00 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1 \times 1 \times 1.00E{-}01 \times 1\ )}{(\ 7.00E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$6.50E{-}03 = \frac{(\ 8.30E{-}01 \times 8.00E{+}00 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1 \times 1 \times 1.00E{-}01 \times 1\ )}{(\ 7.00E{+}01 \times 9.13E{+}03\ )}$$

Intake Factor: Olin McIntosh Landfill

Description: Child Resident Soil Dermal
Abbreviation: crsd
Pathway Type: Dermal Contact with Soil

$$\text{Intake Factor} = \frac{(SA \times EF \times ED \times ME \times AF \times AB \times FI \times CF \times SS)}{(BW \times AT)}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
SA	Surface Area(cm2)	0	1260	0	1260
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
AF	Adherence Factor(mg/cm2)	0	1	0	1
AB	Absorption Factor	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
CF	Conversion Factor(kg/mg)	0	.000001	0	.000001
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$9.33E-06 = \frac{(1.26E+03 \times 3.50E+02 \times 2.00E+01 \times 1 \times 1 \times 1 \times 1 \times 1.00E-06 \times 1)}{(3.70E+01 \times 2.56E+04)}$$

Non-Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$3.27E-05 = \frac{(1.26E+03 \times 3.50E+02 \times 2.00E+01 \times 1 \times 1 \times 1 \times 1 \times 1.00E-06 \times 1)}{(3.70E+01 \times 7.30E+03)}$$

Intake Factor: Olin McIntosh Landfill

Description: Child Resident Soil Ingestion
Abbreviation: crsi
Pathway Type: Ingestion of Soil

$$\text{Intake Factor} = \frac{(\ IR3 \times EF \times ED \times ME \times FI \times CF \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR3	Ingestion Rate(mg/day)	0	130	0	130
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
CF	Conversion Factor (kg/mg)	0	.000001	0	.000001
SS	Site-specific Factor	0	1	0	1
BW	Body Weight (kg)	0	37	0	37
AT	Averaging Time (dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$9.63E{-}07 = \frac{(\ 1.30E{+}02 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1.00E{-}06 \times 1\ )}{(\ 3.70E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$3.37E{-}06 = \frac{(\ 1.30E{+}02 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1.00E{-}06 \times 1\ )}{(\ 3.70E{+}01 \times 7.30E{+}03\ )}$$

Intake Factor: Olin McIntosh Landfill

Description: Child Resident Soil VOC Inhalation
Abbreviation: crsv
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	24	0	24
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.48E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$5.16E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 7.30E{+}03\ )}$$

Intake Factor: Olin McIntosh Landfill

Description: Child Resident Soil Particulate Inhal
Abbreviation: crsp
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	24	0	24
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.48E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$5.16E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 7.30E{+}03\ )}$$

Media Chemical Concentrations: Olin McIntosh Landfill

Medium: surface soil
Abbreviation: soil1
Medium Type: Soil

Chemical	Subchronic Average (mg/kg)	Subchronic R.M.E. (mg/kg)	Chronic/Carcinogenic Average (mg/kg)	Chronic/Carcinogenic R.M.E. (mg/kg)
1,2 dichlorobenzene				2.40E+00
1,2,4 trichlorobenzene				7.40E+00
1,2,4,5 Tetrachlorobenzene				6.60E+00
1,3 dichlorobenzene				1.00E+00
1,4 dichlorobenzene				1.80E+00
2-methylnaphthalene				2.30E-01
Acenaphthene				7.90E-01
Anthracene				8.80E-01
Aroclor 1254				4.70E-01
Arsenic				4.10E+00
Benzo(a)anthracene				1.10E+00
Benzo(a)pyrene				7.40E-01
Benzo(b)fluoranthene				8.10E-01
Benzo(g,h,i)perylene				4.50E-01
Benzo(k)fluoranthene				1.00E+00
is(2 ethylhexyl)phthalate				7.70E-01
Carbazole				5.50E-01
Chlorobenzene				5.70E+00
Chromium VI				3.64E+01
Chrysene				1.30E+00
Copper				1.71E+01
Dibenzofuran				4.50E-01
Endrin				6.70E-03
Ethylbenzene				2.00E-03
Fluoranthene				4.00E+00
Fluorene				9.00E-01
Hexachlorobenzene				4.40E+01
Indeno(1,2,3-c,d)pyrene				4.30E-01
Mercury				2.71E+01
Naphthalene				6.90E-01
Nickel (refinery dust)				7.40E+00
Pentachlorobenzene				3.60E+00
Pentachloronitrobenzene				3.10E+01
Phenanthrene				4.60E+00
Pyrene				3.10E+00

