FINAL

RECORD OF DECISION

MACALLOY CORPORATION SITE
CHARLESTON, SOUTH CAROLINA

Prepared by:

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Acronym List

ARARs	applicable or relevant and appropriate requirements
CAA	Clean Air Act
CDI	chronic daily intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
COC	chemical of concern
CWA	Clean Water Act
DoD	Department of Defense
DPT	direct-push technology
DTT	Dust Treatment Tank
EPA	Environmental Protection Agency
EPC	exposure point concentration
ERM	Effect Range Median
ESD	Explanation of Significant Differences
ESPs	electrostatic precipitators
FS	Feasibility Study
HEAST	Health Effects Assessment Summary Table
HI	hazard index
HQ	hazard quotient
HRC	Hydrogen Release Compound
IRIS	Integrated Risk Information System
mg/L	micro grams per liter
mR/hr	micro Roentgens per hour
MCL	maximum contaminant level
mg/kg	milligram per kilogram
ml/L	milliliters per liter
msl	mean sea level
NCEA	National Center for Environmental Assessment
NCP	National Contingency Plan
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPL	National Priorities List
OCRM	Office of Coastal Resource Management
O&M	operation and maintenance

PPE	personal protective equipment
PRB	permeable reactive barrier
PRPs	potentially responsible parties
RAOs	remedial action objectives
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RFI	RCRA Facility Investigation
RI/FS	Remedial Investigation/Feasibility Study
RME	reasonable maximum exposure
ROD	Record of Decision
SCDHEC	South Carolina Department of Health and Environmental Control
SCDNR	South Carolina Department of Natural Resources
SF	slope factor
s/s	stabilization/solidification
SWMSCP	Storm Water Management Sediment Control Plan
TCLP	toxicity characteristic leaching procedure
TMDL	Total Maximum Daily Load
USEPA	United States Environmental Protection Agency
USI	Unlined Surface Impoundment

I. DECLARATION

RECORD OF DECISION DECLARATION

SITE NAME AND LOCATION

Macalloy Corporation NPL Site
Charleston, South Carolina
CERCLIS I.D. Number SCD003360476

STATEMENT AND BASIS OF PURPOSE

This decision document presents the Final selected remedy for the Macalloy Corporation NPL Site in Charleston, South Carolina. EPA's selected response action was chosen in accordance with the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and to the extent practicable, the National Contingency Plan (NCP). This decision is based on the Administrative Record for the Site.

The State of South Carolina concurs with EPA's Final selected response action.

ASSESSMENT OF THE SITE

The response action selected in this Record of Decision is necessary to protect the public health or welfare or the environment from actual or threatened releases of hazardous substances into the environment.

DESCRIPTION OF THE SELECTED REMEDY

The remedy selected in this decision document is the Final response action for the Macalloy Corporation NPL Site. A removal action was initiated in June 1998 to implement a surface water management system to mitigate transport of contaminants to Shipyard Creek, while a final site wide remedy was being developed. This Record of Decision selects a site wide, multi-media response action to address surface/subsurface soil, radiological debris, shallow groundwater, on-site storm water, and sediments in the 001 tidal creek. The major components of EPA's selected remedy include:

- Ex-situ treatment by mechanical mixing of approximately 115,000 cubic yards of soil contaminated by hexavalent chromium to prevent leaching to underlying groundwater and to permit future industrial land-use;
- In-situ treatment by chemical reduction of shallow groundwater contaminated by hexavalent chromium;
- Excavation and on-site disposal of approximately 1,000 cubic yards of sediment contaminated by chromium, nickel and zinc from the 001 tidal creek which formerly received process water discharge from the facility;

- Excavation and off-site disposal of an estimated 110 cubic yards of soil and debris with elevated levels of gamma radiation; and
- Implementation of a comprehensive storm water management plan to reduce concentrations of hexavalent chromium, arsenic, copper, lead, and zinc discharging to Shipyard Creek.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are applicable or relevant and appropriate to the remedial action, is cost-effective, and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. This remedy also satisfies the statutory preference for treatment as a principal element to significantly reduce the toxicity, mobility, or volume of hazardous substances, pollutants, or contaminants by the ex-situ solidification/stabilization of soils, and by the in-situ chemical reduction of shallow groundwater. Because this remedy will result in hazardous substances, pollutants, or contaminants remaining on-site above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section, which is Part II of this Record of Decision. Additional information can be found in the Administrative Record file for this site.

KEY REMEDY SELECTION INFORMATION	SECTION AND/OR PAGE REFERENCE
Chemicals of Concern and their respective concentrations.	Section 7.0; Tables 7-1/7-2 (page 7-12); Table 7-11 (page 7-20).
Baseline risk represented by the chemicals of concern.	Section 7.1.4 (page 7-8); Tables 7-5 through 7-9 (pages 7-14 through 7-18); Section 7.2; Table 7-13 (page 7-22).
Cleanup levels established for chemicals of concern and the basis for these levels.	Section 8.0 (pages 8-2/8-3); Section 12.4/Table 12-7 (pages 12-33/12-34); Appendix A.
How source materials constituting principal threats are addressed.	Section 11.0 (page 11-1); Section 12.2.1; Section 12.2.3.
Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of groundwater used in the Baseline Risk Assessment and ROD.	Section 6.0 (page 6-1); Section 7.0.

KEY REMEDY SELECTION INFORMATION	SECTION AND/OR PAGE REFERENCE
Potential land and groundwater use that will be available at the site as a result of the selected remedy.	Section 6.0 (page 6-1); Section 12.4.
Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected.	Section 12.3; Tables 12-2 through 12-6 (pages 12-25 through 12-30).
Key factor(s) that led to selecting the remedy (i.e. describe how the selected remedy provides the best balance and tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision).	Section 12.1; Section 10.0.

AUTHORIZING SIGNATURE

Richard D. Green, Director
Waste Management Division
U.S. EPA - Region 4

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Date

II. DECISION SUMMARY

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II. DECISION SUMMARY

1.0 SITE NAME, LOCATION, AND BRIEF DESCRIPTION

The Macalloy Corporation Site (Superfund database identification number: SCD003360476) is located at 1800 Pittsburgh Avenue in Charleston, South Carolina (Figures 1-1 and 1-2). This former ferrochromium alloy manufacturing plant is located on approximately 147 acres fronting Shipyard Creek in an industrial and commercial section of the Charleston Peninsula, which is formed by the confluence of the Ashley and Cooper Rivers. The facility is located directly adjacent to a tidal marsh along Shipyard Creek.

Much of the site is open and not vegetated. Topography of the site is essentially flat with most elevations averaging 10 to 15 feet mean sea level (msl). Onsite storm water runoff flows through settling basins and diversions to two National Pollutant Discharge Elimination System (NPDES) outfalls, with limited areas flowing directly to Shipyard Creek. Shallow groundwater generally flows toward Shipyard Creek.

The plant produced ferrochromium alloy by smelting chromium ore in submerged electric arc furnaces. It was owned and operated by Pittsburgh Metallurgical Company from 1941 to 1966, Airco (British Oxygen Corporation) from 1966 to 1979, and Macalloy from 1979 to July 1998, when alloy production ceased. Macalloy currently retains ownership of the site. At various times from 1942 to the present, the Department of Defense (DoD) has owned, operated, or otherwise used portions of the site to produce and store ferrochromium alloy, chrome ore, and slag (waste). Site activities have impacted site soil, groundwater, and surface water, and sediment in the 001 tidal creek.

The United States Environmental Protection Agency (EPA), the lead agency for site activities, in consultation with the South Carolina Department of Health and Environmental Control (SCDHEC), the support agency, is issuing this Record of Decision (ROD) in accordance with the

National Contingency Plan (NCP) 300.430(f)(4)(i) to document the final selected remedy for the Macalloy Site.

Macalloy has conducted and funded two major response actions under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Administrative Orders on Consent with EPA Region 4 that provided the characterization data and feasibility analysis to support this ROD. In June 1998, Macalloy initiated a removal action under a consent order (No. 98-18-C) with EPA to implement a surface water management plan to mitigate transport of contaminants to Shipyard Creek while a final site-wide remedy was developed. In March 2000, Macalloy entered into a consent order (No. 00-19-C) with EPA to perform a CERCLA Remedial Investigation/Feasibility Study (RI/FS). Enforcement activities prior to CERCLA involvement are discussed further in Section 2.0.

An EPA Macalloy special account in the amount of $9,642,000 has been established by DoD via an appropriation "*to pay for response actions by, or on behalf of, the EPA under CERCLA.*" Funds transferred under the special account to EPA are to be "*used to pay for response actions at the Macalloy site*" and "*shall be credited against any liability of the United States with respect to the site under CERCLA.*" Approximately $200,000 from this special account have been transferred to EPA's National Risk Management Research Laboratory in Ada, Oklahoma, for bench scale and pilot field studies associated with in-situ reduction of chromium (VI) in the shallow groundwater. EPA plans to negotiate with Macalloy, British Oxygen Corporation (predecessor to Macalloy) and other potentially responsible parties where identified to secure the resources needed to fully implement the remedy selected in this ROD.

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2.0 SITE HISTORY AND ENFORCEMENT ACTIVITIES

Ferrochromium alloy was manufactured at the site from 1941 to 1998. The process most recently involved the conversion of chromium-bearing ore (chromite) to ferrochromium in a single submerged arc electric furnace. The alloy was then used to produce high quality stainless-steel. A second furnace on the property had been out of use for several years by the time manufacturing ceased in 1998. Over the years of operation, smelting has included both submerged and open arc furnaces. Open arc (low carbon) furnaces were operated between approximately 1946 and 1967. Submerged arc furnaces were used in subsequent years. Open arc (low carbon) furnaces generally produce more chromium (VI) byproduct than submerged arc furnaces.

The furnace yielded approximately 180 tons of finished ferrochromium per day. The raw material quantities required to achieve this yield consisted of approximately 450 tons of chromite ore, 126 tons of coke, 45 tons of silica, and 36 tons of alumina per day. Waste materials generated during furnace operations included wastewater, airborne waste gases, and particulate matter. Water was used for cooling inside the furnace and as the contact cooling medium for airborne discharges from the furnace. Air emissions control equipment at the Macalloy Site included three baghouses, two gas conditioning towers, and two electrostatic precipitators (ESPs). These systems generated various solid wastes, including dust collected in the ESPs and baghouses and sludge from the gas conditioning towers, including bottom sludge from an onsite NPDES-permitted settling pond (Outfall 001). From 1988 until 1997, an Unlined Surface Impoundment (USI) for treated ESP dust was operated by Macalloy just north of the ferrochromium process area.

During its final years of operation, the plant was regulated by several federal environmental statutes, primarily the Clean Water Act (CWA), the Clean Air Act (CAA), and the Resource Conservation and Recovery Act (RCRA). In 1992, the SCDHEC Bureau of Water Pollution Control issued Administrative Order 92-64-W requiring the Macalloy Corporation to remediate contaminated groundwater on the Macalloy property. Pursuant to this order, a groundwater remediation system was installed in 1994-1995 around the area of the USI. In 1996, Macalloy began the RCRA corrective action process. In January 1997, pursuant to the terms of a consent order with the SCDHEC (No. 96-38-HW), Macalloy initiated offsite disposal of treated ESP dust from the USI. Macalloy also initiated a removal action in June 1998 under a consent order with EPA (No. 98-18-C) to implement a surface water management system to mitigate transport of contaminants to Shipyard Creek while a final site remedy was being developed.

An initial draft RCRA Facility Investigation/Confirmation Sampling Investigation (RFI) Work Plan (October 14, 1998), was submitted to the EPA and the SCDHEC for review and comment. The draft RFI work plan was revised based on technical comments received from both agencies and then resubmitted on November 30, 1999.

After production at the plant ceased in July 1998, Macalloy, EPA, and SCDHEC decided that CERCLA would be a more appropriate mechanism for this site. Subsequently, the site was proposed for inclusion on the National Priorities List (NPL) on October 22, 1999, and was listed as "final" the following February. On March 29, 2000, Macalloy entered into an agreement with the EPA to perform a CERCLA RI/FS.

The revised November 30, 1999, RFI work plan formed the basis of the CERCLA RI/FS work plan, which was converted to fulfill the requirements of the March 29, 2000, agreement with EPA; the RI/FS work plan was approved as final by EPA on June 1, 2000.

In December 2000, the first phase of the RI was completed by Macalloy with oversight by EPA and SCDHEC. The primary focus of Phase I was to assess the nature and extent of soil and groundwater contamination on the Macalloy property and to evaluate the risk to human health and the environment from site media. The *Final Phase I RI Report* was approved by EPA on

May 17, 2001. Several data gaps were identified in the Phase I RI that needed to be filled before an FS could begin. Therefore, a second phase of the RI was conducted in June 2001, primarily to assess risk to human and ecological receptors from potential contamination in Shipyard Creek. The *Final Phase II RI Report* was approved by EPA on March 21, 2002.

Based on the findings presented in the Final Phase I and Phase II RI Reports, an FS was prepared by Macalloy to develop, evaluate, and compare remedial action alternatives that could be used to mitigate hazards and threats to human health and the environment from contaminated soil, groundwater, sediment, and storm water onsite. The *Final Feasibility Study Report* was approved by EPA on April 2, 2002.

Summary of Previous Investigations

Several investigations have been performed by the EPA, SCDHEC, and Macalloy to evaluate environmental conditions at the Macalloy Site. Investigations conducted prior to the CERCLA RI/FS are detailed in the reports listed below in chronological order.

1992

- *Supplemental Groundwater Evaluation and Preliminary Design Report for the Macalloy Plan Site* (Metcalf & Eddy). Characterization of geology and hydrogeology associated with the USI and design of a groundwater recovery system.

1993

- *Supplemental Groundwater Evaluation and Preliminary Design Report Addendum* (Metcalf & Eddy). Addendum to the 1992 report characterizing the USI geology and hydrology and the design of the groundwater recovery system.

- *Macalloy Ground Water Extraction System Redesign* (Metcalf & Eddy). Final geology and hydrology characterization and final design of the groundwater recovery system.

1994

- *EPA Region IV RCRA Case Development Investigation Evaluation* (EPA). Investigation of chromium-bearing waste being produced and managed at the facility. Soils, sediments, surface waters, and waste materials associated with the secondary settling pond and the USI were sampled.

1995

- *RCRA Facility Assessment* (A.T. Kearny, Inc.) This study gathered information about the site regarding industrial processes, waste management practices, regulatory and release histories, and environmental and demographic setting, and evaluated releases of hazardous waste or hazardous constituents to the environment.

1996

- *Dust Treatment Tank (DTT) Closure.* Macalloy operated an in-ground ESP DTT from 1989 to 1994. A RCRA Part A Permit Application was submitted for this unit, which was operated under interim status until closure. ESP dust was treated with ferrous sulfate and water. The resulting slurry was then pumped into the USI as a nonhazardous waste. Partial RCRA closure work for the former DTT was performed in 1996 following approval of the Interim Status Closure Plan of closure in-place. The closure plan included sampling of the surrounding surficial soils, subsurface soils, and shallow groundwater. Final closure for the unit by the SCDHEC is pending implementation of EPA's selected remedy presented in this ROD.

1997

- *Annual Effectiveness Report for Remedial System, Macalloy Corporation Facility* (Integrated Science and Technology). Groundwater sampling and groundwater recovery well system data report.

1998

- *1997 Groundwater Effectiveness Report* (EnSafe). Groundwater sampling and groundwater recovery well system data report.

- *Evaluation of the Hydrogeologic Setting and Ground-Water Remedial System at the Macalloy Corporation Site* (EPA Office of Technical Services). Comprehensive evaluation of the hydrogeologic setting and the groundwater remedial system based on a review of previous site investigations, preliminary groundwater flow and tracking modeling, and the development of a geochemical conceptual model.

1999

- *Storm Water Management Final Report* (EnSafe). Documents activities implemented in 1998 by Macalloy to address potential releases via surface water and presents sampling results to assess contaminant mitigation during storm events. As part of this action, discharge of storm water from the 001 outfall was eliminated. Site soils excavated as part of the storm water control project were characterized in accordance with R.61-79.262 of the South Carolina Hazardous Waste Management Regulations. Storm water management system monitoring was required under the 1998 EPA consent order to evaluate sediment basin effectiveness in reducing concentrations of contaminants in storm water leaving the site.

- *CERCLA Site Inspection Report, Macalloy Site* (EPA). Sediment and surface water samples were collected at selected sites in the wetlands of Shipyard Creek and analyzed for inorganics, volatile organic compounds, semivolatile organic compounds, polychlorinated biphenyls, and polychlorinated dioxins and furans.

- *Preliminary Ecological Risk Evaluation* (EnRisk Management Solutions, LLC). Based on previous EPA findings, EnRisk developed a field study plan that targeted expected site-specific constituents (i.e., metals) to assess the need for a time-critical sediment removal action in Shipyard Creek. The evaluation employed a triad (analytical sediment data, benthic community data, and toxicity data) and weight of evidence approach. The results indicated that a time-critical removal action was not warranted.

2000

- *Unlined Surface Impoundment Closure Report* (EnSafe). Closure of the USI was conducted from June 1999 until January 2000. To the extent possible, dust was removed down to the surrounding grade and sampled for chromium by toxicity characteristic leaching procedure (TCLP). Dust piles with TCLP chromium concentrations exceeding regulatory limits were treated onsite by stabilization. The treated ESP dust was then disposed of in a RCRA Subtitle D lined landfill.

  The material remaining inside the USI footprint (residual dust and berm material) was regraded into four quadrants inside the footprint and sampled. Eight samples were collected from each quadrant and analyzed for RCRA metals and TCLP metals. A statistical analysis of the sampling results [conducted in accordance with *Test Methods for Evaluating Solid Waste, Volume II: Field Physical/Chemical Methods* (EPA, 1986)] indicated that additional samples were needed in the northeast and northwest quadrants to characterize chromium in the berm material. After collecting 29 additional samples in the northeast quadrant and 43 additional samples in the northwest quadrant, the chromium results were re-evaluated. Statistical analysis indicated that the berm material is not a characteristic hazardous waste.

3.0 COMMUNITY PARTICIPATION

On June 8, 2000, EPA held a public information meeting at the Commissioner of Public Works Building, 103 St. Philip Street in Charleston, South Carolina, to explain the Superfund process, provide an overview of the site history, explain the RI/FS sampling strategy, outline the future schedule for site cleanup, and solicit input from the community on this process. After the RI/FS was completed, the Superfund Proposed Plan for the site was made available to the public in early April 2002. Copies of site documents supporting the Proposed Plan, including the Phase I and Phase II RI Work Plans, the Phase I and Phase II RI Reports, and the FS Report were established in the Administrative Record file and information repository maintained at the EPA Region 4 Records Center[1] and the Charleston County Main Library[2]. The notice of Proposed Plan availability was published in the Charleston Post and Courier on April 11, 2002.

The initial 30-day public comment period on the Proposed Plan was held from April 11 to May 11, 2002. On April 18, 2002, EPA held a Proposed Plan public meeting at the Commissioner of Public Works Building, 103 St. Philip Street in Charleston, South Carolina, to discuss the findings of the RI/FS, and the rationale behind EPA's preferred cleanup alternative for the site. At this meeting, representatives from the EPA and SCDHEC answered questions the public had regarding the information available and future activities planned for the Macalloy property. EPA has also solicited input from potential future industrial and commercial users of the site regarding the anticipated redevelopment.

On May 8, 2002, EPA received a request to extend the public comment period by an additional 30 days. As a result, EPA extended the public comment to June 10, 2002. Notice of this public comment period extension was published in *The Charleston Post and Courier* on May 12, 2002. The EPA's response to comments received during the public comment period, and

[1] 61 Forsyth Street, NW, Atlanta, GA 30303.

[2] 68 Calhoun Street, Charleston, SC 29401.

the verbatim transcript of the April 18, 2002, Proposed Plan public meeting are included in the Responsiveness Summary, which is Part III of this ROD.

4.0 SCOPE AND ROLE OF THE RESPONSE ACTION

The response action specified in this ROD is the final action in EPA's overall strategy for remediating the Macalloy Site. It was chosen in accordance with CERCLA (amended by the Superfund Amendments and Reauthorization Act) and the NCP. The decision for this site is based on documents in the Administrative Record and comments received during the public comment period. This site-wide multimedia response action will address surface and subsurface soil, radiological debris, shallow groundwater, sediment in the 001 tidal creek, and onsite storm water.

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5.0 SITE CHARACTERISTICS

This section provides a brief summary of site features, sources, nature and extent of contamination, and contaminant fate and transport. Additional detail is provided in the Final Phase I and Phase II RI Reports. Specific human health and ecological risks posed by site constituents are summarized in Sections 7.1 and 7.2, respectively. Cleanup levels for all media addressed by this response action are specified in Sections 8 and 12.4. The reader is referred to the site Administrative Record for a more detailed account of this subject matter.

5.1 Site Overview

5.1.1 Surface Features

The topography of this 147-acre site is flat with little variation. The ground surface is covered primarily with material from plant operations and is essentially devoid of vegetation except in the far north portion and the extreme southeast corner of the site. Most of the buildings at the former plant have been demolished, although some building foundations remain. Portions of the site have been built up to current grade using slag, sludge, treated and untreated dust from air pollution control equipment, and raw materials. The site contains large piles of berm material from two former surface impoundments.

Surface water drainage from the facility either infiltrates into the underlying soils or flows overland to the east, west, north, and south, discharging into Shipyard Creek through Outfalls 002 and 004. A series of detention basins constructed as part of the consent order with EPA remove suspended solids from storm water runoff prior to discharge through the outfalls. The Macalloy plant is located directly adjacent to and west of a tidal marsh. Wetland areas are adjacent to Shipyard Creek. Discharge of onsite storm water from the 001 Outfall to the adjacent 001 tidal creek was eliminated as part of the consent order with EPA.

5.1.2 Soil

Site geology has been broken into six major lithologic units, presented below in ascending order (oldest to youngest). Figures 5-1 and 5-2 present geologic cross-sections for the site and illustrate the distribution of the lithology encountered during the RI. Figure 5-3 shows illustrates the thickness of fill material across the site.

Ta The Tertiary-age Ashley Formation is an olive to mustard brown calcareous clayey silt. It is regionally pervasive and is a major geologic unit in the area. The Ashley Formation occurs at elevations ranging from approximately 26 to 41 feet below msl in the center and southeast corner of the site, respectively.