Media Chemical Concentrations: Olin McIntosh Landfill

Medium: Surface Soil Dermal Absorption
Abbreviation: soil2
Medium Type: Soil

Chemical	Subchronic Average (mg/kg)	Subchronic R.M.E. (mg/kg)	Chronic/Carcinogenic Average (mg/kg)	Chronic/Carcinogenic R.M.E. (mg/kg)
1,2 dichlorobenzene				2.40E-02
1,2,4 trichlorobenzene				7.40E-02
1,2,4,5 Tetrachlorobenzene				6.60E-02
1,3 dichlorobenzene				1.00E-02
1,4 dichlorobenzene				1.80E-02
2-methylnaphthalene				2.30E-03
Acenaphthene				7.90E-03
Anthracene				8.80E-03
Aroclor 1254				4.70E-03
Arsenic				4.10E-03
Benzo(a)anthracene				1.10E-02
Benzo(a)pyrene				7.40E-03
Benzo(b)fluoranthene				8.10E-03
Benzo(g,h,i)perylene				4.50E-03
Benzo(k)fluoranthene				1.00E-02
Bis(2 ethylhexyl)phthalate				7.70E-03
Carbazole				5.50E-03
Chlorobenzene				5.70E-02
Chromium VI				3.64E-02
Chrysene				1.30E-02
Copper				1.71E-02
Dibenzofuran				4.50E-03
Endrin				6.70E-05
Ethylbenzene				2.00E-05
Fluoranthene				4.00E-02
Fluorene				9.00E-03
Hexachlorobenzene				4.40E-01
Indeno(1,2,3-c,d)pyrene				4.30E-03
Mercury				2.71E-01
Naphthalene				6.90E-03
Nickel (refinery dust)				7.40E-03
Pentachlorobenzene				3.60E-02
Pentachloronitrobenzene				3.10E-01
Phenanthrene				4.60E-02
Pyrene				3.10E-02

Media Chemical Concentrations: Olin McIntosh Landfill

Medium: Soil VOC Inhalation
Abbreviation: soil3
Medium Type: Particulate / VOCs

Chemical	Subchronic Average (mg/m3)	Subchronic R.M.E. (mg/m3)	Chronic/Carcinogenic Average (mg/m3)	Chronic/Carcinogenic R.M.E. (mg/m3)
1,2 dichlorobenzene				
1,2,4 trichlorobenzene				
1,2,4,5 Tetrachlorobenzene				
1,3 dichlorobenzene				
1,4 dichlorobenzene				
2-methylnaphthalene				
Acenaphthene				
Anthracene				
Aroclor 1254				
Arsenic				
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
bis(2 ethylhexyl)phthalate				
Carbazole				
Chlorobenzene				5.54E-02
Chromium VI				
Chrysene				
Copper				
Dibenzofuran				
Endrin				
Ethylbenzene				1.50E-07
Fluoranthene				
Fluorene				
Hexachlorobenzene				
Indeno(1,2,3-c,d)pyrene				
Mercury				
Naphthalene				
Nickel (refinery dust)				
Pentachlorobenzene				
Pentachloronitrobenzene				
Phenanthrene				
Pyrene				

Media Chemical Concentrations: Olin McIntosh Landfill

Medium: Soil Particulate Inhal.
Abbreviation: soil4
Medium Type: Particulate / VOCs

Chemical	Subchronic Average (mg/m3)	Subchronic R.M.E. (mg/m3)	Chronic/Carcinogenic Average (mg/m3)	Chronic/Carcinogenic R.M.E. (mg/m3)
1,2 dichlorobenzene				5.18E-10
1,2,4 trichlorobenzene				1.60E-09
1,2,4,5 Tetrachlorobenzene				1.40E-09
1,3 dichlorobenzene				2.10E-10
1,4 dichlorobenzene				3.80E-10
2-methylnaphthalene				4.90E-11
Acenaphthene				1.70E-10
Anthracene				1.90E-10
Aroclor 1254				1.00E-10
Arsenic				8.80E-10
Benzo(a)anthracene				2.30E-10
Benzo(a)pyrene				1.60E-10
Benzo(b)fluoranthene				1.74E-10
Benzo(g,h,i)perylene				9.70E-11
Benzo(k)fluoranthene				2.10E-10
Bis(2 ethylhexyl)phthalate				1.60E-10
Carbazole				1.10E-10
Chlorobenzene				1.20E-09
Chromium VI				1.00E-08
Chrysene				2.80E-10
Copper				3.70E-09
Dibenzofuran				9.70E-11
Endrin				1.40E-12
Ethylbenzene				4.30E-13
Fluoranthene				8.60E-10
Fluorene				1.90E-10
Hexachlorobenzene				1.00E-08
Indeno(1,2,3-c,d)pyrene				9.20E-11
Mercury				1.00E-08
Naphthalene				1.50E-10
Nickel (refinery dust)				1.60E-09
Pentachlorobenzene				7.70E-10
Pentachloronitrobenzene				1.00E-08
Phenanthrene				9.90E-10
Pyrene				6.60E-10