Qsl A combination of Tertiary-age olive brown very fine silty and clayey phosphatic sand, and Quaternary age very fine green-grey sands. The Tertiary-age sediments are more abundant at this site than those of Quaternary age. The Qsl sand unit generally thins from north to south while maintaining a reasonably uniform development from east to west. It is most developed in the northwest portion of the site and thinnest in the southeast corner of the site.

Qc A green-gray inorganic clay. Qcs is a sand member in the Qc clay unit. Qc typically overlies Qsl and is found across the site, except in the extreme northwest portion. Qc thickens and thins across the site. There are minor occurrences of Qc associated with shallower units, but this interval is the predominant development of inorganic clay beneath the site. Qcs was encountered within the Qc in the center of the site and may only be a narrow channel or patch. Qc forms the basal member of the Intermediate Confining Clay (ICC) unit.

Qm This dark gray to black organic-rich clayey silt occasionally contains disseminated shells and bits of decaying vegetation such as marsh grasses. This material is locally known as marsh clay. Qm thickness varies and is thickest in the south central portion of the site. Qms is a sandy, shelly member in the upper portions of the unit. Portions of this unit include a firmer, somewhat dewatered marsh clay of lesser organic content. Qm forms the upper member of the ICC, which separates the two major sand (Qsu and Qsl) units beneath the site.

Qsu Qsu, the upper sand unit, and is a brown and orange-brown very fine sand often with few fines. Qsc is a silty clayey member of this unit. Qsu is pervasive across the site. Minor clayey sands (Qsc), inorganic clay (Qc), and organic clayey silt (Qm) lenses of limited areal extent are associated with it.

Fill The plant and storage areas of the site are covered with a dark gray to black pebbly slag and clayey silt material related to site activities. Fill in these areas is exposed at the surface. Northern areas of the site have a thin pebbly rubble, containing glass and plastic, which is covered by several feet of soil. A few areas along the Shipyard Creek waterfront are filled with slag and boulder covered by soil. Macalloy topography is essentially flat and most surface elevations average 10 to 15 feet msl. Since the facility's construction, most of the site topography has been modified by placement of fill material; thickness varies over most of the plant area. Fill material from the plant is exposed over the active portion of the site. The far northern areas just south of the northern property line contain fill consisting of pebbly materials with pieces of glass and plastic covered by clean soil, indicating some sort of fill operation. This area is covered by a dense growth of small trees.

5.1.3 Groundwater

Geologic and groundwater information has been correlated into four groundwater units for the site.

- Shallow upper groundwater aquifer consisting primarily of native sand sediments (Qsu) and operating under unconfined conditions. However, some fill materials are also saturated and are included in the shallow aquifer. Despite hydraulic conductivities that are an order of magnitude greater than the deep aquifer (see below), the shallow aquifer is also characterized as a low-yield unit with a mean horizontal hydraulic conductivity of 6.36 ft/day, based on slug tests, or 3.77 ft/day based on specific capacity tests.

- ICC consisting of an organic-rich clayey silt (Qm) overlying an inorganic clay (Qc). The intermediate confining unit, with a mean horizontal hydraulic conductivity of 0.194 ft/day, is pervasive site-wide. However, it does allow some vertical recharge from the shallow to deep aquifer and therefore acts as a leaking aquitard.

- Deep lower aquifer consisting of fine-grained silty phosphatic sands (Qsl) operating under confined conditions. The deep aquifer is generally a very low-yield unit with a mean horizontal hydraulic conductivity of 0.436 ft/day, which is slightly more than twice that of the intermediate confining unit.

- A basal confining unit (BCU) consisting of the Ashley Formation (Ta) prevents vertical groundwater flow from the surficial aquifer to deeper aquifers.

The groundwater system consists of a surficial aquifer that overlies a regional confining unit, which limits vertical groundwater migration. The surficial aquifer comprises a shallow and deep permeable unit separated by a confining clay aquitard. Groundwater in the shallow aquifer is encountered at depths of approximately 3 to 8 feet bgs. Shallow surficial aquifer groundwater flows east towards Shipyard Creek at an average velocity ranging from 0.059 to 0.244 ft/day, and is essentially unaffected by tides. Groundwater discharges to surface water in the 002 Settling Canal and Basin 002A. The shallow aquifer is recharged directly from onsite precipitation and subsurface flow from upgradient source areas. Shallow aquifer matrix saturated thickness contours and shallow groundwater elevation contours are shown in Figures 5-4 and 5-5.

5.1.4 Ecology

The Macalloy facility is located in a highly industrialized and commercial area of North Charleston which has a significant influence on the terrestrial habitat. The adjacent Shipyard Creek contains salt marsh and tidal creek habitats. Deeper waters in Shipyard Creek are maintained by periodically dredging the channel. The saltwater marsh has intertidal marsh, intertidal creek, shallow tidal creek, and subtidal creek components (EnRisk, 1999). Shipyard Creek's marsh ecosystem produces a large proportion of the detritus for the estuarine ecology. Detritus provides shelter and energy, which are important to nursery areas for many species of fish and shellfish, as well as for benthic, aquatic, avian, and terrestrial species.

5.2 RI Sampling Strategy

A conceptual site model for Macalloy, which identifies potential sources, release mechanisms, pathways, and receptors is presented in Figure 5-6.

5.2.1 Phase I

The first phase of the RI was conducted from June 18 to October 12, 2000. Field work followed guidelines in the RI/FS Work Plan (May 10, 2000) and the Quality Assurance Project Plan (QAPP) (May 15, 2000). Where warranted by field conditions, approved procedures were modified and appropriately documented. The primary goal of the soil investigation was to fill data gaps and collect information for the risk assessment, remedial design, and future site reuse.

Soil samples were collected specifically to assess the condition of surficial and subsurface soils across the site and at focused locations. Analytical, geotechnical, and geochemical samples were collected from grid-based soil sample locations across the site (Figure 5-7). Furthermore, to supplement the site-wide soil investigation and address potential source areas identified during the RCRA Facility Assessment, a focused investigation was conducted at the following sites:

- Lake Fill and USI
- ESP Dust Storage/Treatment Area
- Concentrator Area
- Casting Bay and Furnace Building
- Petroleum Sites
- Solid Waste Landfill and Northern Marsh Fill Areas

A hydrogeologic and groundwater investigation was completed to evaluate the status of site hydrogeology, geochemistry, and overall groundwater quality and to address data gaps identified in the RI/FS Work Plan. Groundwater samples were collected from existing and new monitoring wells and wells from the groundwater recovery system (Figure 5-8). The effectiveness of the site's groundwater recovery system was also evaluated.

Onsite sediment and surface water were investigated to identify contaminated sediment in onsite sewers and drainage ditches as a way of evaluating sediment migratory potential and associated adverse human health or ecological risks. Sampling focused on the 002 Settling Canal sediment, 001 Tidal Creek, site-wide surface water, and accessible portions of the sewer system.

A general area gamma radiation survey was performed by the radiation and indoor air section of the EPA to determine potential risk to the public posed by potential radiological contamination across the Macalloy facility. The initial survey established background gamma radiation at

6 micro Roentgens per hour (μR/hr). A 20-foot by 20-foot area west of the former furnace building showed elevated levels of gamma radiation. (See Figure 5-9).

In addition, Macalloy, EPA, SCDHEC, the South Carolina Department of Natural Resources (SCDNR), and the National Oceanic and Atmospheric Administration (NOAA) (both designated as natural resource trustees) agreed in September 2000 to integrate previous sediment and surface water data for Shipyard Creek collected for the 1999 CERCLA Site Inspection Report, the 1999 Preliminary Ecological Risk Evaluation, and the Navy's RFI of the nearby Charleston Naval Complex into the first three steps of the Macalloy Ecological Risk Assessment.

5.2.2 Phase II RI

The Phase II RI was conducted in June 2001 to address the data gaps identified in Phase I.

Radiological Investigation

The general area gamma radiation survey performed by the EPA during Phase I detected elevated radiation levels in an approximately 20-foot-square area directly west of the former furnace building. Additional subsurface investigation of this area was conducted during Phase II. Initial field activities included the excavation and simultaneous field screening of soil and debris with hand-held radiation detection equipment to identify the source of the elevated readings. A sample of debris showing the highest radioactivity measurements was sent to a laboratory for isotopic analysis. Based on the results, the investigation area was gridded into 15- by 15-foot squares and a detailed radiation survey was performed at each grid to establish the lateral extent of the radioactive material. A representative sample of soil and debris was collected from the areas with the highest gamma radiation emission rates to profile the activity and isotopic content of the entire investigation area.

Human Health Risk from Shellfish Ingestion

The Phase I Baseline Human Health Risk Assessment did not evaluate the risk posed by human consumption of fish tissue. Therefore, eastern oyster (*Crassostrea virginica*), blue crab (*Callinictes sapidus*) and brown shrimp (*Paneaus oztecus*) were collected during Phase II from locations in Shipyard Creek downgradient of the Macalloy Site to evaluate risk from shellfish ingestion by recreational fishers in Shipyard Creek.

Ecological Risk in Shipyard Creek

Based on the results of the first three steps of the Ecological Risk Assessment, additional investigation in Shipyard Creek was recommended to address the ecological component of the RI. In addition to sediment chemistry, the following assessment endpoints were used to evaluate ecological risk across three suspected contaminant gradients, Zones A, B, and C (Figure 1-2):

Protection and sustainability of benthic organisms

- Toxicity of Shipyard Creek sediments to the grass shrimp (*Palaemonetes pugio*) in a chronic exposure study.

- Toxicity of Shipyard Creek sediments to the amphipod (*Ampelisca* sp.) in a 10-day acute exposure study.

- Evaluation of grass shrimp abundance in Shipyard Creek.

Protection and sustainability of forage fish

- Comparison of whole-body tissue residue concentrations of potential contaminants in mummichog (*Fundulus* sp.) to residue-based tissue effect concentrations.

Protection and sustainability of piscivorous fish

- Comparison of modeled tissue residue concentrations of potential contaminants in piscivorous fish to residue-based tissue effect concentrations.

Protection and sustainability of invertebrate-eating marsh birds

- Model food-chain pathways to wildlife receptors using site-specific tissue concentrations of potential contaminants in food items.

5.3 Nature and Extent of Contamination

The results of the soil, groundwater, fish tissue, and sediment investigations were used in the Baseline Risk Assessment to evaluate risks to human health and the environment as well as to evaluate contaminant fate and transport. Section 7 contains a detailed summary of the risk assessment. Section 5.4 discusses contaminant fate and transport, and cleanup levels are discussed in Sections 8 and 12.4. This nature and extent of contamination discussion is limited to those contaminants identified as a concern in the human or ecological risk assessment and fate and transport evaluation. A detailed discussion of all chemical detected at the Macalloy Site can be found in the Phase I and Phase II RI Reports.

5.3.1 Soil

Based on the expected industrial land use, no chemicals were identified in surface soils at concentrations greater than those deemed adequately protective of the future site worker. However, concentrations of chromium (VI) in vadose zone soil indicated a significant potential for migration from soil to groundwater.

This soil contamination is primarily concentrated in and around a former marsh (referred to as the lake fill area) that was filled with material from plant operations, including black pebbly slag, raw materials, conditioning tower sludge, and treated and untreated ESP dust. Contamination extends from the surface to a depth of approximately 6 feet. Figure 5-10 shows the areas of the site with vadose zone soil above the cleanup level of 23 milligrams per kilogram (mg/kg). Figures 5-11 and 5-12 are profiles of chromium (VI) contamination in the lake fill area, both above and below the water table.

A small quantity of contaminated soil (1,500 cubic yards) was found in other isolated areas of the plant. In total, approximately 60,000 cubic yards of vadose zone site soil are contaminated with chromium (VI) that can leach to groundwater and surface water at concentrations hazardous to human health and the environment.

An additional 55,000 cubic yards of onsite material was used as berm material for unlined and lined surface impoundments. This berm material comprises primarily gas conditioning tower sludge, slag, and other site materials. Samples collected from the berm material during closure of the USI indicate that this berm material is not hazardous waste, although it contains chromium (VI) above the cleanup level of 23 mg/kg. The lined berm impoundment will be characterized further during remedial design to refine the volume of lined berm material exceeding cleanup levels.

5.3.2 Radiological Material

Approximately 110 cubic yards of soil and debris with gamma radiation levels greater than twice background levels were identified near the former concentrator area (see Figure 5-9). This material is believed to have been brought to the site in railcars carrying feedstock for alloy production. The average depth of the material is 18 inches. The radionuclides detected were radium-226, thorium-232, potassium-40, and uranium-235.

5.3.3 Groundwater

A plume of groundwater contaminated with chromium (VI) extends from this former marsh area to Shipyard Creek. A second plume of chromium (VI) is in the plant's former concentrator area (see Figure 5-13). The plumes are confined to the shallow aquifer and have not penetrated the clay confining layer approximately 20 feet below ground surface.

Contaminated Groundwater Volume

The volume of groundwater that exceeds the chromium (VI) cleanup level of 100 micrograms per liter (μg/L) was calculated based on the following assumptions:

- Porosity of 25%.
- Aquifer thickness ranging from 7 to 20 feet (contamination is present through the entire thickness of the shallow aquifer, which comprises the upper sands).
- Average chromium (VI) concentrations within each specific plume contour.

Impacted volumes are shown in Table 5-1.

Table 5-1
Groundwater Volume Exceeding the Chromium (VI) Cleanup Level and Total Chromium (VI) Mass

Plume	10,000 μg/L	1,000 μg/L	100 μg/L	Total
I	2.0 x 10^6 L 30.8 kg	11.2 x 10^6 L 36.3 kg	8.3 x 10^6 L 2.7 kg	**21.5 x 10^6 L 69.8 kg**
II	none	0.3 x 10^6 L 0.4 kg	0.3 x 10^6 L 0.1 kg	**0.6 x 10^6 L 0.5 kg**
III	none	1.0 x 10^6 L 3.3 kg	1.5 x 10^6 L 0.5 kg	**2.5 x 10^6 L 3.8 kg**
IV	none	2.4 x 10^6 L 7.6 kg	3.6 x 10^6 L 1.2 kg	**6.0 x 10^6 L 8.8 kg**

Table 5-1
Groundwater Volume Exceeding the Chromium (VI) Cleanup Level and Total Chromium (VI) Mass

Plume	10,000 μg/L	1,000 μg/L	100 μg/L	Total
V	3.5×10^6 L 116.6 kg	4.3×10^6 L 14.1 kg	6.2×10^6 L 2.1 kg	**14.0×10^6 L** **132.8 kg**
Total	**5.5×10^6 L** **147.4 kg**	**19.2×10^6 L** **61.7 kg**	**19.9×10^6 L** **6.6 kg**	**44.6×10^6 L** **215.7 kg**

Note:
(a) = Plumes are identified on Figure 5-13.

In addition, the mass of chromium (VI) in the former marsh area, which is considered a significant groundwater contamination source, was calculated using the vertical chromium (VI) profiles presented in Figures 5-11 and 5-12 and the saturated thickness in this area. As discussed above, the chromium (VI)-contaminated material in this area is generally comprised of slag and ESP dust. That said, approximately 12,500 cubic yards or 15,000 tons of fill and 2,800 pounds (1,270 kg) of chromium (VI) were estimated.

5.3.4 Sediment

The results of the Ecological Risk Assessment indicated that sediment in the 001 tidal creek (Zone A, Figure 5-14), formerly an outfall for onsite surface water discharging to Shipyard Creek, contained elevated levels of total chromium, nickel, and zinc. The area of potential ecological concern is the upper, middle, and lower portions of the tidal creek, bordered on both sides by marsh grass. The volume of contaminated sediment was estimated to be 1,000 cubic yards to a depth of 18 inches. In addition, the Ecological Risk Assessment indicated that one measurement endpoint in Zone C had unacceptable risks.

5.3.5 Storm Water

Surface water samples collected pursuant to the NPDES permit indicated the chromium (VI) limit was exceeded in three surface water sampling locations associated with the storm water management system. Other metals including arsenic, copper, lead, and zinc were identified as being a concern due to offsite discharge to Shipyard Creek.

5.4 Fate and Transport Summary

Soil-to-groundwater, groundwater-to-surface water, and onsite soil- and surface water-to-offsite surface water pathways and receptors were evaluated for each constituent detected at Macalloy. Chromium (VI), antimony, arsenic, chromium (III), and copper were identified as contaminants having potentially significant migration pathways in the RI.

Chromium (VI) exceeded its site-specific screening level in soil samples that were generally associated with a groundwater plume. Chromium (VI) groundwater concentrations also exceeded its surface water screening value within the plume. A significant portion of the chromium (VI) groundwater plume lies adjacent to the marsh and Shipyard Creek and could potentially migrate to that surface water body. However, no chromium (VI) was detected in water samples collected in the marsh. Additionally, chromium (VI) is thought to be discharging to onsite surface water due to site hydrogeology. Because of the migration pathways for chromium (VI) from soil and groundwater, it was retained for further evaluation in the FS.

Antimony and arsenic exceeded site-specific screening levels and/or background concentrations in soil. Arsenic also exceeded its maximum contaminant level (MCL) and surface water screening criteria in isolated groundwater wells. However, there is no discernable groundwater plume for either of these metals, and their human health risk assessment in groundwater produced hazard quotients less than 1 (indicating that toxic effects from those chemicals are unlikely). Therefore, antimony and arsenic were not retained for further evaluation in the FS.

Chromium (III) exceeded its surface water screening criteria in several groundwater samples. However, chromium (III)'s solubility (and thus its mobility in groundwater) is very low and its presence in the samples may be associated with solid particles remaining in the well after drilling. These solids are not mobile in groundwater. None of the filtered groundwater samples from the wells in the marsh contained chromium (III) above surface water criteria. Therefore, chromium (III) was not retained for further evaluation in the FS.

Copper in groundwater exceeded its surface water criteria in six isolated wells. But since there was no discernable groundwater plume, and none of the filtered samples from the marsh wells exceeded copper surface water criteria, it was not retained for further evaluation in the FS.

6.0 CURRENT AND POTENTIAL FUTURE LAND AND WATER USES

6.1 Land Uses

Macalloy has discontinued ferrochromium alloy production and redevelopment of the property for other industrial uses is planned. The most likely future land use is commercial/industrial that will utilize the multi-modal transportation options afforded by Interstate 26, adjacent rail lines, and deep water access of Shipyard Creek. The future land use envisioned for the property is consistent with adjacent properties and zoning established by the city of North Charleston. EPA has encouraged prospective purchasers to become involved with remedy selection and implementation so that remediation plans can be reconciled with redevelopment concepts.

6.2 Groundwater and Surface Water Uses

Groundwater at the Macalloy Site is not currently used for consumption and probably won't be in the future because Macalloy is located in a commercial/industrial area that is connected to the city water supply. Available data indicate that water quality of the shallow aquifer does not meet the primary and secondary drinking water standards promulgated under the Safe Drinking Water Act. However, the South Carolina Water Classifications and Standards, R.61-68, classifies all groundwater as a potential underground source of drinking water.

Surface water onsite is found in storm water control basins and canals. Storm water runoff is not used onsite (e.g., for irrigation), but is discharged to Shipyard Creek via two NPDES discharge points. Shipyard Creek is not likely to be used by current or future subsistence fishers because the site is an inactive industrial facility and all of the surrounding property is owned by industrial or municipal entities. In addition, access to the creek is limited and boating is infrequent. However, the creek may be used by recreational fishers.

7

7.0 SUMMARY OF SITE RISKS

A Baseline Risk Assessment was conducted to evaluate current and potential effects on human health and the environment. It estimates what risks the site poses if no action were taken, provides the basis for taking action, and identifies the contaminants and exposure pathways that need to be addressed by the remedial action. This section of the ROD summarizes the results of both the human and ecological components of the Baseline Risk Assessment.

7.1 Summary of Human Risk Assessment

A baseline human health risk assessment analyzes the potential for adverse effects to potential or hypothetical human receptors who could be exposed to hazardous substances at a site assuming no remedial actions are taken to mitigate current environmental contamination. This assessment also considers environmental media and exposure pathways at the site that could result in current or future unacceptable risk.

The human health risk assessment process consists of the following major components: exposure assessment, toxicity assessment, and risk characterization. The exposure assessment identifies potentially exposed populations and pathways, calculates media-specific exposure point concentrations from data generated during the RI, and develops assumptions regarding exposure frequency and duration. The toxicity assessment utilizes existing chemical-specific toxicity information to determine the types of adverse health effects associated with chemical exposures, and the relationship between magnitude of exposure and adverse effects. Risk characterization combines the exposure and toxicity assessments to quantitatively and qualitatively evaluate the potential risks posed.

7.1.1 Identification of Chemicals of Concern

Based upon city of Charleston zoning plans and expected future land-use of the Macalloy site, EPA has based its cleanup levels on a future industrial exposure scenario for the future onsite worker and a recreational fisher in Shipyard Creek. Therefore, only those chemicals of concern (COCs) developed for an industrial reuse scenario or recreational fisher scenario are presented in this section. Tables 7-1 and 7-2 list the COCs and exposure point concentrations (EPCs) for groundwater and fish tissue. The EPCs are the concentrations used to estimate the exposure and risk from each COC. The tables include the range of concentrations detected for each COC, as well as the frequency of detection, the EPC, and how the EPC was derived.

No COCs were identified for surface soil or intermediate and deep groundwater under the industrial reuse scenario. No COCs were identified for shellfish tissue under the assumption that recreational receptors would consume equal amounts of crab, oyster, and shrimp from Shipyard Creek. Using the conservative assumption that receptors consume only shrimp downgradient of Macalloy, arsenic was the only COC.

7.1.2 Exposure Assessment

The objectives of the exposure assessment are to characterize populations that may be potentially exposed, identify actual or potential exposure pathways, and determine (and quantify, if possible) the extent of exposure. A conceptual model for this site is provided in Figure 5-6.

Potential Receptors

The potential receptors considered in this risk assessment are discussed below.

General Industrial Worker

Worker-related exposure was addressed for maximally exposed future site workers. This approach, while providing a conservative assessment of potential health risk to future workers, also provides a conservative approximation of potential risk for current site workers. Because of the location and size of the Macalloy Site, its most likely future use will involve shipping or some other industrial use. In the most likely future land use scenarios, the site would be paved and surface water drainage facilities provided. The assumptions of this risk assessment do not take these measures into account, however. This risk assessment also estimates the risk associated with the consumption of contaminated groundwater for an industrial worker. In reality, it is extremely unlikely that site workers would consume contaminated ground water. The Macalloy Site is located in a highly industrialized area of North Charleston and is connected to the city water supply.

Construction Worker

A construction worker scenario was not evaluated quantitatively in this risk assessment for the following reasons:

- At the present time, it is unknown what type of construction will occur at the Macalloy facility.

- Based on the potential future commercial/industrial use of the property, it is almost certain that the majority of the site will be paved in the future, thus further limits the potential contact with subsurface soil.

The quantitative evaluation of the industrial worker is expected to be protective of the future construction worker, because the industrial worker is assumed to spend many years at the site, while construction activities are likely to be short term. Contaminated subsurface soil that might be encountered by a construction worker was addressed in the FS.

Site Resident

A potential site resident scenario was evaluated quantitatively in this risk assessment for information purposes. It is extremely unlikely that the site will be used for residential development in the future. In the event that the site is developed for residential use, the landscape would likely change. Imported topsoil and vegetation would all but eliminate surface soil exposure. Also, any future site residents would almost certainly be connected to city water, eliminating groundwater as a pathway.

Site Visitor/Trespasser

Although exposure of a site visitor/trespasser to contamination originating from the Macalloy facility is possible, this scenario was not evaluated quantitatively. It was deemed unnecessary to include this pathway because the industrial worker scenario is protective of this receptor. Exposure of a site visitor/trespasser would likely be short-term or intermittent, while for the industrial worker scenario the exposure is long-term and constant.

Recreational Fisher

For purposes of evaluating health risks posed by ingestion of shellfish, older children and young adults (i.e., 7 to 18 years of age), the age group typically recommended by EPA Region IV as the trespasser population, were assumed to be the population most likely to catch fish recreationally from the site and bring it home for consumption.

Exposure Pathways

Exposure pathways for potentially exposed populations are inhalation of airborne particulate-bound contaminants from surface soils when contaminated soil is disturbed by onsite activities, incidental ingestion of contaminants in surface soils, and dermal contact with contaminants in surface soils. Exposure to contaminants in groundwater may include ingestion, inhalation, and dermal pathways. However, exposure to groundwater contaminants by inhalation or dermal contact is expected to be less than by ingestion and was, therefore, was not evaluated in this risk assessment. The exposure pathway for contaminants in shellfish from Shipyard Creek is ingestion. Details regarding exposure frequencies for each scenario, exposure duration, surface area for dermal exposure, and shellfish ingestion rates can be found in Sections 7 of the Phase I RI Report and Section 3 of the Phase II RI Report.

A reasonable maximum exposure (RME) approach was employed to estimate the potential exposures and associated risks at the site. The RME is the highest exposure that is reasonably expected to occur at the site and is intended to estimate a conservative exposure case that is still within the range of possible exposures.

7.1.3 Toxicity Assessment

The toxicity assessment evaluates the potential health impacts posed by contaminants for which exposure pathways have been identified. The EPA has developed toxicological databases that provide information regarding common environmental media contaminants identified at hazardous waste sites. The primary information database used for this purpose is the Integrated Risk Information System (IRIS). If toxicological information for a particular contaminant is not available in IRIS, EPA's Health Effects Assessment Summary Table (HEAST) was used as a secondary reference. In the absence of IRIS or HEAST information, some of the toxicity values used in this risk assessment are provisional values defined by EPA's National Center for Environmental Assessment (NCEA) as cited in EPA Region III RBC tables.

The EPA has established a classification system for rating the potential carcinogenicity of environmental contaminants based on the weight of scientific evidence. The EPA has established slope factors (SFs) for carcinogenic compounds. The SF is defined as a "plausible upper-bound estimate of the probability of a response (cancer) per unit intake of a chemical over a lifetime" (RAGS, Part A). The cancer classes are described below.

A Cancer weight-of-evidence class "A" (human carcinogens) means that human toxicological data have shown a proven correlation between exposure and the onset of cancer.

B The "B1" classification indicates some human exposure studies have implicated the compound as a probable carcinogen. Weight-of-evidence class "B2" indicates a possible human carcinogen, a description based on positive laboratory animal data (for carcinogenicity) in the absence of human data.

C Weight-of-evidence class "C" identifies possible human carcinogens.

D Class "D" indicates a compound not classifiable for its carcinogenic potential.

In addition to potential carcinogenic effects, most substances can also produce other toxic responses at doses greater than experimentally derived threshold concentrations. The EPA has derived reference dose (RfD) values for these substances. A chronic RfD is defined as an estimate of a daily exposure concentration for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of deleterious effects during a lifetime.

Table 7-3 presents the toxicological criteria used to evaluate the carcinogenic health concern for the COCs. Dermal SFs were derived by dividing the oral SFs by an oral-to-dermal adjustment factor.

Table 7-4 lists the toxicological criteria used to evaluate the noncarcinogenic health concern for the COCs. Dermal RfDs were derived by multiplying the oral RfDs by the oral-to-dermal adjustment factor.

7.1.4 Risk Characterization

Cancer risk is generally expressed as the incremental probability of an individual's developing cancer over a lifetime as a result of exposure to the carcinogen. For carcinogenic effects, the chronic daily intake (CDI) is multiplied by the appropriate SF to establish excess lifetime cancer risk. Risk is usually expressed in scientific notation (e.g., $1x10^{-6}$). An excess lifetime cancer risk of $1x10^{-6}$ indicates that an individual experiencing the reasonable maximum exposure estimate has a 1 in 1,000,000 chance of developing cancer as a result of site-related exposure. This is referred to as an "excess lifetime cancer risk" because it would be in addition to the risks of cancer individuals face from other causes such as smoking or exposure to too much sun. EPA's generally acceptable risk range for site-related exposure is $1x10^{-4}$ to $1x10^{-6}$.

The potential for noncarcinogenic effects is evaluated by dividing the CDI by the RfD. The ratio of exposure to toxicity is called a hazard quotient (HQ). An $HQ < 1$ indicates that a receptor's dose of a single contaminant is less than the RfD, and that toxic noncarcinogenic effects from that chemical are unlikely. The Hazard Index (HI) is generated by adding the HQs for all COCs. An $HI < 1$ indicates that, based on the sum of all HQ's from different contaminants and exposure routes, toxic noncarcinogenic effects from all contaminants are unlikely. An $HI > 1$ indicates that site-related exposures may present a risk to human health.

Although both cancer risk and noncancer risks are generally additive (within each group) only if the same target organ is common to multiple chemicals, a most conservative estimate of each may be obtained by summing the individual risks or hazards, regardless of target organ. This risk assessment uses the universal summation approach for each class of toxicant but separates noncarcinogenic effects of concern by target organ as necessary.

Industrial Site Workers

Risk and hazard across all potential contaminants, pathways, and media for the future site worker scenario are summarized in Table 7-5. As mentioned in section 7.1.1, five COCs were identified for shallow groundwater used as a drinking water source by industrial site users: antimony, arsenic, chromium (VI), iron, and manganese. Noncarcinogenic hazard and carcinogenic risk calculations are overwhelmingly driven by the conservative assumption of groundwater consumptive use and exposure to COCs through groundwater ingestion. Chromium (VI) is the primary contributor, accounting for 91% of the noncarcinogenic hazard associated with ingestion (shallow groundwater ingestion HQ = 31.) Both arsenic and antimony had individual HQs less than 1; therefore they were not retained for further evaluation in the FS. Iron and manganese had HQs of 1 and 2, respectively; however, maximum contaminant levels (MCLs) are not available for these metals. Therefore, they were not retained for further evaluation in the FS. Carcinogenic risk ($5x10^{-5}$), which is within the USEPA's acceptable risk range, is due entirely to ingestion of arsenic.

Future Residents

Even though a potential site resident scenario is extremely unlikely, the risk characterization results are presented in Tables 7-6 to 7-8 for information purposes. For the hypothetical future residential adult, ingestion of chromium (VI) in shallow groundwater is responsible for 91% of the total hazard. Other significant contributors to overall site hazard are ingestion of manganese and iron in shallow groundwater, which account for 4% and 3% of the total hazard associated with this pathway, respectively. For the hypothetical future residential child, ingestion of chromium (VI) in shallow groundwater is responsible for 90% of the total hazard. Other significant contributors to overall site hazard are ingestion of manganese and iron in shallow groundwater, which account for 4% and 3% of the total hazard, respectively. Carcinogenic risk associated with the hypothetical future resident was within EPA's acceptable risk range.

Recreational Fishers

Using the conservative assumption that receptors consume only shrimp downgradient of Macalloy, arsenic was the only chemical that exceeded RME hazard quotient and cancer risk values (Table 7-9). However, the calculated risk levels are within the range calculated for ingesting shellfish containing arsenic at background levels. No COCs were identified for the central tendency exposure evaluation, which represents an average recreational exposure. For these reasons, arsenic in shellfish was not retained for further evaluation in the FS.

7.1.5 Risk Uncertainty

The potential for bias is introduced into the risk assessment through the exposure setting, pathway selection, and highly conservative exposure assumptions. For example, exposure to groundwater is not a likely pathway at Macalloy since groundwater is currently not used and it is not anticipated to be used in the future. Groundwater was included in this risk assessment because South Carolina Water Classifications and Standard, R.61-68, classifies all groundwater as a potential underground source of drinking water. Shallow aquifer water quality does not meet the primary and secondary drinking standards promulgated under the Safe Drinking Water Act.

In addition, residential site use is not a likely future scenario. Redevelopment of the property for other industrial uses is planned. Therefore, commercial/industrial is the most likely future land use. Conservative intake parameters used for the RME analysis also have contributed to a conservative estimation of risk. For example, future land use scenarios (e.g., a shipping port) would involve paving much of the site. Ingestion of surface soil would be drastically reduced under such a scenario.

Because shrimp are migratory, arsenic concentrations in shrimp may not be associated with the Macalloy Site. In addition, shrimp could not be collected in Shipyard Creek using a recreational cast net, but were instead harvested using an industrial trawl net. Therefore, the shrimp used in this evaluation may not be representative of those available to a recreational fisherman.

7.2 Summary of Ecological Risk Assessment

A baseline ecological risk assessment was conducted to identify potential risks to wildlife resources using the terrestrial and aquatic habitats of the Macalloy Site and adjacent Shipyard Creek. Ecological exposure pathways included direct exposure of terrestrial and aquatic communities to site soil and Shipyard Creek sediment and surface water as well as indirect (food-chain) exposure to species that use both habitats.

Following a preliminary evaluation of contaminant concentrations in site soil and in Shipyard Creek surface water and sediment, additional data were collected to evaluate risk to ecological receptors across expected contaminant gradients in three zones of Shipyard Creek (A, B, and C) (see Figure 1-2). Sediment chemistry, acute and chronic sediment toxicity testing, grass shrimp abundance, tissue chemistry, and food-chain modeling were used to assess potential risk to ecological receptors based on a multiple lines-of-evidence approach.

Table 7-10 summarizes the ecological exposure pathways for sediment. Table 7-11 presents the concentrations of metals detected in Shipyard Creek sediment and indicates those that exceeded EPA Region 4 Ecological Screening Values. Table 7-12 lists mean concentrations from Zones A, B, and C and from reference sites. Sediment chemistry data are compared to Effect Range-Median (ERM) values obtained from NOAA in Table 7-13, which also summarizes potential unacceptable adverse risks based on the multiple lines of evidence. A shaded cell refers to a measurement endpoint or a specific test within a measurement endpoint that was judged to exhibit an unacceptable adverse effect with respect to that measurement endpoint.

Results from the selected measurement endpoints demonstrated that no unacceptable risk exists in Zone B. One measurement endpoint in Zone C (grass shrimp embryo production) indicated unacceptable risks. However, based on the strength and magnitude of observed adverse effects and the expectation of diminishing risks following remediation, a risk management decision was made to monitor only in Zone C. Sediments in Zone A, which comprises a small tidal creek that historically received process water discharges from plant operations, had elevated concentrations of chromium, nickel, and zinc, resulting in ERM quotients greater than 1 for those constituents in all three sub-zones (upper, middle, and lower). Lead had an ERM quotient of 1.4 in the middle sub-zone of A. The upper and lower sub-zones had lead ERM quotients less than 1. Sediment in Zone A also exhibited chronic effects on grass shrimp in laboratory toxicity tests. For these reasons, EPA concluded there is an unacceptable risk to the benthic community, and Zone A was retained for further evaluation in the FS.

A derivation of sediment concentrations expected to provide adequate protection of ecological receptors at the Macalloy Site is presented in Appendix A. These protective ranges are summarized below.

Contaminant	**Protective Range (mg/kg)**
total chromium	219 — 258
nickel	33 — 35.7
zinc	132 — 163

7.3 Basis for Action

The response action selected in this ROD is necessary to protect human health or welfare or the environment from actual or threatened releases of hazardous substances into the environment. This action will address the remedial action objectives discussed in Section 8.

Table 7-1
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Time Frame:	Future Site Worker
Medium	Groundwater
Exposure Medium:	Shallow Groundwater

Exposure Point	COC	Concentration Detected		Units	Detection Frequency	Exposure Point Concentration	Units	Statistical Measure
		Min	Max					
Ingestion	Antimony	0.003	0.056	mg/L	10/44	0.006	mg/L	95% UCL
	Arsenic	0.003	0.064	mg/L	20/44	0.009	mg/L	95% UCL
	Chromium (VI)	0.002	38.6	mg/L	37/44	9.5	mg/L	95% UCL
	Iron	0.019	58.7	mg/L	44/44	30.2	mg/L	95% UCL
	Manganese	0.001	2.82	mg/L	43/44	3.1	mg/L	95% UCL

Key
mg/L: milligrams per liter
95% UCL: 95% Upper Confidence Limit on the Arithmetic Mean
min and max: minimum and maximum concentration

Table 7-2
Summary of Chemicals of Concern and Medium-Specific Exposure Point Concentrations

Scenario Time Frame:	Future Recreation Fisher
Medium	Shellfish
Exposure Medium:	Shrimp

Exposure Point	COC	Concentration Detected		Units	Detection Frequency	Exposure Point Concentration	Units	Statistical Measure
		Min	Max					
Ingestion	Arsenic	5.3	10	mg/L	10/10	8.4	mg/L	95% UCL

Key
mg/kg: milligrams per kilogram
95% UCL: 95% Upper Confidence Limit on the Arithmetic Mean
min and max: minimum and maximum concentration

Table 7-3
Cancer Toxicity Data Summary

Pathway:	Ingestion, Dermal	
COC	**Oral Cancer Slope Factor**	**Slope Factor Units**
Arsenic	1.5	(mg/kg)/day

Key
A: Human Carcinogen
IRIS: Integrated Risk Information System, EPA

Table 7-4
Non-Cancer Toxicity Data Summary

Pathway: Ingestion

COC	**Chronic/ Subchronic**	**Oral RfD**	**Units**	**Primary Target Organ**	**Combined Uncertainty/ Modifying Factors**	**Source**	**Date**
Antimony	Chronic	$4.0x10^{-4}$	mg/kg-day	Blood	1000	IRIS	2000
Arsenic	Chronic	$3.0x10^{-4}$	mg/kg-day	Skin, cardiovascular	3	IRIS	2000
Chromium (VI)	Chronic	$3.0x10^{-3}$	mg/kg-day	—	900	IRIS	2000
Iron	Chronic	$3.0x10^{-1}$	mg/kg-day	Blood	—	NCEA	2000
Manganese	Chronic	$2.0x10^{-2}$	mg/kg-day	CNS	3	IRIS	2000

Key
— No information available
CNS: Central Nervous System
IRIS: Integrated Risk Information System, EPA
NCEA: USEPA National Center for Environmental Assessment

Table 7-5
Risk Assessment Summary
Reasonable Maximum Exposure
Macalloy Corporation, Charleston, South Carolina

Scenario Timeframe: Future
Receptor Population: Industrial Worker
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Shallow Groundwater	Tap Water	N/A	N/A	N/A	N/A	N/A	Antimony	Blood	0.2	N/A	N/A	0.2
			N/A	N/A	N/A	N/A	N/A	Arsenic	Skin	0.3	N/A	N/A	0.3
			N/A	N/A	N/A	N/A	N/A	Chromium (VI)	None	31	N/A	N/A	31
			N/A	N/A	N/A	N/A	N/A	Iron	Blood	1	N/A	N/A	1
			N/A	N/A	N/A	N/A	N/A	Manganese	Nervous System	2	N/A	N/A	2
			N/A	N/A	N/A	N/A	N/A	(Total)		32	N/A	N/A	34

Total Risk Across [Medium]	N/A
Total Risk Across All Media and All Exposure Routes	N/A
Total Hazard Index Across All Media and Shallow Groundwater	34
Total [Blood] HI =	1
Total [Skin] HI =	0.3
Total [Nervous System] HI =	1.5

Table 7-6
Risk Assessment Summary
Reasonable Maximum Exposure
Macalloy Corporation, Charleston, South Carolina

Scenario Timeframe: Future
Receptor Population: Residential
Receptor Age: Adult

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Groundwater	Shallow Groundwater	Tap Water	N/A	N/A	N/A	N/A	N/A	Antimony	Blood	0.4	N/A	N/A	0.4
			N/A	N/A	N/A	N/A	N/A	Arsenic	Skin	0.9	N/A	N/A	0.9
			N/A	N/A	N/A	N/A	N/A	Chromium (III)	None	0.2	N/A	N/A	0.2
			N/A	N/A	N/A	N/A	N/A	Chromium (VI)	None	87	N/A	N/A	87
			N/A	N/A	N/A	N/A	N/A	Iron	Blood	3	N/A	N/A	3
			N/A	N/A	N/A	N/A	N/A	Manganese	Nervous System	4	N/A	N/A	4
								(Total)		95	N/A	N/A	95

Total Risk Across [Medium]	N/A
Total Risk Across All Media and All Exposure Routes	N/A

Total Hazard Index Across All Media and Shallow Groundwater	95
Total [Blood] HI =	3
Total [Skin] HI =	0.9
Total [Nervous System] HI =	4.3

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Table 7-7
Risk Assessment Summary
Reasonable Maximum Exposure
Macalloy Corporation, Charleston, South Carolina

Scenario Timeframe: Future
Receptor Population: Residential
Receptor Age: Child

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	N/A	N/A	N/A	N/A	N/A	Antimony	Blood	0.2	N/A	N/A	0.2
			N/A	N/A	N/A	N/A	N/A	Arsenic	Skin	0.3	N/A	N/A	0.3
			N/A	N/A	N/A	N/A	N/A	Chromium (VI)	None	0.2	N/A	N/A	0.2
			N/A	N/A	N/A	N/A	N/A	Iron	Blood	0.8	N/A	N/A	0.8
								Manganese	Nervous System	0.2	N/A	N/A	0.2
			N/A	N/A	N/A	N/A	N/A	Nickel	Body Weight	0.2	N/A	N/A	0.2
			N/A	N/A	N/A	N/A	N/A	(Total)		2	N/A	N/A	2
Groundwater	Shallow Groundwater	Tap Water	N/A	N/A	N/A	N/A	N/A	Antimony	Blood	1	N/A	N/A	1
			N/A	N/A	N/A	N/A	N/A	Arsenic	Skin	2	N/A	N/A	2
			N/A	N/A	N/A	N/A	N/A	Chromium (III)	None	0.4	N/A	N/A	0.4
			N/A	N/A	N/A	N/A	N/A	Chromium (VI)	None	203	N/A	N/A	203
			N/A	N/A	N/A	N/A	N/A	Iron	Blood	6	N/A	N/A	6
			N/A	N/A	N/A	N/A	N/A	Manganese	Nervous System	10	N/A	N/A	10
								(Total)		222	N/A	N/A	222
	Intermediate Groundwater	Tap Water	Chromium (VI)	N/A	N/A	N/A	N/A	Chromium (VI)	None	1	N/A	N/A	1
			Manganese	N/A	N/A	N/A	N/A	Manganese	Nervous System	0.24	N/A	N/A	0.2
			(Total)	N/A	N/A	N/A	N/A	(Total)		1	N/A	N/A	1
	Deep Groundwater	Tap Water	Chromium (VI)	N/A	N/A	N/A	N/A	Chromium (VI)	None	0.15	N/A	N/A	0.2
			(Total)	N/A	N/A	N/A	N/A	(Total)		0.17	N/A	N/A	0.2

Total Risk Across [Medium]	N/A
Total Risk Across All Media and All Exposure Routes	N/A

Total Hazard Index Across [Soil]	2
Total Hazard Index Across [Shallow Groundwater]	222
Total Hazard Index Across [Intermediate Groundwater]	1
Total Hazard Index Across [Deep Groundwater]	0.2
Total Hazard Index Across Soil and Shallow Groundwater	224

Table 7-8
Risk Assessment Summary
Reasonable Maximum Exposure
Macalloy Corporation, Charleston, South Carolina

Scenario Timeframe: Future
Receptor Population: Residential
Receptor Age: Lifetime Weighted Avg.

Medium	Exposure Medium	Exposure Point	Chemical	Carcinogenic Risk				Chemical	Non-Carcinogenic Hazard Quotient				
				Ingestion	Inhalation	Dermal	Exposure Routes Total		Primary Target Organ	Ingestion	Inhalation	Dermal	Exposure Routes Total
Soil	Soil	Surface Soil	Arsenic	2E-05	N/A	N/A	2E-05	N/A	N/A	N/A	N/A	N/A	N/A
			BEQs	1E-05	N/A	5E-06	2E-05	N/A	N/A	N/A	N/A	N/A	N/A
			(Total)	3E-05	N/A	5E-06	3E-05	(Total)		N/A	N/A	N/A	N/A
Groundwater	Shallow Groundwater	Tap Water	Arsenic	2E-04	N/A	N/A	2E-04	N/A	N/A	N/A	N/A	N/A	N/A
			(Total)	2E-04	N/A	N/A	2E-04	(Total)		N/A	N/A	N/A	N/A

Total Risk Across [Soil]	3E-05
Total Risk Across [Shallow Groundwater]	2E-04
Total Risk Across Soil and Shallow Groundwater	3E-04
Total Hazard Index Across All Media and All Exposure Routes	N/A

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Table 7-9

Calculation of Noncarcinogenic Hazard
Assuming Receptors Consume Only One Type of Shellfish
Macalloy Corporation, Charleston, South Carolina

Medium	Chemical of Potential Concern	Exposure Point Concentration ($mg_{chemical}/kg_s$)	RME Intake Factor[a] $kg_s/(kg_{BW}*day)$	CTE Intake Factor[a] $kg_s/(kg_{BW}*day)$	Reference Dose ($mg_{chemical}/kg_{BW}*day$)	RME Hazard Quotient[b] (unitless)	CTE Hazard Quotient[b] (unitless)
Shrimp	Arsenic	8.4	1.11E-04	3.56E-05	3E-04	3.111	0.996

Calculation of Carcinogenic Risks
Assuming Receptors Consume Only One Type of Shellfish
Macalloy Corporation, Charleston, South Carolina

Medium	Chemical of Potential Concern	Exposure Point Concentration ($mg_{chemical}/kg_s$)	RME Intake Factor[a] $kg_s/(kg_{BW}*day)$	CTE Intake Factor[a] $kg_s/(kg_{BW}*day)$	Cancer Slope Factor ($mg_{chemical}/kg_{BW}*day$)	RME Cancer Risk[c] (unitless)	CTE Cancer Risk[c] (unitless)
Shrimp	Arsenic	8.40	1.90E-05	6.10E-06	1.5E+00	2.4E-04	7.7E-05

Notes:

mg/kg = milligrams per kilogram
RME = reasonable maximum exposure
CTE = central tendency exposure
BW = body weight
s = shellfish

[a] Intake factor calculations for the RME and CTE evaluation are in Table3-5c (for COPCs other than arsenic) and Table 3-5d (for arsenic).