Chemical List: Olin McIntosh Hg Cell Plant

Chemical	Inhalation			Non-Inhalation		
	Slope Factor (mg/kg/day)-1	Subchronic RFD mg/kg/day	Chronic RFD mg/kg/day	Slope Factor (mg/kg/day)-1	Subchronic RFD mg/kg/day	Chronic RFD mg/kg/day
Mercury		8.60E-05	8.60E-05		3.00E-04	3.00E-04

Receptor/Pathway Summary: Olin McIntosh Hg Cell Plant

Receptor / Pathway	Average Exposure			Reasonable Maximum Exposure		
	Cancer Risk	Subchronic H.I.	Chronic H.I.	Cancer Risk	Subchronic H.I.	Chronic H.I.
Hypothetical Child Resident						
-- Dermal Contact with Surface Soil D	0.00E+00		0.00E+00	0.00E+00		1.79E-02
-- Ingestion of surface soil	0.00E+00		0.00E+00	0.00E+00		1.84E+00
-- Inhalation of Soil Particulate Inh	0.00E+00		0.00E+00	0.00E+00		2.40E-04
	0.00E+00		0.00E+00	0.00E+00		1.86E+00
Industrial Worker						
-- Dermal Contact with Surface Soil D	0.00E+00		0.00E+00	0.00E+00		5.35E-04
-- Ingestion of surface soil	0.00E+00		0.00E+00	0.00E+00		2.67E-02
-- Inhalation of Soil Particulate Inh	0.00E+00		0.00E+00	0.00E+00		3.02E-06
	0.00E+00		0.00E+00	0.00E+00		2.73E-02

Hypothetical Child Resident
Dermal Contact with Surface Soil Dermal Absorption
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	1.64E-01	3.27E-05	5.36E-06	3.00E-04	1.79E-02	
						1.79E-02

Hypothetical Child Resident
Ingestion of surface soil
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	1.64E+02	3.37E-06	5.53E-04	3.00E-04	1.84E+00	
						1.84E+00

Hypothetical Child Resident
Inhalation of Soil Particulate Inhal.
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	4.00E-08	5.16E-01	2.07E-08	8.60E-05	2.40E-04	
						2.40E-04

Industrial Worker
Dermal Contact with Surface Soil Dermal Absorption
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	1.64E-01	9.78E-07	1.60E-07	3.00E-04	5.35E-04	
						5.35E-04

Industrial Worker
Ingestion of surface soil
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	1.64E+02	4.89E-08	8.02E-06	3.00E-04	2.67E-02	
						2.67E-02

Industrial Worker
Inhalation of Soil Particulate Inhal.
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	4.00E-08	6.50E-03	2.60E-10	8.60E-05	3.02E-06	
						3.02E-06

Intake Factor: Olin McIntosh Hg Cell Plant

Description: Industrial Worker Soil Dermal
Abbreviation: iwsd
Pathway Type: Dermal Contact with Soil

$$\text{Intake Factor} = \frac{(SA \times EF \times ED \times ME \times AF \times AB \times FI \times CF \times SS)}{(BW \times AT)}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
SA	Surface Area(cm2)	0	1000	0	1000
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
AF	Adherence Factor(mg/cm2)	0	1	0	1
AB	Absorption Factor	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
CF	Conversion Factor(kg/mg)	0	.000001	0	.000001
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$3.49E-07 = \frac{(1.00E+03 \times 2.50E+02 \times 2.50E+01 \times 1 \times 1 \times 1 \times 1.00E-01 \times 1.00E-06 \times 1)}{(7.00E+01 \times 2.56E+04)}$$

Non-Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$9.78E-07 = \frac{(1.00E+03 \times 2.50E+02 \times 2.50E+01 \times 1 \times 1 \times 1 \times 1.00E-01 \times 1.00E-06 \times 1)}{(7.00E+01 \times 9.13E+03)}$$