[b] Hazard quotient (HQ) calculated using the following equation:

$$HQ = \frac{\text{Exposure Point Concentration} \times \text{Intake Factor}}{\text{Reference Dose}}$$

[c] Cancer risk calculated using equation:

Cancer Risk = Exposure Point Concentration × Intake Factor × Slope Factor

Table 7-10
Ecological Exposure Pathways of Concern

Exposure Medium	Sensitive Environment Flag (Y or N)	Receptor	Endangered/ Threatened Species Flag (Y or N)	Exposure Routes	Assessment Endpoints	Measurement Endpoints
Sediment	N	Benthic organisms	N	Ingestion, respiration, and direct contact with chemicals in contaminated sediments	Protection and sustainability of benthic organisms	• Toxicity of Shipyard Creek sediments to grass shrimp (*Palaemonetes pugio*) in a chronic exposure study • Toxicity of Shipyard Creek sediments to the amphipod (*Ampelisca* sp.) in a 10-day acute exposure study • Evaluation of grass shrimp abundance in Shipyard Creek
		Forage fish	N	Incidental ingestion of chemicals in contaminated sediment and ingestion of contaminated food items	Protection and sustainability of forage fish	• Comparison of whole-body tissue residue concentrations of potential contaminants in mummichog (*Fundulus* sp.) to residue-based tissue effect concentrations
		Piscivorous fish	N	Incidental ingestion of chemicals in contaminated sediment and ingestion of contaminated food items	Protection and sustainability of piscivorous fish	• Comparison of modeled tissue residue concentrations of potential contaminants in piscivorous fish to residue-based tissue effect concentrations
		Invertebrate-eating marsh birds	N	Incidental ingestion of chemicals in contaminated sediment and ingestion of contaminated food items	Protection and sustainability of invertebrate-eating marsh birds	• Model food-chain pathways to wildlife receptors using site-specific tissue concentrations of potential contaminants in food items.

Table 7-11 Concentrations of Metals in Composite Sediment Samples Collected June 2001 from Shipyard Creek and the Reference Areas.

Sediment Metals Concentrations, mg/kg dry weight	Reference Sites				Zone A						Zone B				Zone C					
	FOSM-REF001	qual	RATM-REF001	qual	SYCM-A0L001	qual	SYCM-A0M001	qual	SYCM-A0U001	qual	SYCM-BOL001	qual	SYCM-B0U001	qual	SYCM-00L001	qual	SYCM-00M001	qual	SYCM-00U001	qual
Aluminum	5510		18600		13800		21300		13900		3030		7650		14600		14900		21100	
Antimony	1.7	UJ	2.2	UJ	1.7	UJ	2.6	UJ	1.6	UJ	13.6	UJ	1.6	UJ	2.1	UJ	2.2	UJ	2.9	UJ
Arsenic	4.2		13.5		13.1		19.3		11.8		16.3	J	7.1		10.7		11.1		14.8	
Barium	13.8	J	22.9	J	32.3	J	55.5	J	54.4	J	19	J	15.4	J	23.3	J	26.5	J	35	J
Beryllium	0.29	J	0.88	J	0.61	J	0.89	J	0.58	J	1	J	0.5	J	0.74	J	0.75	J	0.97	J
Cadmium *	0.23	U	0.29	U	0.63	J	0.82	J	0.54	J	1.8	U	0.5	J	0.5	J	0.71	J	1	J
Calcium	1730	J	11100		11600		10100		7090		118000		47700		59100		54300		54300	
Chromium *	13	J	40.1	J	1780	J	2980	J	3070	J	79.7	J	191	J	219	J	317	J	258	J
Hexavalent Chromium *	3.8	U	5.4	U	4.5	U	6.2	U	4.3	U	3	U	3.6	U	5.1	U	5.9	U	6.5	U
Cobalt	1.7	J	5.2	J	14.3	J	20.4	J	21.1		3	J	2	J	3.8	J	4.1	J	5.7	J
Copper *	6.2	J	18.4	J	39.7	J	63.9	J	47.9	J	28.4	J	12.4	J	24.5	J	28.5	J	52.9	J
Iron	7750		23800		20000		29600		21600		9730		7190		14000		14700		22300	
Lead *	7.6	J	20.2	J	147	J	310	J	189	J	6.4	J	11.8	J	77.5	J	37.3	J	56.3	J
Magnesium	2090		6530		43500		61100		72200		2610	J	3500		7350		7850		8710	
Manganese *	44.8		238		377		747		682		84.4		55.3		116		105		161	
Mercury *	0.062	J	0.016		0.12		0.22		0.13		0.062	J	0.087		0.12		0.17		0.3	J
Nickel *	3.4	J	10.9	J	373		474		606		28.6	J	19.4		35		40.7		35.7	
Potassium	1080	J	2940		1890	J	3220		1680	J	977	J	1150	J	2020	J	2030	J	2830	J
Selenium *	1.6	U	2.1	U	1.6	U	2.4	U	1.5	U	13	U	1.5	U	2	U	2.1	U	2.8	U
Silver	0.3	U	0.39	U	0.3	U	0.46	J	0.54	J	2.4	U	0.29	U	0.37	U	0.39	U	0.52	U
Sodium	6660		16300		9420		15600		9150		4910	J	5850		10400		10700		14100	
Thallium	1.8	U	2.4	U	1.9	U	2.8	U	1.7	U	14.8	U	1.8	U	2.8	J	2.4	U	3.3	J
Vanadium *	15.7	J	51.2	J	38.8	J	66.1	J	40.4	J	19.1	J	19.5	J	34	J	32.5	J	49	J
Zinc *	22.7	J	60.5	J	847	J	1640	J	1330	J	98.4	J	55.9	J	132	J	163	J	227	J

Notes: Qualifier Codes: UJ = analyte was not detected and the detection limit reported is a quantitative estimate; U = analyte was not detected at the quantitation limit; J = analyte concentration was detected but the concentration is an estimate.

Shaded Cells: Shaded cells indicate an exceedance of EPA Region IV Ecological Screening Value. Refer to Appendix 8A, Final Phase I Remedial Investigation Report (EnSafe, 2001).

Asterisk: Asterisks indicate metal COPCs retained following initial screening and problem formulation step.

Table 7-12. Mean Concentrations of Metals in Sediment Samples from Zones A, B, and C of Shipyard Creek and Individual Measurements Made in the Reference Areas.

Sediment Metals Concentrations, Mg/kg dry weight	Foster Creek[1]	Rathall Creek[1]	Zone A[2]	Zone B[2]	Zone C[2]
Aluminum	5510	18600	16333.3	5340.0	16866.7
Antimony	1.7	2.2	1.0	3.8	1.2
Arsenic	4.2	135	14.7	11.7	12.2
Barium	13.8	22.9	47.4	17.2	28.3
Beryllium	0.29	0.88	0.7	0.8	0.8
Cadmium	<0.23	<0.29	0.7	0.7	0.7
Calcium	1730	11100	9596.7	82850.0	55900.0
Chromium	13	40.1	2610.0	85.4	264.7
Hexavalent Chromium	<3.8	<5.4	2.5	1.7	2.9
Cobalt	1.7	5.2	18.6	2.5	4.5
Copper	6.2	18.4	50.5	20.4	35.3
Iron	7750	23800	23733.3	8460.0	17000.0
Lead	7.6	20.2	215.3	9.1	57.0
Magnesium	2090	6530	58933.3	3055.0	7970.0
Manganese	44.8	238	602.0	69.9	127.3
Mercury	0.062	0.016	0.2	0.1	0.2
Nickel	3.4	10.9	484.3	24.0	36.5
Potassium	1080	2940	2263.3	1063.5	2293.3
Selenium	<1.6	<2.1	0.9	3.6	1.2
Silver	<0.3	<0.39	0.4	0.7	0.2
Sodium	6660	16300	11390.0	5380.0	11733.3
Thallium	<1.8	<2.4	1.1	4.2	2.4
Vanadium	15.7	51.2	48.4	19.3	38.5
Zinc	22.7	60.5	1272.3	77.2	174.0

Notes:

[1] Non-detected measurements are signified by "<" and reported at the detection limit.

[2] Mean concentrations are calculated using detected concentrations and ½ the detection limit for non-detected measurements.

Table 7-13 Weight of Evidence Summary Table

Test / Analysis	Zone A			Zone B		Zone C		
	Upper	Middle	Lower	Upper	Lower	Upper	Middle	Lower
Sediment Concentration, mg/kg / ERM Quotient								
Cadmium	0.54 / 0.06	0.82 / 0.09	0.63 / 0.07	0.5 / 0.05	<1.8 / 0.09	1 / 0.1	0.71 / 0.07	0.5 / 0.05
Chromium	3070 / 8.3	2980 / 8.1	1780 / 4.8	91 / 0.25	79.7 / 0.2	258 / 0.7	317 / 0.9	219 / 0.6
Hexavalent Chromium	<4.3 / 0.01	<6.2 / 0.1	<4.5 / 0.01	<3.6 / 0.0	<3 / 0.0	<6.5 / 0.01	<5.9 / 0.01	<5.1 / 0.01
Copper	47.9 / 0.2	63.9 / 0.2	39.7 / 0.1	12.4 / 0.05	28.4 / 0.1	52.9 / 0.2	28.5 / 0.1	24.5 / 0.09
Lead	189 / 0.9	310 / 1.4	147 / 0.7	11.8 / 0.05	6.4 / 0.03	56.3 / 0.3	37.3 / 0.2	77.5 / 0.4
Manganese	682 / --	747 / --	377 / --	55.3 / --	84.4 / --	161 / --	105 / --	116 / --
Mercury	0.13 / 0.2	0.22 / 0.3	0.12 / 0.2	0.087 / 0.1	0.062 / 0.09	0.3 / 0.4	0.17 / 0.2	0.12 / 0.2
Nickel	606 / 12	474 / 9.2	373 / 7.2	19.4 / 0.4	28.6 / 0.5	35.7 / 0.7	40.7 / 0.8	33 / 0.6
Selenium	<1.5 / --	<2.4 / --	<1.6 / --	<1.5 / --	<13 / --	<2.8 / --	<2.1 / --	<2 / --
Vanadium	40.4 / --	66.1 / --	38.8 / --	19.5 / --	19.1 / --	49 / --	32.5 / --	34 / --
Zinc	1330 / 3.2	1640 / 4.0	847 / 2.1	55.9 / 0.1	98.4 / 0.2	227 / 0.6	163 / 0.4	132 / 0.3
ERM Quotient								
Mean ERM Quotient	3.1	2.9	1.9	0.1	0.2	0.4	0.3	0.3

Table 7-13 continued

	Test / Analysis	Zone A			Zone B		Zone C		
		Upper	Middle	Lower	Upper	Lower	Upper	Middle	Lower
Assessment Endpoint No. 1	**Grass Shrimp Toxicity**								
	Survival								
	Ovary Production								
	Embryo Production								
	Embryo Hatching								
	DNA Damage								
	Amphipod Toxicity								
	Survival								
	Mysid Toxicity								
	Survival								
	Grass Shrimp Population								
	Abundance of Adult (*P. pugio*)								
	Total Biomass (*P. pugio*)								
	Abundance of male (*P. pugio*)								
	Abundance of nongravid female (*P. pugio*)								
	Abundance of gravid (*P. pugio*)								

Table 7-13 continued

	Test / Analysis	Zone A			Zone B		Zone C		
		Upper	Middle	Lower	Upper	Lower	Upper	Middle	Lower
	Sex ratio of (*P. pugio*)								
Assessment Endpoint Nos. 2 and 3	**Risks to Fish**								
	Forage Fish								
	Piscivorous Fish								
Assessment Endpoint No. 4	**Risks to Marsh Birds**								
	Marsh wren								
	Spotted sandpiper								
Total Number of Potential Unacceptable Risk Indicators:		5	5	5				1	

8.0 REMEDIAL ACTION OBJECTIVES

The results of the RI indicated that the primary impacts from the Macalloy Site are to vadose zone soil, shallow site groundwater, storm water, and sediment in the 001 tidal creek. The migration pathways are groundwater discharge and leaching of soil. The primary COC in soil and groundwater is chromium (VI); however, suspended solids and inorganic compounds (metals) with potential saltwater ecological toxicity have been identified as a concern in storm water discharges, and chromium, nickel, and zinc were identified as COCs in sediment. In addition, soil and debris in the concentrator area with radiation readings above background were also identified as a concern.

Therefore, the following remedial action objectives (RAOs) for the Macalloy Site were developed based on reasonably anticipated future land use, potential beneficial groundwater use, and legal requirements:

- Prevent future site worker exposure to unacceptable hazard levels in groundwater.
- Remediate shallow groundwater zones exhibiting the highest concentrations of chromium (VI) and limit its migration to Shipyard Creek to minimize long-term threats.
- Remediate soil that leaches chromium (VI) to groundwater and surface water at concentrations hazardous to human health and the environment.
- Mitigate offsite chromium (VI) discharges in storm water to Shipyard Creek through a combination of the aforementioned remediation measures and a comprehensive site-wide storm water management plan.

- Manage storm water discharges of toxic inorganic compounds in accordance with the comprehensive storm water management plan to protect ambient saltwater quality in Shipyard Creek.

- Remediate soil and debris that produce elevated levels of gamma radiation to mitigate current exposure pathways.

- Mitigate the exposure of benthic organisms to contaminated sediments in the tidal creek.

The actions proposed in this plan will address these RAOs by:

- Reducing chromium (VI) concentrations in soil to 23 milligrams per kilogram (mg/kg). This cleanup level is a site-specific concentration calculated to prevent leaching of chromium (VI) from soil to groundwater at concentrations above the groundwater MCL.

- Reducing radiation levels in soil and debris to 12 micro-Roentgens per hour, which is twice the background radiation level at the Macalloy Site.

- Reducing chromium (VI) concentrations in groundwater to less than 100 micrograms per liter (μg/L). MCL compliance will be monitored on a site-wide basis to ensure groundwater quality remains protective of human health and the environment.

- Reducing concentrations of lead, arsenic, chromium (VI), copper, and zinc in storm water to the cleanup levels listed below. These goals were developed to meet the substantive requirements of the Clean Water Act.

Parameter	Limit
Flow	Report
Total suspended solids (μg/L)	110,000
Total lead (μg/L)	220
Total arsenic (μg/L)	69
Total copper (μg/L)	5.8
Total zinc (μg/L)	9.5
Chromium (VI) (μg/L)	1,100
Acute Whole Effluent Toxicity	report

- Reducing exposure of benthic organisms to unacceptable concentrations of chromium, nickel, and zinc in tidal creek sediment.

9

9.0 DESCRIPTION OF ALTERNATIVES

Remedial technologies were screened to develop remediation alternatives which would meet RAOs. Table 9-1 summarizes remedial alternatives for the Macalloy Site. The alternatives are numbered to correspond with alternatives presented in the FS report.

Table 9-1
Summary of Remedial Alternatives
Macalloy Corporation Site

Environmental Media	FS Designation	Description
Soil	S1	No Action
	S2a	Onsite chemical reduction and stabilization/solidification: in situ injection and ex situ treatment of berm and shallow isolated areas
	S2b	Onsite chemical reduction and stabilization/solidification: ex situ treatment with mechanical mixing
	S2c	Onsite chemical reduction and stabilization/solidification: ex situ treatment with a pugmill
	S3	Excavation with offsite disposal
	S4	Hot mix asphalt cap
Radiological Material	R1	No action
	R2	Excavation and offsite disposal
	R3	Soil cover
Groundwater	G1	No Action
	G2a	Enhanced in situ reduction: Hydrogen Release Compound™
	G2b	Enhanced in situ reduction: chemical reductant
	G2c	Enhanced in situ reduction: carbohydrate reductant
	G3	Zero-valent iron permeable reactive barrier with enhanced in situ reduction
	G4	Groundwater containment
Sediment	M1	No action
	M2	Enhanced monitored natural recovery
	M3	Cap
	M4	Removal with upland disposal
Storm Water	—	Comprehensive storm water management plan

9.1 Description of Remedy Components

Major components of remedial alternatives are provided in the following subsections. Each alternative description is followed by a cost and construction/monitoring schedule summary.

9.1.1 Soil Alternatives

Alternative S1: No Action

The no-action alternative is considered a baseline against which other alternatives are compared. In the no-action alternative, no remedial actions are taken to contain, remove, or treat contaminated soil, or to prevent leaching from soil to groundwater. Under this alternative no changes would be made to existing site conditions or exposure scenarios. NCP-required five-year monitoring costs are associated with this alternative. Present worth analysis costs are based on review once every five years for 30 years.

Alternative S1 Summary	
Estimated capital cost	$0
Estimated annual operation and maintenance (O&M) cost	$10,000 (every five years)
Estimated present worth cost	$22,000 (30 years with a 7% discount rate)
Estimated construction time frame	none
Estimated time to achieve RAOs	N/A

Alternative S2a: Onsite Chemical Reduction and Stabilization/Solidification: In Situ Injection and Ex Situ Treatment of Berm and Shallow Isolated Areas

Reduction and stabilization/solidification (s/s) systems reduce the solubility or chemical reactivity of a waste by changing its chemical state or by physical entrapment of the waste. The actual mechanisms of reduction and s/s depend on the chemical agents used and characteristics of the soil. Reduction and s/s occur either in situ or ex situ.

Chemical reduction can be promoted by injecting, infiltrating, or mixing a reductant into the soil that results in the conversion of chromium (VI) to chromium (III), a less toxic and less mobile form of the metal. Ferrous sulfate has been demonstrated to be an effective reductant for soil contaminated with chromium (VI). The success of in situ reduction depends on the method's ability to effectively distribute the reductant to all impacted soil zones and to permanently convert all chromium (VI) to chromium (III). Reductant distribution systems include injection via soil borings, infiltration via a surface impoundment or a network of subsurface pipes, and soil mixing via rotary augers. S/s generally requires mixing the soil with an s/s agent, such as Portland cement, to immobilize contaminants and strengthen the soil.

Treatment Components

- Remedial design, which includes a treatability study, delineation sampling, and overall system design.

- Approximately 55,000 cubic yards of berm material and 1,500 cubic yards of shallow, isolated soil areas would be treated by chemical reduction and s/s ex situ with a mixing device such as a pugmill and placed as a compacted fill onsite consistent with site redevelopment.

- Approximately 60,000 cubic yards of vadose zone soil would be treated by chemical reduction by in situ injection techniques, which would likely include either injection, infiltration, or soil mixing.

- Confirmation sampling would be required to verify that cleanup levels have been met following treatment.

EPA has recently conducted bench-scale and pilot-scale studies to evaluate various reductants and injection methods for treating chromium(VI)-contaminated soil at Macalloy. Direct-push technology (DPT) was applied during the pilot study at strategic locations. DPT provides a mechanism for rapid, economical injection of reductants (s/s agents are not used with this delivery option). This system uses hydraulic pressure and/or a percussion hammer to push metal rods into subsurface soil. The reductant can be injected into the soil as the rods are slowly removed from the subsurface. The EPA pilot study results indicated that this method has limited effectiveness in Macalloy soil.

Institutional Controls

One or more of the following institutional controls would be installed as part of the alternative to prohibit future residential use of the property:

- Covenant — provisions in any subsequent property transfer agreements to restrict use.

- Informational devices — tools (e.g., deed notices, state registries of hazardous waste sites, and advisories), which often rely on property record systems, used for providing public information about risks from contamination.

Operations and Maintenance

None.

Monitoring Requirements

Long-term effectiveness of this alternative would be evaluated with the groundwater monitoring program to be developed for groundwater remedial alternatives.

Alternative S2a Summary	
Estimated capital cost	$6,773,000
Estimated annual O&M cost	$0
Estimated present worth cost	$6,773,000
Estimated construction time frame	6 months
Estimated time to achieve RAOs	6 months

Alternative S2b: Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with Mechanical Mixing

This alternative is similar to S2a, except that all 115,000 cubic yards of contaminated berm material and soil would be excavated and treated by chemical reduction and s/s ex situ by mechanical mixing methods. Though ex situ treatment methods involve significantly more material handling than in situ methods, they offer the ability to carefully control mixing and blending ratios and may require less reagent than in situ techniques. Mechanical mixing techniques can also be used to treat contaminated soil in place below the water table.

Treatment Components

- Remedial design, which includes a treatability study, delineation sampling, and overall system design.

- 115,000 cubic yards of contaminated berm material and soil would be excavated and treated ex situ by mechanical mixing methods. Soil would be mixed with reductants and s/s agents using common construction equipment such as tillers and scarifiers, augers, backhoes, track mixers, or high speed rotary mixers.

- Treated soil would be replaced in its original location or at other onsite locations consistent with site redevelopment.

- Confirmation sampling would verify that cleanup levels have been met following treatment.

Institutional Controls

This alternative would include covenants and/or informational devices designed to restrict residential use of the property (see Alternative S2a for descriptions).

Operations and Maintenance

None.

Monitoring Requirements

Long-term effectiveness of this alternative would be evaluated with the groundwater monitoring program to be developed for groundwater remedial alternatives.