Intake Factor: Olin McIntosh Hg Cell Plant

Description: Industrial Worker Soil Ingestion
Abbreviation: iwsi
Pathway Type: Ingestion of Soil

$$\text{Intake Factor} = \frac{(\ IR3 \times EF \times ED \times ME \times FI \times CF \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR3	Ingestion Rate(mg/day)	0	50	0	50
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
CF	Conversion Factor (kg/mg)	0	.000001	0	.000001
SS	Site-specific Factor	0	1	0	1
BW	Body Weight (kg)	0	70	0	70
AT	Averaging Time (dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.75E{-}08 = \frac{(\ 5.00E{+}01 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1.00E{-}01 \times 1.00E{-}06 \times 1\ )}{(\ 7.00E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$4.89E{-}08 = \frac{(\ 5.00E{+}01 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1.00E{-}01 \times 1.00E{-}06 \times 1\ )}{(\ 7.00E{+}01 \times 9.13E{+}03\ )}$$

Intake Factor: Olin McIntosh Hg Cell Plant

Description: Industrial Worker Soil Particulate Inhal
Abbreviation: iwsp
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\text{IR} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{ME} \times \text{DF} \times \text{CC} \times \text{FI} \times \text{SS})}{(\text{BW} \times \text{AT})}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	8	0	8
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$2.32\text{E-03} = \frac{(8.30\text{E-01} \times 8.00\text{E+00} \times 2.50\text{E+02} \times 2.50\text{E+01} \times 1 \times 1 \times 1 \times 1.00\text{E-01} \times 1)}{(7.00\text{E+01} \times 2.56\text{E+04})}$$

Non-Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$6.50\text{E-03} = \frac{(8.30\text{E-01} \times 8.00\text{E+00} \times 2.50\text{E+02} \times 2.50\text{E+01} \times 1 \times 1 \times 1 \times 1.00\text{E-01} \times 1)}{(7.00\text{E+01} \times 9.13\text{E+03})}$$

Intake Factor: Olin McIntosh Hg Cell Plant

Description: Child Resident Soil Dermal
Abbreviation: crsd
Pathway Type: Dermal Contact with Soil

$$\text{Intake Factor} = \frac{(SA \times EF \times ED \times ME \times AF \times AB \times FI \times CF \times SS)}{(BW \times AT)}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
SA	Surface Area(cm2)	0	1260	0	1260
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
AF	Adherence Factor(mg/cm2)	0	1	0	1
AB	Absorption Factor	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
CF	Conversion Factor(kg/mg)	0	.000001	0	.000001
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$9.33E-06 = \frac{(1.26E+03 \times 3.50E+02 \times 2.00E+01 \times 1 \times 1 \times 1 \times 1 \times 1.00E-06 \times 1)}{(3.70E+01 \times 2.56E+04)}$$

Non-Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$3.27E-05 = \frac{(1.26E+03 \times 3.50E+02 \times 2.00E+01 \times 1 \times 1 \times 1 \times 1 \times 1.00E-06 \times 1)}{(3.70E+01 \times 7.30E+03)}$$

Intake Factor: Olin McIntosh Hg Cell Plant

Description: Child Resident Soil Ingestion
Abbreviation: crsi
Pathway Type: Ingestion of Soil

$$\text{Intake Factor} = \frac{(\text{IR3} \times \text{EF} \times \text{ED} \times \text{ME} \times \text{FI} \times \text{CF} \times \text{SS})}{(\text{BW} \times \text{AT})}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR3	Ingestion Rate(mg/day)	0	130	0	130
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
CF	Conversion Factor (kg/mg)	0	.000001	0	.000001
SS	Site-specific Factor	0	1	0	1
BW	Body Weight (kg)	0	37	0	37
AT	Averaging Time (dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$9.63\text{E-07} = \frac{(1.30\text{E+02} \times 3.50\text{E+02} \times 2.00\text{E+01} \times 1 \times 1 \times 1.00\text{E-06} \times 1)}{(3.70\text{E+01} \times 2.56\text{E+04})}$$

Non-Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$3.37\text{E-06} = \frac{(1.30\text{E+02} \times 3.50\text{E+02} \times 2.00\text{E+01} \times 1 \times 1 \times 1.00\text{E-06} \times 1)}{(3.70\text{E+01} \times 7.30\text{E+03})}$$

Intake Factor: Olin McIntosh Hg Cell Plant

Description: Child Resident Soil Particulate Inhal
Abbreviation: crsp
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	24	0	24
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.48E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$5.16E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 7.30E{+}03\ )}$$

Media Chemical Concentrations: Olin McIntosh Hg Cell Plant

Medium: surface soil
Abbreviation: soil1
Medium Type: Soil

Chemical	Subchronic		Chronic/Carcinogenic	
	Average (mg/kg)	R.M.E. (mg/kg)	Average (mg/kg)	R.M.E. (mg/kg)
Mercury				1.64E+02