Alternative S2b Summary	
Estimated capital cost	$7,883,000
Estimated annual O&M cost	$0
Estimated present worth cost	$7,883,000
Estimated construction time	7 months
Estimated time to achieve RAOs	7 months

Alternative S2c: Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with a Pugmill

This alternative is similar to S2b, except that the 115,000 cubic yards of excavated soil and berm material would be mixed in a pugmill. Although a pugmill is an effective and proven mixing technology, it does not offer the ability to treat contaminated soil in place below the water table. Also, a pugmill is sensitive to the size, hardness, and abrasiveness of the material being treated.

Treatment Components

- Remedial design, which includes a treatability study, delineation sampling, and overall system design.

- 115,000 cubic yards of excavated soil and berm material would be mixed in a pugmill. This technology includes:

  — Staging excavated soil.

  — Screening soil to remove materials too large in diameter to be effectively treated by pugmill.

  — Blending the reducing and stabilizing agents and water in a continuous feed or batch operation.

  — Placing the treated material back into the excavation or in other areas needing fill.

  — Conducting confirmation sampling.

- Excavated soil would be replaced in thin layers in its original location or at other onsite locations consistent with site redevelopment.

Institutional Controls

This alternative would include covenants and/or informational devices designed to restrict residential use of the property (see Alternative S2a for descriptions).

Operations and Maintenance

None.

Monitoring Requirements

Long-term effectiveness of this alternative would be evaluated with the groundwater monitoring program to be developed for groundwater remedial alternatives.

Alternative S2c Summary	
Estimated capital cost	$10,372,000
Estimated annual O&M cost	$0
Estimated present worth cost	$10,372,000
Estimated construction time frame	7 months
Estimated time to achieve RAOs	7 months

Alternative S3: Excavation with Offsite Disposal

Approximately 115,000 cubic yards of contaminated soil and berm material would be excavated and transported to a RCRA-permitted offsite treatment and/or disposal facility. Prior to disposal, some pretreatment may be required to meet land disposal restrictions.

Treatment Components

- Remedial design, which includes a treatability study, delineation sampling, and overall system design.

- Approximately 115,000 cubic yards of contaminated soil and berm material would be excavated with backhoes, front-end loaders, continuous excavators, scrapers, or other equipment.

- Excavated materials would be staged for waste characterization and pretreated as necessary to limit leaching before being transported to a RCRA-permitted offsite treatment and/or disposal facility.

- The soil would be loaded for transportation with front-end loaders after stockpiling, classifying, and pre-treating. Landfill disposal typically requires that no free liquid be present in the material and/or that the materials meet TCLP leaching criteria.

- Confirmation samples would be collected from the excavation to confirm removal of soil with contaminant concentrations exceeding the cleanup level. The open excavation would then be backfilled with clean soil.

Institutional Controls

This alternative would include covenants and/or informational devices designed to restrict residential use of the property (see Alternative S2a for descriptions).

Operations and Maintenance

None.

Monitoring Requirements

No long-term maintenance or monitoring would be required after excavating and disposing of the contaminated soil.

Alternative S3 Summary	
Estimated capital cost	$8,872,000
Estimated annual O&M cost	$0
Estimated present worth cost	$8,872,000
Estimated construction time frame	6 months
Estimated time to achieve RAOs	6 months

Alternative S4: Hot Mix Asphalt Cap

An asphalt cap is a source containment alternative used to control the vertical migration of contaminants by reducing or eliminating surface water infiltration through soil that results in the production of leachate. Institutional controls and regular maintenance are required to ensure performance of the cap over time. The cap would be designed to reduce the leaching of chromium (VI) to minimize groundwater and surface water contamination, as well as to support industrial traffic loads.

Treatment Components

- Remedial design, which includes a treatability study/mix design, delineation sampling, and overall system design.

- Approximately 55,000 cubic yards of berm material and contaminated soil from isolated areas would be excavated and treated ex situ using the chemical reduction and s/s techniques discussed in Alternative S2c.

- Treated berm material would be consolidated in the approximately 12-acre cap area and compacted to form a dense, strong base to support a hot mix asphalt cap for the remaining 60,000 cubic yards of contaminated soil remaining in place.

Institutional Controls

This alternative would include covenants and/or informational devices designed to restrict residential use of the property and ensure that any necessary excavation or disturbance of the cap would be properly repaired.

Operations and Maintenance

During the life of the cap, the pavement would be inspected and repaired as needed to maintain protective capacity. Resurfacing of the capped area with asphalt after 15 years was included in the cost estimate. The long-term effectiveness of this alternative would be a function of proper and regular maintenance because of the susceptibility of the cap to weathering, cracking, and subsidence.

Monitoring Requirements

The system would require five-year reviews and ongoing inspections and repairs.

Alternative S4 Summary	
Estimated capital cost	$6,259,000
Estimated annual O&M cost	$11,000 (with $732,000 at year 15)
Estimated present worth cost	$6,681,000 (30 years with a 7% discount rate)
Estimated construction time frame	5 months
Estimated time to achieve RAOs	5 months

9.1.2 Radiological Materials Alternatives

Alternative R1: No Action

The no-action alternative is considered a baseline against which other alternatives are compared. In this alternative, no remedial actions would be taken to contain, remove, or treat radioactive materials, and no changes would be made to existing site conditions or exposure scenarios. NCP-required five-year monitoring costs are associated with this alternative.

Alternative R1 Summary	
Estimated capital cost	$0
Estimated annual O&M cost	$5,000 (every 5 years)
Estimated present worth cost	$11,000 (30 years with a 7% discount rate)
Estimated construction time frame	none
Estimated time to achieve RAOs	N/A

Alternative R2: Excavation with Offsite Disposal

In this alternative, approximately 110 cubic yards of soil and debris that produce gamma radiation exceeding the cleanup level would be excavated and disposed of in a Subtitle D landfill in South Carolina. Confirmation screening (sampling) would be conducted to verify that materials producing gamma radiation above the twice background levels were removed. The area would be backfilled using onsite borrow materials. No long-term operation, maintenance, or monitoring is associated with this alternative.

Alternative R2 Summary	
Estimated capital cost	$15,000
Estimated annual O&M cost	$0
Estimated present worth cost	$15,000
Estimated construction time frame	1 week
Estimated time to achieve RAOs	1 week

Alternative R3: Soil Cover

Onsite soil would be used to cover the radioactive soil and debris to mitigate current exposure pathways. The approximately 8,000 square feet of cover would consist of a seeded, 2-foot-thick soil layer designed to reduce surface radiation below remedial goals. Because the radioactive soil and debris would remain in place, institutional controls would be required to restrict use in this area and prevent future land users from digging there. Long-term monitoring and 5-year reviews would be required to ensure the protectiveness of the cover.

Alternative R3 Summary	
Estimated capital cost	$24,000
Estimated annual O&M cost	$14,000
Estimated present worth cost	$41,000 (30 years with a 7% discount rate)
Estimated construction time frame	1 week
Estimated time to achieve RAOs	30 years

9.1.3 Groundwater Alternatives

Alternative G1: No Action

The NCP requires that a no-action alternative be considered as a baseline against which all other alternatives will be evaluated. In the no-action alternative, no remedial action would be taken, future site use would be uncontrolled, and groundwater could be used for residential purposes. Groundwater would remain in place to attenuate according to natural processes. No engineering or institutional controls would be implemented. NCP-required five-year monitoring costs are associated with this alternative. Costs are based on sampling and data review once every five years for 30 years.

Alternative G1 Summary	
Estimated capital cost	$40,000
Estimated annual O&M cost	$18,000 (every five years)
Estimated present worth cost	$79,000 (30 years with a 7% discount rate)
Estimated construction time frame	none
Estimated time to achieve RAOs	N/A

Alternative G2a: Enhanced In Situ Reduction: Hydrogen Release Compound™

In situ reductive treatment covers subsurface zones where migrating contaminants are intercepted and permanently immobilized or degraded into harmless end products. The soil and groundwater geochemistry evaluation indicates that chromium (VI) reduction is favorable in the shallow aquifer. Redox manipulation, if applied strategically in plume areas, would be a more aggressive remedial strategy than relying on natural attenuation/reduction or other passive technologies. The reductants can be delivered passively, actively, or as a combination, as well as provide downgradient containment.

Treatment Components

- Remedial design, which includes additional delineation sampling, pilot-scale testing, and final amendment delivery system design.

- A grid-based application of the reductant would be delivered to the groundwater plume by DPT in one or two applications. The reductant in this alternative is Hydrogen Release Compound™, a proprietary compound manufactured as a viscous gel, which promotes biological reduction of chromium (VI) to chromium (III), which is less toxic and less mobile. An advantage of the Hydrogen Release Compound™ (HRC) is that it is a time-release compound that can take advantage of groundwater movement for contaminant reduction.

Institutional Controls

No long-term institutional controls are associated with this alternative.

Operations and Maintenance

The need for reapplication depends on plume management strategy and site-specific biodegradation performance. For plume area treatments, one or two reapplications could be necessary over the course of the project, although each reapplication would likely use a smaller area and dose than the initial application. For barrier-based designs without complete source treatment, reapplications would be necessary every one or two years as long as there is a need to prevent contaminant migration. However, with the plume and source areas targeted, a long-term application strategy would not be required.

An effectiveness monitoring program would be required to evaluate changes in contaminant concentrations during and after treatment. Groundwater geochemistry would also be monitored during the reductant application phase.

Monitoring Requirements

Routine monitoring of the groundwater plume is required for five years to evaluate the long-term effectiveness of the alternative.

Alternative G2a Summary	
Estimated capital cost	$1,462,000
Estimated annual O&M cost	$84,000
Estimated present worth cost	$1,672,000 (2 years with a 7% discount rate)
Estimated construction time frame	2 months
Estimated time to achieve RAOs	2 years

Alternative G2b: Enhanced In Situ Reduction: Chemical Reductant

This alternative is similar to Alternative G2a, except that a chemical reductant is used rather than the Hydrogen Release Compound™. The EPA has recently completed a pilot study indicating that a mixture of ferrous sulfate and sodium dithionite quickly and effectively reduced chromium (VI) to chromium (III) in shallow groundwater at the Macalloy Site. Other chemicals may also be considered during remedial design.

Treatment Components

- Remedial design, which includes additional delineation sampling, bench- and pilot-scale testing, and final amendment delivery system design.

- Potential delivery methods include grids of DPT points, temporary groundwater wells, a gallery of pipes, or surface impoundments to infiltrate the reductant. Chemical reductants would be applied using a plume-wide application followed by a strategic redosing to address residual contamination.

Institutional Controls

No long-term institutional controls are associated with this alternative.

Operations and Maintenance

The chemical reductant application strategy, based on the findings of the pilot-scale test, would be designed for one dosing. Though one or two reapplications could be necessary over the course of the project, each reapplication would likely use a smaller area and dose than the initial application.

An effectiveness monitoring program would be required to evaluate changes in contaminant concentrations during and after treatment. Groundwater geochemisstry would also be monitored during the reductant application phase.

Monitoring Requirements

Routing monitoring of the groundwater plume is required for five years to evaluate the long-term effectiveness of the alternative.

Alternative G2b Summary	
Estimated capital cost	$1,843,000
Estimated annual O&M cost	$84,0000
Estimated present worth cost	$2,053,000 (2 years with a 7% discount rate)
Estimated construction time frame	2 months
Estimated time to achieve RAOs	2 years

Alternative G2c: Enhanced In Situ Reduction: Carbohydrate Reductant

This alternative is similar to Alternative G2a and G2b, except that a common carbohydrate is used as the reductant.

Treatment Components

- Remedial design, which includes additional delineation sampling, bench- and pilot-scale testing, reductant selection, and final amendment delivery system design.

- The carbohydrate reductant would be routinely delivered via groundwater wells, infiltration gallery, or trenches during the treatment period. Because the carbohydrate would have to be routinely injected over a period of time, it may not achieve cleanup levels as quickly as the Hydrogen Release Compound™ or a chemical reductant.

Institutional Controls

No long-term institutional controls are associated with this alternative.

Operations and Maintenance

Carbohydrate reductant redosing rates depend on the plume management strategy and site-specific biodegradation performance. An effectiveness monitoring program would be required to evaluate changes in contaminant concentrations during and after treatment. Groundwater geochemistry would also be monitored during the reductant application phase.

Monitoring Requirements

Routine monitoring of the groundwater plume is required for five years to evaluate the long-term effectiveness of the alternative.

Alternative G2c Summary	
Estimated capital cost	$471,000
Estimated annual O&M cost	$192,000
Estimated present worth cost	$1,012,000 (3 years with a 7% discount rate)
Estimated construction time frame	1 month
Estimated time to achieve RAOs	3 years

Alternative G3: Zero-Valent Iron Permeable Reactive Barrier (PRB) with Enhanced In Situ Reduction

A PRB would be installed downgradient of the chromium (VI) plume along Shipyard Creek, perpendicular to groundwater flow, to treat chromium (VI) in groundwater before it migrates offsite. Groundwater would flow through a reactive medium (iron filings) and be passively treated to meet cleanup levels. Enhanced in situ reduction as discussed in Alternative G2b would be used to target the chromium (VI) contamination near the concentrator area.

Treatment Components

Implementation of a PRB at Macalloy would include several elements: conceptual design, bench-scale testing, full-scale design and installation, system monitoring, and rejuvenation and/or replacement (if necessary).

- Bench-scale testing would be conducted to evaluate the length of PRB effectiveness and optimize reactive material mix designs.

- The PRB would be constructed in two sections to intercept the plumes migrating towards Shipyard Creek. Approximately 500- and 300-foot-long sections would be constructed north and south of the 001 pond, respectively.

- The concentrator area plume, which is essentially independent of the other plumes, would be addressed using a strategic application of enhanced in situ reduction rather than a third PRB.

- PRB media replacement may be required if significant fouling problems occur.

Institutional Controls

Long-term institutional controls could include covenants to restrict groundwater use and prohibit well drilling in the shallow aquifer, easements to allow continued groundwater monitoring access, and informational devices such as deed notices to provide information to the public about risks from contamination.

Operation and Maintenance

Replacement or rejuvenation of the reactive media may be required if significant fouling problems occur.

Monitoring Requirements

The PRB provides containment only and does not remove or destroy the source of contamination. The effectiveness of the PRB and enhanced in situ reduction requires an effectiveness monitoring program in addition to compliance monitoring. An operating period of 30 years was assumed for the FS.

Alternative G3 Summary	
Estimated capital cost	$1,958,000
Estimated annual O&M cost	$51,000
Estimated present worth cost	$2,591,000 (30 years with a 7% discount rate)
Estimated construction time frame	1 month
Estimated time to achieve RAOs	30 years

Alternative G4: Groundwater Containment

Pump-and-treat is a containment remedy for chromium (VI)-contaminated groundwater. It includes long-term groundwater extraction, treatment, and disposal of the extracted groundwater. Macalloy operated a pump-and-treat system for chromium (VI)-contaminated groundwater from 1996 to June 2000. Groundwater was pumped from 21 extraction wells to a treatment system that used ferrous sulfate to convert chromium (VI) to chromium (III). The treated water was then discharged to Shipyard Creek via a permitted outfall. Effectiveness of the groundwater remediation system was evaluated during the RI. Results indicated that the extraction wells cannot be pumped at a sustainable rate that would maintain a significant and effective capture zone. Operation of the system was suspended prior to the RI so that the groundwater investigation would not be artificially influenced by the extraction system.

The proposed pump-and-treat alternative would completely replace the existing extraction system and modify the existing treatment system. The goal of the new groundwater collection system would be to minimize downgradient migration of chromium (VI).

Treatment Components

- Abandonment of the current groundwater extraction wells.
- Installation of collection trenches.
- Upgrade of the current ex situ treatment system, and system monitoring.
- Discharging treated groundwater to the sanitary sewer, directly to waters of the state via an NPDES permit, or reinjecting into the same aquifer.

Institutional Controls

Long-term institutional controls could include covenants to restrict groundwater use and prohibit well drilling in the shallow aquifer, easements to allow continued groundwater monitoring access, and informational devices such as deed notices to provide information to the public about risks from contamination.

Operation and Maintenance

Routine process control samples would also be collected to evaluate treatment system effectiveness and ensure that effluent limits are consistently met.

Monitoring Requirements

The pump-and-treat system would require a groundwater monitoring program to verify its effectiveness. Wells within the source area would be monitored to evaluate changes in concentration, while downgradient wells would be used to determine if containment was complete. These data would be typically monitored on a set basis (quarterly) to determine whether cleanup levels are being met downgradient of the containment system.

Alternative G4 Summary	
Estimated capital cost	$655,000
Estimated annual O&M cost	$99,000
Estimated present worth cost	$1,883,000 (30 years with a 7% discount rate)
Estimated construction time frame	1 month
Estimated time to achieve RAOs	30 years

9.1.4 Sediment Alternatives

Alternative M1: No Action

In the no-action alternative, no remedial actions are taken to contain, remove, or treat contaminated sediment. This alternative consists of leaving the contaminated sediment in place in anticipation that natural sedimentation will bury or contain pollutants, forming a natural cap of clean sediment over the contaminated sediments, and reducing or eliminating the transfer of pollutants from the sediments to overlying water and biota.

The 001 outfall, the source of sediment contamination in the tidal creek, has been eliminated. The contaminated sediments are in a relatively low-energy, non-erosive environment that will not likely be disturbed by future dredging or construction. However, data are not currently available for sedimentation rates in the tidal creek. Therefore, it is not possible to quantify current natural sedimentation rates or to accurately estimate the time required to naturally cover existing sediments.

For the cost estimate, five-year monitoring was assumed to consist of sediment chemistry sampling for the three chemicals of concern — total chromium, nickel, and zinc.

Alternative M1 Summary	
Estimated capital cost	$0
Estimated annual O&M cost	$12,000 (every 5 years)
Estimated present worth cost	$26,000 (30 years with a 7% discount rate)
Estimated construction time frame	none
Estimated time to achieve RAOs	N/A

Alternative M2: Enhanced Monitored Natural Recovery

This alternative is similar to the no-action alternative described in the previous section in that contaminated sediments would remain in place to attenuate naturally to mitigate risks to benthic organisms. However, this alternative is distinguished from the no-action alternative in three important ways.

- It provides for more extensive monitoring of natural creek recovery.
- It assesses the rate of natural sedimentation and provides for enhanced sedimentation through the use of sediment barriers, if necessary.
- It provides a way to assess the success/failure of the alternative, leading to a decision of no further action, continued monitoring, or implementation of an engineered remedial option.

Under this alternative, contaminated sediments would be left in place and the site would be monitored annually to evaluate the effectiveness of natural processes in reducing risk to the environment. Each annual monitoring event would include five elements:

1. Sediment sampling and analysis for chemicals of concern to evaluate changes in concentrations.

2. Laboratory testing to assess their potential bioavailability.

3. Acute and chronic toxicity testing to evaluate changes in toxicity over time.

4. Sampling of sediment-dwelling organisms to evaluate changes in species composition, abundance, and diversity over time.

5. Measurements of sediment accumulation above marker horizons placed during the initial monitoring event to assess the rate of natural sedimentation.

After the initial monitoring event, sediment barriers such as biodegradable wooden board baffles would be installed at selected intervals to enhance sedimentation within the tidal creek if necessary.

Alternative M2 Summary	
Estimated capital cost	$50,000
Estimated annual O&M cost	$82,000
Estimated present worth cost	$626,000 (10 years with a 7% discount rate)
Estimated construction time frame	2 weeks
Estimated time to achieve RAOs	10 years

Alternative M3: Cap

The contaminated sediment in the tidal creek would be capped to prevent exposure to benthic organisms. The cap would consist of a nonwoven geotextile, a coarse sand layer filled to an elevation equal to the adjacent marsh (approximately 3 feet), and marsh grasses planted throughout the former tidal creek area. Though erosion is not a primary design consideration, the newly planted grasses will provide erosion control for the targeted area.

The cap would require annual monitoring for three years following installation to ensure its integrity; inspections would be conducted in years 5 and 10 as well. If there are no signs of significant erosion during the first 10 years, the cap would only be reinspected following a major storm event. If monitoring indicates excessive erosion, lost material would be replaced with new backfill and marsh grass. Depth gauges would be placed in the channel to help assess erosive changes.

Alternative M3 Summary	
Estimated capital cost	$498,000
Estimated annual O&M cost	$5,000 (years 1-3, 5, and 10 with $52,000 at year 10)
Estimated present worth cost	$559,000 (30 years with a 7% discount rate)
Estimated construction time frame	1 month
Estimated time to achieve RAOs	30 years

Alternative M4: Removal with Upland Disposal

The top 18 inches of contaminated sediment in the tidal creek (approximately 1,000 cubic yards) would be removed using hydraulic dredging equipment and pumped to an onsite dewatering area, which drains to onsite storm water detention basins. Once dewatered, the removed sediment would be sampled for total metals and hexavalent chromium.

Depending on the analytical results, dredged material would be left in place or managed with onsite contaminated soil (see soil alternatives). Confirmation samples would be collected after dredging is complete to assess whether additional sediment must be removed. During dredging, sediment resuspension and removal rates would be monitored. Engineering controls would be implemented to control sediment resuspension in the water. Dredging in the Tidal Creek will be conducted in a manner that minimizes physical disturbance and impacts to the adjacent vegetated salt marsh.

Alternative M4 Summary	
Estimated capital cost	$492,000
Estimated annual O&M cost	$0
Estimated present worth cost	$492,000
Estimated construction time frame	1 month
Estimated time to achieve RAOs	1 month

9.1.5 Storm Water Management

Storm water at the Macalloy Site will be managed to mitigate the discharge of pollutants into Shipyard Creek. The remedy will include a comprehensive site-wide storm water management and sediment control plan to meet the requirement of the South Carolina Storm Water Management and Sediment Reduction Act, as administered by the Office of Ocean and Coastal Resource Management.

The storm water management plan, in conjunction with selected soil and groundwater remedies, will be developed to achieve cleanup levels for chromium (VI) discharges from Macalloy to Shipyard Creek and will control sediment (total suspended solids) concentrations in the discharge, thereby reducing lead, arsenic, copper, and zinc to levels meeting remedial goals.

Storm water runoff from disturbed areas will be collected and routed through detention basins or other sediment removal devices to decrease suspended solids in the discharge. Currently, offsite storm water runoff commingles with storm water from disturbed onsite areas, increasing the quantity of water that must be managed. This increase jeopardizes the effectiveness of the detention basins at removing solids. To address this concern, the proposed storm water management plan will include an upgradient offsite collection ditch to intercept offsite storm water before it commingles with onsite runoff.