Media Chemical Concentrations: Olin McIntosh Hg Cell Plant

Medium: Surface Soil Dermal Absorption
Abbreviation: soil2
Medium Type: Soil

Chemical	Subchronic Average (mg/kg)	Subchronic R.M.E. (mg/kg)	Chronic/Carcinogenic Average (mg/kg)	Chronic/Carcinogenic R.M.E. (mg/kg)
Mercury				1.64E-01

Media Chemical Concentrations: Olin McIntosh Hg Cell Plant

Medium: Soil Particulate Inhal.
Abbreviation: soil4
Medium Type: Particulate / VOCs

Chemical	Subchronic		Chronic/Carcinogenic	
	Average (mg/m3)	R.M.E. (mg/m3)	Average (mg/m3)	R.M.E. (mg/m3)
Mercury				4.00E-08

Chemical List: Olin McIntosh Well Sand Residue Area

Chemical	Inhalation			Non-Inhalation		
	Slope Factor (mg/kg/day)-1	Subchronic RFD mg/kg/day	Chronic RFD mg/kg/day	Slope Factor (mg/kg/day)-1	Subchronic RFD mg/kg/day	Chronic RFD mg/kg/day
Mercury		8.60E-05	8.60E-05		3.00E-04	3.00E-04

Receptor/Pathway Summary: Olin McIntosh Well Sand Residue Area

Receptor / Pathway	Average Exposure			Reasonable Maximum Exposure		
	Cancer Risk	Subchronic H.I.	Chronic H.I.	Cancer Risk	Subchronic H.I.	Chronic H.I.
Hypothetical Child Resident						
-- Dermal Contact with Surface Soil D	0.00E+00		0.00E+00	0.00E+00		2.29E-03
-- Ingestion of surface soil	0.00E+00		0.00E+00	0.00E+00		2.26E-01
-- Inhalation of Soil Particulate Inh	0.00E+00		0.00E+00	0.00E+00		2.59E-05
	0.00E+00		0.00E+00	0.00E+00		2.28E-01
Industrial Worker						
-- Dermal Contact with Surface Soil D	0.00E+00		0.00E+00	0.00E+00		6.85E-05
-- Ingestion of surface soil	0.00E+00		0.00E+00	0.00E+00		3.28E-03
-- Inhalation of Soil Particulate Inh	0.00E+00		0.00E+00	0.00E+00		3.26E-07
	0.00E+00		0.00E+00	0.00E+00		3.35E-03

Hypothetical Child Resident
Dermal Contact with Surface Soil Dermal Absorption
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	2.10E-02	3.27E-05	6.86E-07	3.00E-04	2.29E-03	
						2.29E-03

Hypothetical Child Resident
Ingestion of surface soil
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	2.01E+01	3.37E-06	6.77E-05	3.00E-04	2.26E-01	
						2.26E-01

Hypothetical Child Resident
Inhalation of Soil Particulate Inhal.
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	4.32E-09	5.16E-01	2.23E-09	8.60E-05	2.59E-05	
						2.59E-05

Industrial Worker
Dermal Contact with Surface Soil Dermal Absorption
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Dermal Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	2.10E-02	9.78E-07	2.05E-08	3.00E-04	6.85E-05	
						6.85E-05

Industrial Worker
Ingestion of surface soil
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/kg)	Ingestion Intake Factor (kg/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	2.01E+01	4.89E-08	9.83E-07	3.00E-04	3.28E-03	
						3.28E-03

Industrial Worker
Inhalation of Soil Particulate Inhal.
Reasonable Maximum Exposure

Hazard Index -- Chronic

Chemical	Chemical Concentration (mg/m3)	Inhalation Intake Factor (m3/kg/day)	Daily Intake (mg/kg/day)	Chronic RFD (mg/kg/day)	Hazard Quotient	Hazard Index
Mercury	4.32E-09	6.50E-03	2.81E-11	8.60E-05	3.26E-07	
						3.26E-07

Intake Factor: Olin McIntosh Well Sand Residue Area

Description: Industrial Worker Soil Dermal
Abbreviation: iwsd
Pathway Type: Dermal Contact with Soil

$$\text{Intake Factor} = \frac{(SA \times EF \times ED \times ME \times AF \times AB \times FI \times CF \times SS)}{(BW \times AT)}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
SA	Surface Area(cm2)	0	1000	0	1000
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
AF	Adherence Factor(mg/cm2)	0	1	0	1
AB	Absorption Factor	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
CF	Conversion Factor(kg/mg)	0	.000001	0	.000001
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$3.49E-07 = \frac{(1.00E+03 \times 2.50E+02 \times 2.50E+01 \times 1 \times 1 \times 1 \times 1.00E-01 \times 1.00E-06 \times 1)}{(7.00E+01 \times 2.56E+04)}$$

Non-Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$9.78E-07 = \frac{(1.00E+03 \times 2.50E+02 \times 2.50E+01 \times 1 \times 1 \times 1 \times 1.00E-01 \times 1.00E-06 \times 1)}{(7.00E+01 \times 9.13E+03)}$$

Intake Factor: Olin McIntosh Well Sand Residue Area

Description: Industrial Worker Soil Ingestion
Abbreviation: iwsi
Pathway Type: Ingestion of Soil

$$\text{Intake Factor} = \frac{(\ IR3 \times EF \times ED \times ME \times FI \times CF \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR3	Ingestion Rate(mg/day)	0	50	0	50
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
CF	Conversion Factor (kg/mg)	0	.000001	0	.000001
SS	Site-specific Factor	0	1	0	1
BW	Body Weight (kg)	0	70	0	70
AT	Averaging Time (dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.75E{-}08 = \frac{(\ 5.00E{+}01 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1.00E{-}01 \times 1.00E{-}06 \times 1\ )}{(\ 7.00E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$4.89E{-}08 = \frac{(\ 5.00E{+}01 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1.00E{-}01 \times 1.00E{-}06 \times 1\ )}{(\ 7.00E{+}01 \times 9.13E{+}03\ )}$$

Intake Factor: Olin McIntosh Well Sand Residue Area

Description: Industrial Worker Soil Particulate Inhal
Abbreviation: iwsp
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	8	0	8
EF	Exposure Freq.(dys/yr)	0	250	0	250
ED	Exposure Duration(yrs)	0	25	0	25
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	.1	0	.1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	70	0	70
AT	Averaging Time(dys)	0	25550	0	9125

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$2.32E{-}03 = \frac{(\ 8.30E{-}01 \times 8.00E{+}00 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1 \times 1 \times 1.00E{-}01 \times 1\ )}{(\ 7.00E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$6.50E{-}03 = \frac{(\ 8.30E{-}01 \times 8.00E{+}00 \times 2.50E{+}02 \times 2.50E{+}01 \times 1 \times 1 \times 1 \times 1.00E{-}01 \times 1\ )}{(\ 7.00E{+}01 \times 9.13E{+}03\ )}$$

Intake Factor: Olin McIntosh Well Sand Residue Area

Description: Child Resident Soil Dermal
Abbreviation: crsd
Pathway Type: Dermal Contact with Soil

$$\text{Intake Factor} = \frac{(SA \times EF \times ED \times ME \times AF \times AB \times FI \times CF \times SS)}{(BW \times AT)}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
SA	Surface Area(cm2)	0	1260	0	1260
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
AF	Adherence Factor(mg/cm2)	0	1	0	1
AB	Absorption Factor	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
CF	Conversion Factor(kg/mg)	0	.000001	0	.000001
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$9.33E-06 = \frac{(1.26E+03 \times 3.50E+02 \times 2.00E+01 \times 1 \times 1 \times 1 \times 1 \times 1.00E-06 \times 1)}{(3.70E+01 \times 2.56E+04)}$$

Non-Carcinogenic: Average Exposure

$$0.00E+00 = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$3.27E-05 = \frac{(1.26E+03 \times 3.50E+02 \times 2.00E+01 \times 1 \times 1 \times 1 \times 1 \times 1.00E-06 \times 1)}{(3.70E+01 \times 7.30E+03)}$$

Intake Factor: Olin McIntosh Well Sand Residue Area

Description: Child Resident Soil Ingestion
Abbreviation: crsi
Pathway Type: Ingestion of Soil

$$\text{Intake Factor} = \frac{(\text{IR3} \times \text{EF} \times \text{ED} \times \text{ME} \times \text{FI} \times \text{CF} \times \text{SS})}{(\text{BW} \times \text{AT})}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR3	Ingestion Rate(mg/day)	0	130	0	130
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
CF	Conversion Factor (kg/mg)	0	.000001	0	.000001
SS	Site-specific Factor	0	1	0	1
BW	Body Weight (kg)	0	37	0	37
AT	Averaging Time (dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Carcinogenic: Reasonable Maximum Exposure

$$9.63\text{E-07} = \frac{(1.30\text{E+02} \times 3.50\text{E+02} \times 2.00\text{E+01} \times 1 \times 1 \times 1.00\text{E-06} \times 1)}{(3.70\text{E+01} \times 2.56\text{E+04})}$$