For onsite storm water management, perimeter berms and ditches will collect runoff and route it through a series of detention basins for sediment removal and discharge flow control. The perimeter berms and ditches also will prevent onsite storm water from leaving the property except at specified locations.

A monitoring program will be developed to evaluate the effectiveness of the storm water plan, along with soil and groundwater remedies, in meeting the storm water remedial goals. The program will include automatic samplers that monitor and record rainfall and flow at each outfall. Monthly storm water samples will be collected and analyzed to assess effectiveness in meeting storm water cleanup levels.

Toxicity tests will be performed quarterly on a species to be determined. South Carolina regulations recommend *Ceriodaphnia dubia* for freshwater and *Mysidopsis bahia* for saltwater. A detailed sampling and analysis plan will be developed during remedial design to outline the methods and procedures for storm water system monitoring. The sampling plan will be implemented for one year after remedial construction is completed. After that time, the frequency and scope of the sampling plan will be re-evaluated.

Alternative Summary	
Estimated capital cost	$1,010,000
Estimated annual O&M cost	$246,000
Estimated present worth cost	$1,256,000
Estimated construction time frame	2 months
Estimated time to achieve RAOs	1 year

9.2 Common Elements and Distinguishing Features of Each Alternative

Key elements for each of the soil, groundwater, sediment, and radiological material alternatives are summarized in Table 9-2. Other distinguishing features for each medium are discussed below.

9.2.1 Soil Alternatives

Alternatives S2a, S2b, and S2c share a common remediation approach but differ in mechanical application of reductants used to reduce chromium (VI) to chromium (III). The quantity of untreated contaminated soil remaining under Alternatives S2a, S2b, and S2c would be less than under Alternatives S1 and S4, which ranges from 115,00 cubic yards for S1 to 60,000 cubic yards for S4. All alternatives except S3 would require monitoring to evaluate effectiveness of the remedy. The effectiveness of Alternatives S2a, S2b, and S2c would be monitored with the groundwater remedy. Alternative S4 involves operation and maintenance costs directly related to the engineered cap and institutional controls. Alternatives S2a, S2b, S2c, and S3 are permanent and are complete in 6 to 7 months.

9.2.2 Radiological Material Alternatives

Under Alternative R1, the site would undergo no remedial action but would have five-year reviews. Alternative R2 would completely remove the source of gamma radiation-producing material for landfill disposal to achieve cleanup levels in approximately one week. Comparatively, Alternative R3 would cover the radiological materials in place and require 30-year operation and maintenance as well as long-term institutional controls.

9.2.3 Groundwater Alternatives

Alternatives G2a, G2b, and G2c are active remediation alternatives and share a common remediation approach, but differ in application method (e.g., DPT versus infiltration wells) and reductant (e.g., HRC versus chemical reductant) used to reduce chromium (VI) to chromium (III). Time to achieve RAOs using these alternatives ranges from two to three years. All three would effectively leave no untreated waste in groundwater.

Alternative G3 is a passive approach to reduce chromium (VI) to chromium (III) as it migrates through the PRB, while G4 is a hydraulic containment alternative with ex situ chemical treatment.

G3 and G4 require 30 years to achieve RAOs. G3 does not treat the main plume source area as do G2a, G2b, and G2c.

9.2.4 Sediment Alternatives

Alternatives M1, M2, and M3 all leave contaminated sediment in place. However, M3 differs by covering contaminated sediments with an engineered cap to isolate them from surface water and benthic organisms. M1 and M2 are very similar in that contaminated sediments would remain in place without an engineered cap and allowed to attenuate naturally over time. However, M2 enhances sedimentation to develop a natural cap and includes a more detailed evaluation and monitoring program for evaluating remedy effectiveness. The cost for M2 is subsequently higher than for M1. Alternative M3 would require routine monitoring to maintain the integrity of the engineered cap. All three alternatives involve annual O&M costs ranging from approximately $2,500 for M1 to $82,000 for M2. Alternative M4 removes contaminated sediment from the tidal channel, leaving no residual contamination above cleanup levels, within 30 days of implementation.

9.3 Expected Outcomes of Each Alternative

The goal of the response action includes the following key elements:

- Minimize the migration of chromium (VI) from soil to groundwater and surface water.

- Minimize exposure to debris that produces elevated levels of gamma radiation.

- Control risks to future site workers posed by the ingestion of chromium (VI) in groundwater and limit groundwater migration to Shipyard Creek.

- Mitigate the discharge of contaminated storm water to Shipyard Creek.

- Prevent direct exposure of benthic organisms to contaminated sediments in the 001 tidal creek.

Alternative-specific outcomes are discussed below.

9.3.1 Soil Alternatives

Alternative S1 would leave contaminated soil in place to continue leaching chromium (VI) to groundwater. As a result, groundwater cleanup levels would not be met for some time. No controls would be in place to prevent residential reuse of the property, which could results in an unacceptable health risk.

The S2 alternatives address chromium (VI)-contaminated soil in the vadose zone with in situ or ex situ treatment. No additional chromium (VI)-leaching would be expected. This would expedite groundwater remediation by eliminating a source of chromium (VI) in the vadose zone. No additional O&M or monitoring would be required, other than that associated with the groundwater remedy. The site could be available for industrial reuse in approximately one year after remedial construction begins.

In Alternative S3, chromium (VI)-contaminated soil would be excavated, treated if necessary, and disposed of in a permitted landfill. Like Alternative S2, no additional leaching of chromium (VI) would be expected. This would expedite groundwater remediation by eliminating a source of chromium (VI) contamination in vadose zone soil. No additional O&M or monitoring would be required. The site could be available for industrial reuse in approximately one year after remedial construction begins as a result of the remedy.

In Alternative S4, berm materials would be treated and stabilized and then used as a sub-base in an asphalt cap for the remaining chromium (VI)-contaminated soil. The cap would limit surface water infiltration to minimize the soil-to-groundwater migration pathway. Though contaminated materials would remain in place, the site could be available for industrial reuse in approximately one year after remedial construction begins. O&M and monitoring would be required for 30 years to maintain the cap's integrity. However, as a benefit, the cap could be designed as a functional part of the site's reuse plan.

9.3.2 Radiological Alternatives

Under Alternative R1, no remedial actions would be taken to contain, remove, or treat radioactive materials, and no changes would be made to existing site conditions or exposure scenarios. Radioactive material concentrations exceed background levels. However, without a site-specific risk assessment, the overall hazard to exposed populations is unknown.

Impacted soil and debris would be excavated and disposed of in a permitted landfill under Alternative R2. The remedy is expected to take approximately one week to achieve RAOs. No additional O&M or monitoring would be required.

In Alternative R3, a soil and vegetative cap would cover the impacted soil and debris to eliminate exposure pathways. The remedy is expected to take approximately one week to achieve RAOs. Long-term O&M would be required to maintain the integrity of the cap.

9.3.3 Groundwater Alternatives

No action would be taken to reduce chromium (VI) concentrations in groundwater in Alternative G1. As a result, groundwater cleanup levels would not be met for some time (natural attenuation coupled with vadose zone source removal could reduce chromium [VI] concentrations over time).

Enhanced in situ reduction would be used in the G2 alternatives to meet groundwater cleanup levels. Chromium (VI) would be reduced to chromium (III) using either biological or chemical mechanisms. Groundwater would be expected to be available for use in two or three years after remedial construction begins but not as a source of potable water. No additional O&M would be required beyond the two to three-year remediation time frame. The groundwater plume would be monitored for 5 years.

Alternative G3 would passively treat chromium (VI)-contaminated groundwater before it migrates offsite. After PRB implementation, the site would be available for industrial redevelopment. Aside from several monitoring wells, there are no aboveground features that would interfere with reuse. O&M would be required for 30 years; it's possible that PRB rejuvenation might be required during this period. Groundwater would not be suitable for drinking water, and other beneficial uses may not be available for some time because chromium (VI) cleanup levels would not be met for 30 years.

Similar to Alternative G3, Alternative G4 would intercept chromium(VI)-contaminated groundwater before it migrated offsite. Groundwater would be collected, pumped to, and treated in an ex situ system before it is discharged to surface water or the local publicly owned treatment works. O&M would be required for 30 years. After installation of the system, the site could be available for industrial reuse; however, the treatment system must be considered in the site redevelopment plan. Groundwater would not be suitable for drinking water, and other beneficial uses may not be available for some time because chromium (VI) cleanup levels would not be met for 30 years.

9.3.4 Sediment Alternatives

No action would be taken to address metals-contaminated sediment in the 001 tidal creek in Alternative M1. Because contamination sources have been eliminated and the creek is a low-energy environment, natural processes such as sedimentation may reduce direct exposure of benthic organisms to the contaminated sediment. However, data are not currently available for sedimentation rates in the tidal creek. Therefore, it is not possible to quantify current natural sedimentation rates or to accurately estimate the time required to naturally cover existing sediments.

Alternative M2 enhances the natural sedimentation processes by installing baffles. Routine monitoring would be conducted to assess progress of site restoration. Benthic organisms would be expected to repopulate this site over time. O&M would be required for 10 years following implementation.

A sand cap would be placed over the contaminated sediment in Alternative M3 to reduce exposure pathways for the benthic community. Though waste materials would remain in place, benthic organisms would be expected to repopulate this site over time. O&M would be required for 30 years following implementation.

The contaminated sediment would be dredged in Alternative M4. Though dredging would eliminate benthic organisms in the area of application, species would be expected to recolonize the area.

9.3.5 Storm Water Alternative

A comprehensive storm water management plan would be implemented to reduce suspended solids concentrations in storm water discharges from the site and reduce water volume by diverting offsite runoff. This would result in significantly reduced metals concentrations at the outfalls. Storm water would be monitored for one year following implementation.

Table 9-2
Common Elements and Distinguishing Features of Each Alternative

Alt.	Long-Term Reliability	Waste Quantities	Time for Design and Construction	Time to Reach Cleanup Levels	Cost Estimates
Soil Alternatives					
S1	Not reliable.	Waste materials left in place.	None.	Not met.	C: $0 O&M: $10,000[a] P: $22,000
S2a	Reliable — contaminated materials treated onsite. Ex situ and in situ methods.	115,000 CY treated onsite. Reused as onsite fill.	6 months.	6 months.	C: $6,773,000 O&M: $0 P: $6,773,000
S2b	Reliable — contaminated materials treated onsite using mechanical mixing.	Same as above.	7 months.	7 months.	C: $7,883,000 O&M: $0 P: $7,883,000
S2c	Reliable — contaminated materials treated onsite using a pugmill.	Same as above.	7 months.	7 months.	C: $10,372,000 O&M: $0 P: $10,372,000
S3	Reliable — contaminated materials excavated and removed from site.	115,000 CY excavated and disposed of in a landfill.	6 months.	6 months.	C: $8,872,000 O&M: $0 P: $8,872,000
S4	Reliable — routine O&M required to maintain cap integrity.	55,000 CY treated and used as cap sub-base. 60,000 CY remains in place.	5 months.	5 months.	C: $6,259,000 O&M: $11,000[b] P: $6,681,000

Table 9-2
Common Elements and Distinguishing Features of Each Alternative

Alt.	Long-Term Reliability	Waste Quantities	Time for Design and Construction	Time to Reach Cleanup Levels	Cost Estimates
Radiological Material Alternatives					
R1	Not reliable.	Approximately 110 CY of gamma radiation-producing soil would remain in place.	None.	Not met.	C: $0 O&M: $5,000[a] P: $11,000
R2	Reliable — contaminated materials excavated and removed from site.	Approximately 110 CY of gamma radiation-producing soil would be excavated and disposed of offsite.	1 week.	1 week.	C: $15,000 O&M: $0 P: $15,000
R3	Reliable — routine O&M required to maintain cap integrity.	Waste would remain in place and covered with a soil cap.	1 week.	30 years.	C: $24,000 O&M: $1,400 P: $41,000
Groundwater Alternatives					
G1	Not reliable.	Waste materials left in place.	None.	Not met.	C: $40,000 O&M: $18,000[a] P: $79,000
G2a	Reliable — contaminated groundwater treated in situ with HRC. Chromium (III) to chromium (VI) re-oxidation is not expected.	All groundwater above chromium (VI) cleanup level will be addressed in situ	2 months.	2 years.	C: $1,462,000 O&M: $84,000 P: $1,672,000
G2b	Reliable — contaminated groundwater treated in situ with chemical reductant. Chromium (III) to chromium (VI) re-oxidation is not expected.	Same as above.	2 months.	2 years.	C: $1,843,000 O&M: $84,000 P: $2,053,000

Table 9-2
Common Elements and Distinguishing Features of Each Alternative

Alt.	Long-Term Reliability	Waste Quantities	Time for Design and Construction	Time to Reach Cleanup Levels	Cost Estimates
Groundwater Alternatives (continued)					
G2c	Reliable — contaminated groundwater treated in situ with carbon reductant. Chromium (III) to chromium (VI) re-oxidation is not expected.	Same as above.	1 month.	3 years.	C: $471,000 O&M: $192,000 P: $1,012,000
G3	Reliable and proven, though media replacement may be required. No source treatment.	Intercepts and treats chromium (VI)-contaminated groundwater before it migrates offsite.	1 month.	30 years.	C: $1,958,000 O&M: $51,000 P: $2,591,000
G4	Historically reliable and effective. No source treatment.	Intercepts chromium (VI)-contaminated groundwater before it migrates offsite Treats ≈35 gpm in ex situ system.	1 month.	30 years	C: $655,000 O&M: $99,000 P: $1,883,000
Sediment Alternatives					
M1	Relies on natural processes to reduce risk.	Waste materials (≈1,000 CY) left in place.	None.	Not met.	C: $0 O&M: $12,000[a] P: $26,000
M2	Relies on enhanced sedimentation to reduce risks. Reliability would be evaluated during implementation and O&M period.	Waste materials (≈1,000 CY) left in place.	2 weeks.	10 years.	C: $50,000 O&M: $82,000 P: $626,000

Table 9-2
Common Elements and Distinguishing Features of Each Alternative

Alt.	Long-Term Reliability	Waste Quantities	Time for Design and Construction	Time to Reach Cleanup Levels	Cost Estimates
Sediment Alternatives (continued)					
M3	Long-term effectiveness of this alternative is a function of ecological recovery and prosperity and cap integrity.	Waste materials (≈1,000 CY) left in place. Cap would be placed over contaminated materials.	1 month.	30 years.	C: $498,000 O&M: $5,000[c] P: $559,000
M4	Dredging eliminates potential long-term risk to benthic organisms and the overall ecology posed by the contaminated sediments.	Waste materials (≈1,000 CY) dredged, dewatered, and managed with soil.	1 month.	1 month.	C: $492,000 O&M: $0 P: $492,000

Notes:
(a) Every 5 years.
(b) $732,000 at year 15.
(c) Annual costs during years 1-3, 5, and 10 with an additional $52,000 at year 10.
C = capital cost
CY = cubic yards
O&M = annual operations and maintenance costs
P = present worth

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10.0 COMPARATIVE ANALYSIS OF ALTERNATIVES

Nine evaluation criteria have been developed to address the CERCLA requirements and considerations, and to address the additional technical and policy considerations that have proven important for selecting among remedial alternatives. These evaluation criteria serve as the basis for conducting the detailed analysis during the FS and selecting an appropriate remedial action. The NCP provides that the ROD must explain how the nine criteria were used to select the remedy (NCP 300.430[f][5][i]). The major objective is to evaluate the relative performance of the alternatives with respect to the nine evaluation criteria so that the advantages and disadvantages of each are clearly understood.

Evaluation Criteria

Threshold Criteria

- Overall protection of human health and the environment
- Compliance with applicable or relevant and appropriate requirements (ARARs)

Balancing Criteria

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

Modifying Criteria

- State acceptance
- Community acceptance

Each alternative is evaluated according to the above criteria, as described in the following sections. The comparison for each medium is also summarized in Tables 10-1 to 10-4 at the end of this section.

10.1 Threshold Criteria

Alternatives must meet two threshold criteria to be considered: overall protection of human health and the environment and compliance with ARARs.

10.1.1 Overall Protection of Human Health and the Environment

This criterion addresses whether each alternative adequately protects human health and the environment and describes how risks posed through each exposure pathway are eliminated, reduced, or controlled through treatment, engineering controls, and/or institutional controls.

All of the alternatives, except the no-action alternatives (S1, R1, G1, and M1), would provide adequate protection of human health and the environment. Because the no-action alternatives are not considered adequately protective, they were eliminated from consideration under the remaining eight criteria in this ROD.

Soil Alternatives S2a, S2b, and S2c provide protection of human health and the environment through treatment by reducing chromium (VI) to chromium (III), which is less toxic and mobile. Soil Alternative S3 provides protection by removing contaminated soil from the site and disposing of it in a landfill. Soil Alternative S4 protects by minimizing infiltration of water and thus the leaching of soil contaminants to groundwater; however, long-term maintenance and monitoring would be required to ensure that the cap remained effective.

Radiological material Alternative R2 eliminates direct exposure to radiological material by removing it from the site. Alternative R3 minimizes exposure by capping; however, long-term maintenance of the cap is required to ensure protectiveness.

All of the groundwater alternatives would eliminate human and environmental risks from direct contact with contaminated groundwater through treatment. Alternatives G2a, G2b, and G2c reduce chromium (VI) in the groundwater to chromium (III). Alternatives G3 and G4 prevent migration of chromium (VI) to Shipyard Creek, but do not include source area treatment.

Sediment capping Alternatives M2 and M3 protect the environment by reducing benthic organism exposure to contaminants. M2 is natural capping by enhanced sedimentation and M3 is an engineered cap. Both require monitoring to ensure the cap's effectiveness. Alternative M4 offers protection by removing contaminated sediments through dredging and upland disposal.

10.1.2 Compliance with ARARs

Section 121(d) of CERCLA and NCP §300.430(f)(1)(ii)(B) require that remedial actions at CERCLA sites at least attain legally applicable or relevant and appropriate federal and state requirements, standards, criteria, and limitations, collectively referred to as ARARs, unless such ARARs are waived under CERCLA Section 121(d)(4).

Applicable requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that specifically address a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance found at a CERCLA site. Relevant and appropriate requirements are those cleanup standards, standards of control, and other substantive requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting laws that, while not applicable to a hazardous substance, pollutant, contaminant, remedial action, location, or other circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well-suited to the particular site. Only those state standards that are identified in a timely manner and are more stringent than federal requirements may be applicable or relevant and appropriate.

The "compliance with ARARs criterion" addresses whether a remedy will meet all applicable or relevant and appropriate requirements of other federal and state environmental statutes or provides a basis for a invoking waiver. Except for the no action alternatives, all remedial alternatives would meed their respective ARARs from federal and state laws. Key ARARs for the alternatives evaluated for the Macalloy Site are presented in Tables 10-5 to 10-7.

10.2 Balancing Criteria

10.2.1 Long-Term Effectiveness and Permanence

Long-term effectiveness and permanence refers to expected residual risk and the ability of a remedy to maintain reliable protection of human health and the environment over time once cleanup levels have been met. This criterion includes the consideration of residual risk that will remain onsite following remediation and the adequacy and reliability of controls.

Soil Alternatives S2a, S2b, S2c, and S3 would eliminate the threats to site groundwater posed by the leaching of chromium (VI) from soil. Further controls would not be necessary to ensure long-term effectiveness and permanence. (Groundwater monitoring as part of the groundwater remedy would be used to assess the effectiveness of the S2 alternatives.) Alternative S4 (capping) would minimize the leaching of contaminants to groundwater; however, long-term maintenance and monitoring would be necessary to ensure long-term effectiveness and permanence.

Contaminant removal Alternatives R2 (radiological materials) and M4 (sediment) reduce threats without additional long-term controls. Capping Alternatives R3, M2, and M3 require monitoring to ensure long-term effectiveness and permanence.

Groundwater Alternatives G2a, G2b, and G2c would reduce threats to human health and the environment without needing long-term controls to ensure long-term effectiveness and permanence. Groundwater monitoring would be required for five years. Alternatives G3 and G4 prevent offsite migration of contaminants but do not address source contamination. Long-term operation, maintenance, and monitoring of Alternatives G3 and G4 would be required to ensure long-term effectiveness.

10.2.2 Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment

The S2 soil alternatives would reduce the toxicity and mobility of contaminated site soil through treatment. Although some reduction in toxicity and mobility is expected with S3 (pretreatment may be required prior to disposal) and S4 (treatment of the berm material and isolated areas), these alternatives do not incorporate treatment into the remedy to the same degree as the S2 alternatives. All of the groundwater alternatives achieve some reduction in toxicity, mobility, or volume through treatment. However, Alternatives G3 and G4 also require containment as part of the remedy. Treatment is not a component of any of the radiological material or sediment alternatives.

10.2.3 Short-Term Effectiveness

Short-term effectiveness addresses the period of time needed to implement the remedy and any adverse impacts on workers, the community, or the environment during construction and operation of the remedy until cleanup levels are achieved.

All soil alternatives involve some excavation of contaminated soil and thus present some potential for short-term exposure. Alternative S3 also presents short-term risk during transportation to an offsite disposal facility. The contaminants are not volatile so the risk of release is principally limited to wind-blown soil transport or surface water runoff. Control of dust and runoff will limit the amount of material that may migrate to a potential receptor.

Radiological materials alternative R2 presents greater short-term risks since material is excavated and transported offsite. However, these risks can be effectively managed with proper engineering controls and health and safety protocols.

Precautions taken during the construction of groundwater alternatives would eliminate any short-term risk to the public. Short-term risks to workers associated with normal construction hazards and potential contact with contaminated water would be eliminated through appropriate controls and adherence to proper health and safety protocols.

Sediment Alternatives M3 and M4 pose a greater short-term risk to the environment than M2, which relies on natural processes to reduce risks. M3 and M4 will result in short-term elimination of benthic organisms in the creek. M3 will also replace the tidal creek habitat with tidal marsh. Dredging could result in possible contamination of the water column or impact adjoining wetlands. However, these risks can be minimized with proper engineering controls during dredging.

10.2.4 Implementability

Implementability addresses the technical and administrative feasibility of a remedy from design through construction and operation. Factors such as availability of services and materials, administrative feasibility, and coordination with other governmental entities are also considered. All technologies and remedies are readily available and generally proven. All alternatives have few associated administrative difficulties.