Non-Carcinogenic: Average Exposure

$$0.00\text{E+00} = \frac{(0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0)}{(0 \times 0)}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$3.37\text{E-06} = \frac{(1.30\text{E+02} \times 3.50\text{E+02} \times 2.00\text{E+01} \times 1 \times 1 \times 1.00\text{E-06} \times 1)}{(3.70\text{E+01} \times 7.30\text{E+03})}$$

Intake Factor: Olin McIntosh Well Sand Residue Area

Description: Child Resident Soil Particulate Inhal
Abbreviation: crsp
Pathway Type: Inhalation

$$\text{Intake Factor} = \frac{(\ IR \times ET \times EF \times ED \times ME \times DF \times CC \times FI \times SS\ )}{(\ BW \times AT\ )}$$

Parameters:

Abbreviation	Description	Carcinogenic Ave	Carcinogenic RME	Non-Carcinogenic Ave	Non-Carcinogenic RME
IR	Inhalation Rate(m3/hr)	0	.83	0	.83
ET	Exposure Time(hrs/dy)	0	24	0	24
EF	Exposure Freq.(dys/yr)	0	350	0	350
ED	Exposure Duration(yrs)	0	20	0	20
ME	Matrix Effect	0	1	0	1
DF	Deposition Factor	0	1	0	1
CC	Ciliary Clearance	0	1	0	1
FI	Fraction Contaminated	0	1	0	1
SS	Site-Specific Factor	0	1	0	1
BW	Body Weight(kg)	0	37	0	37
AT	Averaging Time(dys)	0	25550	0	7300

Intake Factor Calculations:

Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Carcinogenic: Reasonable Maximum Exposure

$$1.48E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 2.56E{+}04\ )}$$

Non-Carcinogenic: Average Exposure

$$0.00E{+}00 = \frac{(\ 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0 \times 0\ )}{(\ 0 \times 0\ )}$$

Non-Carcinogenic: Reasonable Maximum Exposure

$$5.16E{-}01 = \frac{(\ 8.30E{-}01 \times 2.40E{+}01 \times 3.50E{+}02 \times 2.00E{+}01 \times 1 \times 1 \times 1 \times 1 \times 1\ )}{(\ 3.70E{+}01 \times 7.30E{+}03\ )}$$

Media Chemical Concentrations: Olin McIntosh Well Sand Residue Area

Medium: surface soil
Abbreviation: soil1
Medium Type: Soil

Chemical	Subchronic Average (mg/kg)	Subchronic R.M.E. (mg/kg)	Chronic/Carcinogenic Average (mg/kg)	Chronic/Carcinogenic R.M.E. (mg/kg)
Mercury				2.01E+01

Media Chemical Concentrations: Olin McIntosh Well Sand Residue Area

Medium: Surface Soil Dermal Absorption
Abbreviation: soil2
Medium Type: Soil

Chemical	Subchronic		Chronic/Carcinogenic	
	Average (mg/kg)	R.M.E. (mg/kg)	Average (mg/kg)	R.M.E. (mg/kg)
Mercury				2.10E-02

Media Chemical Concentrations: Olin McIntosh Well Sand Residue Area

Medium: Soil Particulate Inhal.
Abbreviation: soil4
Medium Type: Particulate / VOCs

Chemical	Subchronic Average (mg/m3)	Subchronic R.M.E. (mg/m3)	Chronic/Carcinogenic Average (mg/m3)	Chronic/Carcinogenic R.M.E. (mg/m3)
Mercury				4.32E-09