10.2.5 Cost

Alternative S4 is the least costly of the soil alternatives, although it requires long-term maintenance to ensure long-term effectiveness. R2 is the least costly radiological material remedy and Alternative M4 is the least costly sediment remedy. Groundwater Alternatives G2 and G4 are less costly than Alternative G3. However, Alternative G4 provides containment only and requires long-term operation and maintenance.

10.3 Modifying Criteria

10.3.1 State Agency Acceptance

The SCDHEC has reviewed the Proposed Plan and ROD and concurs with the EPA's Selected Remedy presented in Section 12. SCDHEC's concurrence letter is in Appendix B of this ROD.

10.3.2 Community Acceptance

A 60 day public comment period on EPA's Proposed Plan was conducted from April 11 to June 10, 2002. During this time frame, EPA received written comments from five entities which included: the Honorable Keith Summey (Mayor of North Charleston), the Macalloy Corporation, the South Carolina Department of Natural Resources, SCDHEC's Office of Ocean and Coastal Resource Management, and CSX Transportation. After full consideration of these written comments, EPA does not believe significant or fundamental changes to the Proposed Plan remedy components are warranted. EPA's individual responses to specific comments received are provided in the Responsiveness Summary, which is Part III of this ROD.

Table 10-1
Comparative Analysis of Soil Alternatives

Evaluation Criteria	Alternative S1	Alternative S2	Alternative S3	Alternative S4
Threshold Criteria				
Overall protectiveness				
Human health	No risk reduction.	Protects by reducing chromium (VI) to chromium (III), which is less toxic and mobile. Soil concentrations would be reduced to below the cleanup level.	Protects by removing contaminants from the site. Very effective and reliable.	Protects by minimizing infiltration of water and leaching of contaminants to groundwater.
Environment	No risk reduction.	Protects by reducing chromium (VI) to chromium (III) in vadose zone soil that could leach to groundwater and surface water.	Protects by removing contaminants from the site that could leach to groundwater and surface water. Very effective and reliable.	Protects by minimizing infiltration of water and leaching of contaminants to groundwater and surface water.
Compliance with ARARs				
Chemical-specific ARARs	Does not comply with chemical-specific ARARs.	Meets chemical-specific ARARs.	Same as Alternative S2.	Same as Alternative S2.
Location-specific ARARs	No location-specific ARARs are triggered.	Meets location-specific ARARs.	Same as Alternative S2.	Same as Alternative S2.
Action-specific ARARs	No action-specific ARARs are triggered.	Meets action-specific ARARs.	Same as Alternative S2.	Same as Alternative S2.

Table 10-1
Comparative Analysis of Soil Alternatives

Evaluation Criteria	Alternative S1	Alternative S2	Alternative S3	Alternative S4
Balancing Criteria				
Long-term effectiveness and permanence				
Magnitude of residual risk	Contaminated soil volume and chromium (VI) concentrations would remain unchanged, except for intrinsic attenuation.	Long-term effectiveness is expected via onsite chemical reduction and s/s. Reoxidation of chromium (III) to chromium (VI) is not expected.	Excavation and offsite disposal eliminates site risk effectively and permanently.	Effectively minimizes leaching of chromium (VI) to groundwater and surface water. Because contaminated soil remains onsite, maintenance will be required to ensure effectiveness.
Adequacy and reliability of controls	No controls over remaining contamination. No reliability. Chromium (VI) would remain onsite above cleanup levels.	Demonstrated treatment technology. Chromium (VI) concentrations are expected to be reduced to below the cleanup level. Re-oxidation of chromium (III) to chromium (VI) is not expected.	Very reliable because contaminated soil is removed from the site and placed in a secure landfill with modern controls.	Caps are reliable controls but require long-term maintenance to ensure effectiveness.
Reduction of toxicity, mobility, or volume through treatment				
Treatment process used	None. Degradation of site contaminants is left to natural attenuation processes.	Chemical reduction and s/s.	Some pretreatment by chemical reduction may be required prior to disposal to meet land disposal restrictions.	Berm material and isolated areas would be treated by chemical reduction and s/s for use as a cap base or fill material.
Amount destroyed or treated	None.	115,000 cubic yards of vadose zone soil and berm material exceeding the cleanup level would be treated onsite.	It is estimated that 25% of the vadose zone (15,000 cubic yards) would require pretreatment prior to disposal.	Approximately 56,500 cubic yards of berm material and isolated exceedances would be treated for use as a cap base or fill material.

Table 10-1
Comparative Analysis of Soil Alternatives

Evaluation Criteria	Alternative S1	Alternative S2	Alternative S3	Alternative S4
Balancing Criteria (continued)				
Reduction of toxicity, mobility, or volume through treatment (continued)				
Reduction of toxicity, mobility, or volume	None.	Toxicity and mobility are reduced by chemical reduction and s/s. Soil volume may increase.	May require pretreatment prior to disposal, which would reduce toxicity and mobility.	Berm material and isolated exceedances would be treated for use in the cap or as fill material.
Irreversible treatment	Not applicable.	Re-oxidation of chromium (III) to chromium (VI) is not expected.	Same as Alternative S2.	Same as Alternative S2.
Type and quantity of residuals remaining after treatment	Chromium (VI)-contaminated soil remains onsite.	None.	None.	Chromium (VI)-contaminated soil remains onsite.
Short-term effectiveness				
Community protection	Offers no additional community protection.	Minor increase in dust during construction activities.	Same as Alternative S2.	Same as Alternative S2.
Worker protection	No risk to workers.	No short-term risks are anticipated with proper PPE and health and safety procedures.	Same as Alternative S2.	Same as Alternative S2.
Environmental impacts	Continued impact from existing conditions.	Excavation and construction activities would require engineering controls to minimize impacts to adjacent wetlands and water bodies.	Same as Alternative S2.	Same as Alternative S2.

Table 10-1
Comparative Analysis of Soil Alternatives

Evaluation Criteria	Alternative S1	Alternative S2	Alternative S3	Alternative S4
Balancing Criteria (continued)				
Short-term effectiveness (continued)				
Time until remedial action is complete	Not applicable.	After the final design, this alternative is expected to take approximately 5 to 7 months to implement.	After the final design, this alternative is expected to take approximately 6 months to implement.	After the final design is complete, this alternative is expected to take approximately 4 to 5 months to implement. O&M for 30 years.
Implementability				
Ability to construct and operate	No construction or operation.	Easy to construct and operate.	Same as Alternative S2.	Same as Alternative S2.
Ease of additional action if needed	May require ROD amendment if future problems arise.	Additional soil could be treated in situ or ex situ. Remobilization costs would be incurred.	Additional soil could be excavated and disposed of offsite. Remobilization costs would be incurred.	The cap could be extended if needed. Additional mobilization costs would be incurred.
Ability to monitor effectiveness	Not applicable.	Confirmation sampling would ensure that treated soil meets the cleanup level.	Confirmation sampling would ensure that contaminated soil exceeding the cleanup level was excavated for offsite disposal.	Additional delineation sampling would ensure that soil exceeding the cleanup level was capped.
Ability to obtain approvals and coordinate with other agencies	No approval necessary.	Easily obtained.	Same as Alternative S2.	Same as Alternative S2.
Availability of equipment, specialist, and materials	None required.	No special equipment necessary. Equipment readily available.	Same as Alternative S2.	Same as Alternative S2.

Table 10-1
Comparative Analysis of Soil Alternatives

Evaluation Criteria	Alternative S1	Alternative S2	Alternative S3	Alternative S4
Balancing Criteria (continued)				
Implementability (continued)				
Availability of technologies	None required.	Technology readily available. Will require pilot testing.	Technology readily available.	Same as alternative S3.
Cost				
Capital cost	None	$6,773,000 to $10,372,000	$8,872,000	$6,259,000
Annual cost	$10,000 (every 5 years)	None	None	$11,000 (for 30 years); $723,000 at year 15
Present worth cost	$22,000	$6,773,000 to $10,372,000	$8,872,000	$6,681,000
Modifying Criteria				
State acceptance	SCDHEC will have opportunity to review and comment on this technology. Acceptance unlikely.	SCDHEC will have opportunity to review and comment on this technology. Acceptance likely.	Same as Alternative S2.	Same as Alternative S2.
Community acceptance	Community acceptance will be established after the public comment period. Acceptance unlikely.	Community acceptance will be established after the public comment period. Acceptance likely.	Same as Alternative S2.	Same as Alternative S2.

Notes:
Alternative S1 = No action
Alternative S2 = Onsite chemical reduction and stabilization/solidification
Alternative S3 = Excavation with offsite disposal
Alternative S4 = Hot mix asphalt cap

Table 10-2
Comparative Analysis of Radiological Material Alternatives

Evaluation Criteria	Alternative R1	Alternative R2	Alternative R3
Threshold Criteria			
Overall protectiveness			
Human health	No risk reduction.	Excavation and offsite disposal protects human health by removing soil and debris that produce gamma radiation above background levels. Risk from direct exposure to radioactive materials would be eliminated.	The soil and vegetative cover would protect human health by minimizing critical exposure pathways.
Environment	No risk reduction.	Risk from direct exposure to radioactive materials would be eliminated.	Same as Alternative R2.
Compliance with ARARs			
Chemical-specific ARARs	May not comply with chemical-specific ARARs. A site-specific risk assessment would be required to assess whether exposed populations would be at risk.	Meets chemical-specific ARARs.	Same as Alternative R2.
Location-specific ARARs	No location-specific ARARs are triggered.	Meets location-specific ARARs.	Same as Alternative R2.
Action-specific ARARs	No action-specific ARARs are triggered.	Meets action-specific ARARs.	Same as Alternative R2.
Balancing Criteria			
Long-term effectiveness and permanence			
Magnitude of residual risk	Source not addressed. Existing risk remains.	No risk would remain after radioactive soil and debris are removed.	Risk reduced as long as cap is adequately maintained.
Adequacy and reliability of controls	No controls over remaining radioactive materials. No reliability.	Though landfill disposal would be extremely reliable, future liability could be incurred.	A maintained cap would adequately and reliably control exposure to radioactive soil and debris.

Table 10-2
Comparative Analysis of Radiological Material Alternatives

Evaluation Criteria	Alternative R1	Alternative R2	Alternative R3
Balancing Criteria (continued)			
Reduction of toxicity, mobility, or volume through treatment			
Treatment process used	None.	None. Excavation and offsite disposal would be used.	None. Capping would be used.
Amount destroyed or treated	None.	None.	None.
Reduction of toxicity, mobility, or volume	None. Contaminants would remain untreated and in place.	None; onsite radioactive material would be excavated and disposed of offsite.	None. Exposure minimized.
Irreversible treatment	Not applicable.	Not Applicable.	Not applicable.
Type and quantity of residuals remaining after treatment	Radioactive soil and debris would remain onsite.	No radioactive soil or debris producing gamma radiation above cleanup levels would remain onsite.	Though covered/contained to minimize exposure, radioactive soil and debris would remain onsite.
Short-term effectiveness			
Community protection	No additional community protection.	Minor increase in dust during construction activities.	Minor increase in dust during construction activities.
Worker protection	No risk to workers.	Worker risk would be minimized with dust suppression and radiation monitoring.	Same as Alternative R2.
Environmental impacts	Continued impact from existing conditions.	Minimal.	Same as Alternative R2.
Time until remedial action is complete	Not applicable.	Less than one week.	Less than one week.

Table 10-2
Comparative Analysis of Radiological Material Alternatives

Evaluation Criteria	Alternative R1	Alternative R2	Alternative R3
Balancing Criteria (continued)			
Implementability			
Ability to construct and operate	No construction or operation.	Easy to implement.	Same as Alternative R2.
Ease of additional action if needed	May require ROD amendment if future problems arise.	Easy to increase excavated quantity if necessary.	Easy to extend cap if necessary.
Ability to monitor effectiveness	No monitoring.	Radiation screening would be used during excavation to ensure removal of soil and debris producing gamma radiation above cleanup levels.	Radiation screening would be used during cap construction to ensure soil and debris producing gamma radiation above cleanup levels are covered. Cap would be routinely monitored.
Ability to obtain approvals and coordinate with other agencies	No approval necessary.	Same as Alternative R1.	Same as Alternative R1.
Availability of equipment, specialist, and materials	None required.	No special equipment or materials required.	Same as Alternative R2.
Availability of technologies	None required.	Technology is readily available.	Same as Alternative R2.
Cost			
Capital cost	None	$15,000	$24,000
Annual O&M cost	$5,000 (every 5 years)	None	$1,400
Present worth cost	$11,000	$15,000	$41,000

Table 10-2
Comparative Analysis of Radiological Material Alternatives

Evaluation Criteria	Alternative R1	Alternative R2	Alternative R3
Modifying Criteria			
State acceptance	SCDHEC will have an opportunity to review and comment on this technology. Regulatory approval of this alternative is unlikely without an assessment that demonstrates that risks are acceptable.	SCDHEC will have an opportunity to review and comment on this technology.	Same as Alternative R2.
Community acceptance	Community acceptance will be determined after the public-comment period. Community acceptance of this alternative is unlikely without an assessment that demonstrates that risks are acceptable.	Community acceptance will be determined after the public-comment period.	Same as Alternative R2.

Notes:
Alternative R1 = No action
Alternative R2 = Excavation with offsite disposal
Alternative R3 = Soil cover

Table 10-3
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4
Threshold Criteria				
Overall protectiveness				
Human health	No risk reduction.	Reduction of chromium (VI) to cleanup levels would minimize risk to future site users.	Protects human health by intercepting chromium (VI) before it migrates offsite. However, groundwater exceeding cleanup levels would remain in source areas.	Same as Alternative G3.
Environment	No risk reduction.	Migration of chromium (VI) to Shipyard Creek and risk to the environment would be minimized by reducing chromium (VI) to chromium (III), which is less toxic and mobile.	Migration of chromium (VI) to Shipyard Creek and risk to the environment would be minimized by intercepting chromium (VI) before it migrates offsite.	Same as Alternative G3.
Compliance with ARARs				
Chemical-specific ARARs	Does not comply with chemical-specific ARARs.	Meets chemical-specific ARARs.	Same as Alternative G2.	Same as Alternative G2.
Location-specific ARARs	No location-specific ARARs are triggered.	Meets location-specific ARARs.	Same as Alternative G2.	Same as Alternative G2.
Action-specific ARARs	No action-specific ARARs are triggered.	Meets action-specific ARARs.	Same as Alternative G2.	Same as Alternative G2.

Table 10-3
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4
Balancing Criteria				
Long-term effectiveness and permanence				
Magnitude of residual risk	Contaminated groundwater volume and chromium (VI) concentrations would remain unchanged, except for intrinsic attenuation.	Risk reduction and long-term effectiveness of enhanced in situ reduction is expected to be exceptional, particularly if source materials are removed or targeted in the design.	Reactive media are expected to have long-term treatment capacity. Risk minimized by containing chromium (VI) migration.	Groundwater contaminant migration is expected to be arrested by the containment system. Risk minimized by containing chromium (VI) migration.
Adequacy and reliability of controls	No controls over remaining contamination. No reliability. Chromium (VI) would remain onsite above cleanup levels.	Demonstrated treatment technology. Chromium (VI) concentrations are expected to be reduced to below cleanup levels within three years. Reoxidation of chromium (III) to chromium (VI) is not expected.	Demonstrated treatment technology. Reactive media rejuvenation may be necessary. Reoxidation of chromium (III) to chromium (VI) is not expected. Although chromium (VI) would remain onsite above the cleanup level, shallow groundwater is not expected to be used as drinking water.	Groundwater collection, pump, and treat is a reliable containment technology. Although chromium (VI) would remain onsite above the cleanup level, shallow groundwater is not expected to be used as drinking water.
Reduction of toxicity, mobility, or volume through treatment				
Treatment process used	None. Degradation of site contaminants is left to natural attenuation processes.	Enhanced in situ reduction.	Chromium (VI) reduction to chromium (III) using zero-valent iron.	Groundwater containment and ex situ chromium (VI) reduction using ferrous sulfate.
Amount destroyed or treated	None.	>99% of chromium (VI) would be biologically or chemically reduced to chromium (III), which is less mobile and toxic.	>99% of chromium (VI) would be reduced to chromium (III) before groundwater migrates offsite. No source treatment.	>99% of chromium (VI) would be reduced to chromium (III) in ex situ treatment process. No in situ treatment.

Table 10-3
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4
Balancing Criteria (continued)				
Reduction of toxicity, mobility, or volume through treatment (continued)				
Reduction of toxicity, mobility, or volume	None.	Toxicity, mobility, and volume would be reduced by enhancing already occurring natural attenuation processes.	Chromium (VI) mobility would be reduced via containment. Minimal toxicity and volume reductions because source area would be unaffected.	Same as Alternative G3.
Irreversible treatment	Not applicable.	Reoxidation of chromium (III) to chromium (VI) is not expected.	Same as Alternative G2.	Same as Alternative G2.
Type and quantity of residuals remaining after treatment	Chromium (VI)-contaminated groundwater remains onsite.	None.	Same as Alternative G1.	Same as Alternative G1.
Short-term effectiveness				
Community protection	Offers no additional community protection.	Minor increase in dust during construction activities.	Same as Alternative G2.	Same as Alternative G2.
Worker protection	No risk to workers.	No short-term risks are anticipated with proper PPE and health and safety procedures.	No short-term risks are anticipated with proper PPE and health and safety procedures. No open-trench hazards associated with one-pass trencher.	Same as Alternative G3.
Environmental impacts	Continued impact from existing conditions.	Minimal.	Minimal.	Minimal.
Time until remedial action is complete	Not applicable.	Including pilot-study, construction complete in less than one year. Treatment complete in three years.	Construction complete in approximately three weeks. Containment required for at least 30 years.	Same as Alternative G3.

Table 10-3
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4
Balancing Criteria (continued)				
Implementability				
Ability to construct and operate	No construction or operation.	Easy to implement and operate.	Same as G2.	Same as G2.
Ease of additional action if needed	May require ROD amendment if future problems arise.	Easy to install additional DPT point or monitoring wells if necessary.	PRB could be extended if necessary. Additional mobilization costs would be incurred. Additional DPT points or monitoring wells can be installed in the concentrator area if necessary.	Collection trenches could be extended if necessary. Additional mobilization costs would be incurred.
Ability to monitor effectiveness	Groundwater monitoring event every five years.	Groundwater monitoring would help gauge system efficacy.	Same as Alternative G2.	Same as Alternative G2.
Ability to obtain approvals and coordinate with other agencies	No approval necessary.	Easily obtained.	Same as Alternative G2.	Must demonstrate compliance with discharge permits.
Availability of equipment, specialist, and materials	None required.	No special equipment necessary. Equipment readily available.	Trenching equipment and ZVI-PRB specialists are readily available.	Trenching equipment is readily available.
Availability of technologies	None required.	Technology readily available. Will require pilot testing.	Technology readily available.	Same as alternative G3.
Cost				
Capital cost	$40,000	$471,000 to $1,843,000	$1,958,000	$655,000
Annual O&M cost	$18,000 (every 5 years)	$84,000 to $192,000	$51,000	$99,000
Present worth cost	$79,000	$1,012,000 to $2,053,000	$2,591,000	$1,883,000

Table 10-3
Comparative Analysis of Groundwater Alternatives

Evaluation Criteria	Alternative G1	Alternative G2	Alternative G3	Alternative G4
Modifying Criteria				
State acceptance	SCDHEC will have an opportunity to review and comment on this technology. Regulatory reluctance is expected.	SCDHEC will have an opportunity to review and comment on this technology. Acceptance is likely.	Same as Alternative G2.	Same as Alternative G2.
Community acceptance	Community acceptance would be established after comment period. Community reluctance is expected.	Community acceptance will be determined after the public-comment period. Acceptance is likely.	Same as Alternative G2.	Same as Alternative G2.

Notes:
Alternative G1 = No action
Alternative G2 = Enhanced in situ reduction
Alternative G3 = ZVI-PRB with enhanced in situ reduction
Alternative G4 = Groundwater containment

Table 10-4
Comparative Analysis of Sediment Alternatives

Evaluation Criteria	Alternative M1	Alternative M2	Alternative M3	Alternative M4
Threshold Criteria				
Overall protectiveness				
Human health	No human health risks were identified in the RI for contaminated sediments in the 001 tidal creek.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.
Environment	No risk reduction except through natural processes such as dispersion or sedimentation.	Risk reduction through natural processes such as dispersion or sedimentation. Natural processes are enhanced, if needed, by adding barriers to increase sedimentation rates. This alternative includes extensive monitoring of conditions so that another alternative can be selected if the RAO is not met.	Protects by reducing exposure of benthic organisms to contaminated sediments. Loss of ecological tidal habitat is expected.	Protects by removing contaminants from the site that pose a risk to benthic organisms.
Compliance with ARARs				
Chemical-specific ARARs	Complies with ARARs.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.
Location-specific ARARs	Complies with ARARs.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.
Action-specific ARARs	Complies with ARARs.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.

Table 10-4
Comparative Analysis of Sediment Alternatives

Evaluation Criteria	Alternative M1	Alternative M2	Alternative M3	Alternative M4
Balancing Criteria				
Long-term effectiveness and permanence				
Magnitude of residual risk	Contaminated sediment mobility and COC concentrations would remain unchanged, except for natural processes such as dispersion and sedimentation.	Contaminated sediment mobility and COC concentrations would remain unchanged except for natural processes such as dispersion and sedimentation. If needed, sedimentation will be enhanced to increase sedimentation rates.	Effective at minimizing exposure to contaminated sediments. Because contaminated sediment may remain onsite, maintenance will be required to ensure effectiveness.	Excavation and disposal eliminates risk onsite effectively and permanently.
Adequacy and reliability of controls	No controls over remaining contamination. Limited reliability.	This alternative provides for monitoring of the conditions in the creek so that another alternative can be selected if the RAO is not met.	Caps are reliable controls but require long-term maintenance to ensure effectiveness.	Very reliable because contaminated sediment is removed, treated if needed, and placed in a secure area.
Reduction of toxicity, mobility, or volume through treatment				
Treatment process used	None. Reduction of site contaminants is left to natural attenuation processes.	None.	None.	None.
Amount destroyed or treated	None.	None.	None.	None.