Appendix 1

Woodward-Clyde Consultants

4 9 0746

ELUTRIATE MERCURY SEDIMENT RESULTS
ALL UNITS ARE MG/L

SAMPLE ID	PARAMETER	CONCENTRATION	DETECTION LIMIT	SAMPLE DATE	DEPTH (FT)	SAMPLE TYPE	LOCATION
SCC102	ELUTRIATE MERC	ND	.0002	8/23/91	1.0 - 2.0	CORE	BASIN
SCC104	ELUTRIATE MERC	.1530	.0002	8/23/91	3.0 - 4.0	CORE	BASIN
SCC202	ELUTRIATE MERC	ND	.0002	8/23/91	1.0 - 2.0	CORE	BASIN
SCC204	ELUTRIATE MERC	.1530	.0002	8/23/91	3.0 - 4.0	CORE	BASIN
SCC302	ELUTRIATE MERC	.1140	.0002	8/27/91	1.0 - 2.0	CORE	FMR DISCH DITCH
SCC304	ELUTRIATE MERC	.2370	.0002	8/27/91	3.0 - 4.0	CORE	FMR DISCH DITCH
SGC05	ELUTRIATE MERC	ND	.0002	8/13/91	0.0 - .5	GRAB	BASIN
SGC06	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGC06DUP	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGC10	ELUTRIATE MERC	ND	.0002	8/08/91	0.0 - .5	GRAB	BASIN
SGD06	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGD10	ELUTRIATE MERC	ND	.0002	8/08/91	0.0 - .5	GRAB	BASIN
SGDD01	ELUTRIATE MERC	ND	.0002	8/28/91	0.0 - .5	GRAB	DISCHARGE DITCH
SGF07	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGG03	ELUTRIATE MERC	ND	.0002	8/13/91	0.0 - .5	GRAB	BASIN
SGG08	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGG09	ELUTRIATE MERC	ND	.0002	8/09/91	0.0 - .5	GRAB	BASIN
SGH04	ELUTRIATE MERC	ND	.0002	8/13/91	0.0 - .5	GRAB	BASIN
SGH08	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGI10	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGJ06	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGJ07	ELUTRIATE MERC	ND	.0002	8/11/91	0.0 - .5	GRAB	BASIN
SGK04	ELUTRIATE MERC	ND	.0002	8/13/91	0.0 - .5	GRAB	BASIN
SGOD06	ELUTRIATE MERC	ND	.0002	8/28/91	0.0 - .5	GRAB	WASTEWATER DTCH
SGOD17	ELUTRIATE MERC	.0120	.0002	8/28/91	0.0 - .5	GRAB	WASTEWATER DTCH
SGOD17DUP	ELUTRIATE MERC	.0160	.0002	8/28/91	0.0 - .5	GRAB	WASTEWATER DTCH
SGOD20	ELUTRIATE MERC	.0120	.0002	8/29/91	0.0 - .5	GRAB	WASTEWATER DTCH
RS02	ELUTRIATE MERC	ND	.0002	8/26/91	0.0 - .5	GRAB	RESIDENTIAL SAM

ND = Not detected

METHODS:

ELUTRIATE TEST: Plumb, R.H.,Jr. 1981. Procedure for handling and chemical analysis of sediment and water samples. Technical Report EPA/CE-81-1, prepared by Great Lakes Laboratory, State University College at Buffalo, N.Y., for the U.S.EPA/Corps of Engineers technical commitee on criteria for dredged and fill material. Published by the U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Mississippi. Pages 2-28 to 2-32.

MERCURY ANALYSIS: U.S. Environmental Protection Agency. 1991. Contract Laboratory Program Statement of work for inorganic analysis multi-media multi-concentration. Document number ILM02.0. Office of Emergency and Remedial Response. METHOD 245-1 CLP-M

APPENDIX I

SUMMARY OF ELUTRIATE MERCURY RESULTS

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Olin CHEMICALS
P.O. BOX 248, 1186 LOWER RIVER ROAD, CHARLESTON, TN 37310
Phone: (615) 336-4000

December 21, 1993

VIA FEDERAL EXPRESS

RECEIVED
DEC 22 1993
EPA - REGION IV
ATLANTA, GA.

:neth A. Lucas
.or Remedial Project Manager
:ted States Environmental Protection Agency
Courtland Street Northeast
:nta, Georgia 30365

Re: Revised Section 6 of RI Report
Olin Chemicals/McIntosh Plant Site
McIntosh, Alabama

:r Mr. Lucas:

:etter of December 14, 1993, Olin responded to part of your letter of December 993, which conveyed EPA's comments on the Final Remedial Investigation (RI) :rt submitted by Olin on July 30, 1993. This letter, with its attachment and :osures, completes Olin's response. Attachment 1 provides a response to each :PA's comments in Appendix A of the December 6 letter. These responses :ribe how Section 6 of the RI report was revised in accordance with EPA's :ments.

.r letter directed Olin to submit only a revised Section 6, Baseline Risk :ssment, and appropriate appendices. You and I agreed in telephone :ersations on December 10 and 20 that changes in Section 6 needed to be :porated into the Executive Summary and Section 7 of the RI report. :ordingly, the enclosures to this letter include five unbound copies of the :owing: a revised Table of Contents and Executive Summary; Section 6 as revised :ccordance with EPA's comments; Section 7 as revised; and Appendix N of :me II of the RI report as revised. The enclosures consist of all pages between :ort tabs to facilitate updating the RI report. Remove all pages behind the :owing report tabs: Table of Contents, Section 6, Section 7, and Appendix N. :rt the enclosed replacement pages for each of these tab sections.

: reiterates its strong belief that the future on-site residential scenario will never :r. Olin agreed to include this scenario to provide information to risk managers :t the range of risks that could occur if the site were ever allowed to become