Table 10-4
Comparative Analysis of Sediment Alternatives

Evaluation Criteria	Alternative M1	Alternative M2	Alternative M3	Alternative M4
Balancing Criteria (continued)				
Reduction of toxicity, mobility, or volume through treatment (continued)				
Reduction of toxicity, mobility, or volume	None.	None.	None.	Dredged sediment may be treated onsite with contaminated soil.
Irreversible treatment	Not applicable.	Not applicable.	Not applicable.	Dredged sediment may be treated onsite with contaminated soil.
Type and quantity of residuals remaining after treatment	Not applicable.	Not applicable.	Not applicable.	Dredged sediment may be treated onsite with contaminated soil.
Short-term effectiveness				
Community protection	Offers no additional community protection.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.
Worker protection	No risk to workers.	Same as Alternative M1.	No short-term risks are anticipated with proper PPE and health and safety procedures.	Same as Alternative M3.
Environmental impacts	Continued potential impact from existing conditions.	Same as alternative M1.	Implementation of the cap could result in short-term elimination of benthic organisms. It will also impact the tidal creek ecological habitat.	Dredging will result in short-term elimination of benthic organisms and possible contamination of the water column. It may also impact the adjoining marsh wetlands.

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Table 10-4
Comparative Analysis of Sediment Alternatives

Evaluation Criteria	Alternative M1	Alternative M2	Alternative M3	Alternative M4
Balancing Criteria (continued)				
Short-term effectiveness (continued)				
Time until remedial action is complete	Not enough data to predict.	Not enough data to predict.	After the final design, this alternative is expected to take approximately 4 weeks to implement.	After the final design is complete, this alternative is expected to take approximately 4 weeks to implement.
Implementability				
Ability to construct and operate	No construction or operation.	Same as Alternative M1.	Easy to construct and operate.	More complicated to construct.
Ease of additional action if needed	May require ROD amendment if future problems arise.	Monitoring plan would allow for implementation of another alternative if enhanced recovery does not meet the RAO.	The cap could be extended if needed. Additional mobilization costs would be incurred.	Additional sediment could be removed and disposed of upland. Remobilization costs would be incurred.
Ability to monitor effectiveness	NCP 5-year reviews required.	Annual sampling would be required to monitor effectiveness.	Long-term O&M required to monitor cap integrity.	System monitoring during implementation. No long-term O&M required.
Ability to obtain approvals and coordinate with other agencies	No approval necessary.	Easily obtained.	Dredge/fill permits required.	Same as Alternative M3.
Availability of equipment, specialist, and materials	None required.	Readily available.	Readily available.	Readily available.
Availability of technologies	None required.	Technology readily available.	Technology readily available.	Technology readily available.

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Table 10-4
Comparative Analysis of Sediment Alternatives

Evaluation Criteria	Alternative M1	Alternative M2	Alternative M3	Alternative M4
Balancing Criteria (continued)				
Cost				
Capital cost	None	$50,000	$498,000	$492,000
Annual O&M cost	$12,000 (every 5 years)	$82,000	$5,000 (years 1-3, 5, and 10) $52,000 (cap repair: year 10)	$0
Present worth cost	$26,000	$626,000	$559,000	$492,000
Modifying Criteria				
State acceptance	SCDHEC will have opportunity to review and comment on this technology.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.
Community acceptance	Community acceptance will be established after the public-comment period.	Same as Alternative M1.	Same as Alternative M1.	Same as Alternative M1.

Notes:
Alternative M1 = No action
Alternative M2 = Enhanced monitored natural recovery
Alternative M3 = Cap
Alternative M4 = Removal with upland disposal

Table 10-5
Summary of Potential Chemical-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
Federal Requirements			
Safe Drinking Water Act MCLs *40 CFR 141.11 - 141.16*	Relevant and Appropriate	MCLs have been set for toxic compounds as enforceable standards for public drinking water systems. SMCLs are unenforceable goals regulating the aesthetic quality of drinking water.	Available data indicate that shallow aquifer water quality does not meet the primary and secondary drinking water standards promulgated under the SDWA. However, South Carolina Water Classifications and Standards, SC R.61-68, classify all groundwater as GB (a potential underground source of drinking water).
Safe Drinking Water Act MCLGs *40 CFR 141.50-141.51*	Relevant and Appropriate	MCLGs are unenforceable goals under the SDWA.	Available data indicate that shallow aquifer water quality does not meet the primary and secondary drinking water standards promulgated under the SDWA. However, South Carolina Water Classifications and Standards, R.61-68, classify all groundwater as GB (a potential underground source of drinking water).
Clean Water Act Federal Water Quality Criteria *51 Federal Register 43665*	Applicable	Effluent limitations must meet Best Achievable Technology. Ambient Water Quality Criteria are provided for toxic chemicals.	Discharges to water bodies during remedial activities would have AWQC as potential goals.

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Table 10-5
Summary of Potential Chemical-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
State Requirements			
South Carolina Drinking Water Regulations *SC R.61-58.5*	Relevant and Appropriate	Establishes primary and secondary MCLs as well as sampling and analytical requirements.	Available data indicate that shallow aquifer water quality does not meet the primary and secondary drinking water standards promulgated under the SDWA. However, South Carolina Water Classifications and Standards, SC R.61-68, classify all groundwater as GB (a potential underground source of drinking water).
South Carolina Water Classification and Standards *SC R.61-68*	Applicable	Establishes a system and rules for managing and protecting the quality of South Carolina surface water and groundwater.	Remedial objectives require protection of surface water and groundwater.

Table 10-6
Summary of Potential Location-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
Federal Requirements			
CERCLA *104, 106, 107, 120, 121, 122*	Applicable	Regulations controlling inactive hazardous waste sites.	Applicable as some form of remedial action is likely required at Macalloy.
National Environmental Policy Act *40 CFR Part 6, Appendix A*	Applicable	Sets forth USEPA policy carrying out the provisions of Executive Order 11988, Flood Plain Management Policy, and Executive Order 11990, Wetlands Protection Policy.	The Macalloy site is located within a 100-year floodplain and abuts wetlands areas.
Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) *33 CFR Part 320 to Part 330* *40 CFR 6.302*	Applicable	Fish and wildlife must be protected from actions modifying streams or areas affecting streams.	Construction activities, particularly storm/surface water management strategy modifications, must meet these requirements.
RCRA Location Requirements *40 CFR 264.18*	Relevant and Appropriate	Sets forth minimum requirements for design, construction, and operation of a facility where treatment, storage, or disposal of hazardous waste will be within a 100-year floodplain.	If treatment of hazardous waste is required onsite, and treatment occurs within the 100-year floodplain, RCRA location requirements may be relevant and appropriate.

Table 10-6
Summary of Potential Location-Specific ARARs

Requirements	**Status**	**Requirement Synopsis**	**Application to the Remedial Alternatives**
State Requirements			
Ocean and Coastal Resource Management *SC R 30*	Applicable	Serves to protect and enhance the state's coastal resources.	Remediation activities and storm water must be managed in accordance with these requirements.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities: Location Standards *SC R 61-79*.264.18	Relevant and Appropriate	Sets forth minimum requirements for design, construction, and operation of a facility where treatment, storage, or disposal of hazardous waste will be within a 100-year floodplain.	Remedial activities may include the generation of hazardous waste. Treatment, disposal, and storage of hazardous waste may be required. Some waste management may occur within the 100-year floodplain.
Hazardous Waste Management Location Standards *SC R.61-104*	Relevant and Appropriate	This regulation creates requirements for the location of hazardous waste treatment, storage, or disposal facilities.	Macalloy remediation system(s) should be limited to those areas where there will be minimal impact to human health and the environment.

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Table 10-7
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
Federal Requirements			
CERCLA *121 (d)(3)*	Applicable	CERCLA wastes can only be transferred to facilities that are in compliance with RCRA, the Toxic Substance and Control Act, or other applicable federal and state requirements.	Applicable if hazardous wastes are generated onsite.
Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Responses Standard and OSHA General Safety and Health Standards *29 CFR 1910.120* *29 CFR Part 1926*	Applicable	Sets limits on exposure to workers on hazardous sites or emergency responses, sets forth minimum health and safety requirements such as personal protection and training, and establishes reporting requirements.	All activities taking place at Macalloy including remediation, construction, and monitoring are subject to OSHA health and safety regulations.
Clean Air Act Permits Regulation *40 CFR 72*	Applicable	Establishes requirements for major source permitting and operation.	Applies to any remedial action with a major source air emission.
CWA National Pollutant Discharge Elimination System (NPDES) *40 CFR 122, 125, 129, 136*	Applicable	Prohibits unpermitted discharge of any pollutant or combination of pollutants. Standards and limitations are established for discharges to waters of the U.S. from any point source.	Remedial actions may include the discharge of treated groundwater, runoff, or other flows to surface water.
CWA Wetlands Regulations Part 404 *40 CFR 230*	Applicable	Controls the discharge of dredged or fill materials into waters of the U.S. such that the physical and biological integrity is maintained.	Remedial actions may include capping or dredging sediment in wetlands.

Table 10-7
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
Federal Requirements (continued)			
RCRA Identification of Hazardous Waste *40 CFR 261*	Applicable	Criteria for identifying those solid wastes subject to regulation as hazardous wastes under RCRA.	Solid wastes meeting the requirements of RCRA hazardous waste may be generated onsite during remedial actions.
RCRA Generator Standards *40 CFR 262*	Relevant and Appropriate	Establishes standards for generators of RCRA hazardous waste(s).	Solid wastes meeting the requirements of RCRA hazardous waste may be generated onsite during remedial actions.
RCRA Facility Standards *40 CFR 264 and 265*	Relevant and Appropriate	Establishes standards for the management and storage of RCRA hazardous waste(s).	Solid wastes meeting the requirements of RCRA hazardous waste may be generated onsite during remedial actions.
RCRA Land Disposal Restrictions (LDRs) *40 CFR 268*	Applicable	Certain classes of waste are restricted from land disposal without acceptable treatment.	If hazardous wastes are generated during remedial activities, they will require treatment to comply with LDRs before disposed in a permitted landfill.
National Contingency Plan *40 CFR 300*	Applicable	Governs all actions at CERCLA sites.	Applicable as some form of remedial action is likely required at Macalloy.
CWA General Pretreatment Regulations for Existing and New Sources of Pollution *40 CFR 403*	Relevant and Appropriate	Establishes limits for the discharge of pollutants to publicly owned treatment works (POTW) and the requirement for pre-treatment if applicable.	Remedial actions could include discharge of treated groundwater to a POTW.

Table 10-7
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
Federal Requirements (continued)			
RCRA Cap Requirements 40 CFR 264.310, Closure and Post Closure Care	Relevant and Appropriate	Mandates design specifications for a completed landfill cover.	A cap that meets the RCRA permeability performance standard is a remedial alternative for soil.
Department of Transportation Rules for the Transport of Hazardous Substances *49 CFR Parts 107 and 171-179*	Applicable	Regulates the labeling, packaging, placarding, and transportation of solid and hazardous wastes offsite.	Remedial actions may include the offsite transport and disposal of solid and hazardous wastes.
State Requirements			
General Rules and Standards for the National Pollutant Discharge Elimination System *SC R.61-68*	Applicable	Establishes design and performance standards and permit requirements for discharge facilities.	Remedial actions may include the discharge of treated groundwater, runoff, or other flows to surface water.
General Pretreatment Regulations for Existing and New Sources of Pollution *SC R.61-9.403*	Relevant and Appropriate	Establishes the requirements for pretreatment of waste waters prior to discharge to a POTW.	Remedial actions may include the discharge of treated groundwater to a local POTW.

Table 10-7
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
State Requirements (continued)			
Air Pollution Control Regulations and Standards: Control of Fugitive Particulate Matter *SC R.61-62.6*	Applicable	Establishes guidelines for dust suppression during construction activities in attainment and non-attainment areas.	Charleston is in an attainment area as of January 2001.
Licensing of Naturally Occurring Radioactive Material (NORM) *SC R.61-63 Part IX*	Applicable	This part establishes radiation protection standards for the possession, use, transfer, transport, and/or storage of NORM or the recycling of NORM-contaminated materials not subject to regulation under the Atomic Energy Act of 1954, as amended.	NORM may be managed as part of remediation activities at Macalloy.
Well Standards *SC R.61-71*	Applicable	Establishes local criteria for design, installation, and abandonment of monitoring wells.	Installation of monitoring wells will be a necessary part of site remediation. Existing wells may be abandoned.
Identification and Listing of Hazardous Waste *SC R.61-79.261*	Applicable	Criteria for identifying those solid wastes subject to regulation as hazardous waste under RCRA.	Solid wastes meeting the requirements of RCRA hazardous waste may be generated onsite during remedial actions.
Standards Applicable to Generators of Hazardous Waste *SC R.61-79.262*	Relevant and Appropriate	Establishes standards for generators of RCRA hazardous waste(s).	Solid wastes meeting the requirements of RCRA hazardous waste may be generated onsite during remedial actions.

Table 10-7
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Remedial Alternatives
State Requirements (continued)			
Hazardous Waste Management Regulations *SC R.61-79.264*	Applicable	The purpose of this part is to establish minimum state standards that define the acceptable management of hazardous waste. The standards in this part apply to owners and operators of all facilities which treat, store, or dispose of hazardous waste, except where noted otherwise.	Solid wastes meeting the requirements of RCRA hazardous waste may be generated onsite during remedial actions.
Land Disposal Restrictions (LDRs) *SC R.61-79.268*	Applicable	Certain classes of waste are restricted from land disposal without acceptable treatment.	If hazardous wastes are generated during remedial activities, they will require treatment to comply with LDRs before disposed in a permitted landfill.
Proper Closeout of Wastewater Treatment Facilities *SC R 61-82*	Applicable	These regulations outline proper closeout of wastewater treatment lagoons.	The storm water management plan may include the closeout of onsite lagoons.
Underground Injection Control Regulations *SC R.61-87*	Relevant and Appropriate	These regulations set forth the specific requirements for controlling underground injection in SC and include provisions for the following: classification and regulation of injection wells; prohibiting unauthorized injection; protecting underground sources of drinking water from injection; classifying underground sources of drinking water; and requirements for abandonment, monitoring, and reporting for existing injection wells used to inject wastes or contaminants.	Re-injection of treated groundwater is a remedial alternative evaluated in this FS. Injection of amendments to stimulate contaminant reduction must meet the requirements of this regulation.

11.0 PRINCIPAL THREAT WASTES

Contaminated soil in the vadose and phreatic zones of the dust impoundment and former marsh area are source materials that continue to impact groundwater and surface water quality. Therefore, this material is considered a principal threat waste.

Impacted vadose zone soil would be addressed with in situ and/or ex situ treatment (Alternative S2), excavation (Alternative S3), or capping of the area to minimize leaching (Alternative S4). Principal wastes in the saturated zone would be addressed (indirectly) with Alternative G2, which would target the source area via in situ reduction. The other groundwater alternatives (G3 and G4) would mitigate offsite migration only.

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12.0 SELECTED REMEDY

The remedies listed below have been selected based on the consideration of CERCLA requirements, the analysis of remedial alternatives, public comments made during the 60-day comment period of the Proposed Plan, and feedback from SCDHEC. Section 12.1 presents EPA's rationale for selecting these remedies; Section 12.2 details remedy components for soil, radiological material, groundwater, sediment, and storm water; Section 12.3 estimates remedial costs; and Section 12.4 presents EPA's cleanup levels for chemicals of concern and the expected outcomes of the remedies.

EPA's Cleanup Plan for the Macalloy Corporation Site

Media	Alternative/Description
Soil	*Alternative S2b:* Onsite chemical reduction and stabilization/solidification: ex situ treatment with mechanical mixing.
Groundwater	*Alternative G2b:* Enhanced in situ reduction: chemical reductant.
Radiological Material	*Alternative R2:* Excavation with offsite disposal.
Sediment	*Alternative M4:* Removal with upland disposal (001 tidal creek); five-year monitoring and review only (Zone C).
Storm Water	Comprehensive storm water and sediment control management plan.

12.1 Summary of Rationale for the Selected Remedy

Remedy selection was based on the best balance among the nine evaluation criteria discussed in Section 10. The selected Macalloy Site remedy is protective of human health and the environment, complies with ARARs, is cost-effective, uses permanent solutions and treatment or recovery to the maximum extent practicable, and satisfies the preference for treatment as a principal element.

Chemical reduction with stabilization/solidification was selected over the other soil alternatives because it is expected to achieve substantial and long-term risk reduction through treatment without long-term maintenance or monitoring (other than groundwater monitoring, which will be implemented with the groundwater remedy). Mechanical mixing offers better control of mixing and blending ratios than in situ methods. Unlike other ex situ methods such as a pugmill, it can also be used to treat contaminated soil in place below the water table, thereby potentially reducing the saturated thickness treated by the selected groundwater remedy component. The cost-effectiveness of the ex situ method will be evaluated during pilot treatability studies conducted in the field during remedial design. If ex-situ method(s) do not prove cost effective during the remedial design evaluation, treatment with a pugmill or excavation with off-site disposal in a landfill may be implemented.

Excavation and disposal in a landfill was selected over the other radiological material alternatives because it was the least costly and, unlike capping, it does not require long-term monitoring. Enhanced in situ reduction was selected over the other groundwater alternatives because it is expected to achieve substantial risk reduction through treatment of contaminants in groundwater. Unlike the other alternatives, which provide containment only, enhanced in situ reduction is a rapid treatment alternative that also achieves source treatment.

Dredging of the 001 tidal creek was selected over the other two sediment alternatives because it does not require long-term maintenance or monitoring and it is the least costly option. Five-year monitoring will be conducted for Zone C.

12.2 Description of the Selected Remedy

The selected remedies are described in the following sections. They may change somewhat as a result of further pilot study, remedial design, and construction processes. Changes to the remedies described in this ROD will be documented in a technical memorandum in the Administrative Record, an Explanation of Significant Differences (ESD), or ROD amendment.

12.2.1 Soil

The objective of EPA's selected soil remedy is to prevent the leaching of chromium (VI) from site soil to groundwater at concentrations exceeding the groundwater cleanup level of 100 μg/L. A soil cleanup level of 23 mg/kg was calculated based on site-specific leaching ratios and the groundwater cleanup level. Figure 5-10 shows the locations of soil samples in which chromium (VI) concentrations exceed the cleanup level and the depths at which these exceedances occur. These locations are in fill material, generally gray to black pebbly slag, raw materials, conditioning tower sludge, and treated and untreated electrostatic precipitator dust. The total volume of contaminated soil is estimated to be 60,000 cubic yards. In addition, a 40,000-cubic-yard mound of berm material with chromium (VI) concentrations exceeding the cleanup level covers much of the lake fill area. This berm material is primarily gas conditioning tower sludge, slag, and other site materials. A second stockpile of berm material (approximately 15,000 cubic yards, primarily slag) from a lined impoundment north of the USI may also contain chromium (VI) concentrations exceeding the cleanup level.

Based on these estimates, approximately 115,000 cubic yards of soil with chromium (VI) concentrations exceeding the cleanup level of 23 mg/kg will be excavated and treated by onsite chemical reduction and s/s using mechanical mixing techniques. Treated soil can then be used onsite to backfill excavations or to regrade sections of the site and construct storm water management diversions. The selected soil remedy will allow the site to be used as industrial property without either institutional controls (other than a deed restriction preventing residential reuse) or long-term maintenance costs, since the remedy is permanent.

EPA's soil remedy combines the following general components:

- Treatability studies (both bench- and pilot-scale) to select chemical reductants and evaluate mixing methods.

- Delineation sampling to refine the extent of soil and berm areas requiring excavation.

- Excavation and treatment of approximately 115,000 cubic yards of soil and berm material.

- Confirmation sampling to monitor performance of the remedy during implementation.

- Backfilling with treated material.

- Institutional controls to prohibit residential use of the property.

- Groundwater monitoring to evaluate the effectiveness of the soil remedy.

Treatability Study

The treatability study will be initiated by bench-scale tests to evaluate the effectiveness of several chemical reductants in reducing chromium (VI) in site soil to chromium (III), which is less toxic and less mobile. Criteria used to select the chemical reductant will include:

- The reagent quantity needed to reduce a representative concentration of chromium (VI) to the cleanup level.

- The ability of s/s agents to further immobilize contaminants and strengthen the soil.

- Handling characteristics: safety, stability, and effort.

- The ability to mix with wet and dry site soils.

- Cost of reductant and s/s materials.

In 1998, Kiber Environmental Services, Inc., of Norcross, Georgia, conducted a bench-scale treatability study to evaluate chemical reduction and s/s of chromium (VI)-contaminated dust and berm material from the Macalloy Site. The objective was to produce a treated material that would pass regulatory TCLP levels for metals. Several reagents, including sulfuric acid, ferrous sulfate (heptahydrate), and sodium meta-bisulfate, were evaluated to chemically reduce chromium (VI) to chromium (III). The best results were obtained from 3% mixtures of ferrous sulfate. Kiber also evaluated seven stabilization mixtures with pretreated dust. Although the lowest TCLP results were obtained with 12% Type I Portland cement, additional testing is needed to determine the optimum stabilization reagent rates for onsite treatment.

Pilot studies will be implemented after selecting chemical reductants and s/s agents to evaluate the effectiveness of several excavation and mixing methods. Criteria for evaluating prospective excavation and mixing methods for this remedy will include:

- Effectiveness and efficiency of soil excavation and handling.

- Efficiency of handling and mixing selected reductants and s/s agents with site soil, specifically with respect to uniformity of mixture, volume processed, degree of effort, and time-per-unit volume of soil.

- The depth to which the application can be extended to soils below the water table. This will eliminate as much source material in site soils as possible and aid the groundwater remedy by reducing the leachate source below the shallow aquifer water table and simultaneously reducing dissolved concentrations of chromium (VI) in groundwater.

- The unconfined compressive strength and permeability of the treated material.

- Cost-per-unit volume of treated soil.

- Time required to implement the remedy.

- Potential hazards to site workers.

Treatment in a pugmill or excavation and disposal of the soil and berm material in a landfill will be considered as an alternative component of the remedy if the pilot study indicates that onsite treatment is not cost effective.

Delineation Sampling

The design phase will include development of a sampling and analysis plan for collecting additional samples to further delineate the extent of chromium (VI) contamination in soil and berm material, especially in the lined impoundment berm. This will improve time, material, and cost estimates. EPA and SCDHEC will have the opportunity to review and approve the work plan and the delineation sampling results.

Excavation and Treatment

Approximately 115,000 cubic yards of contaminated berm material and soil will be excavated and treated ex situ by mechanical mixing methods. The chemical reduction reagents will be slurried in water to ensure thorough mixing with the contaminated material. S/s reagents can be mixed dry to improve material-handling properties. Soil will be mixed with the reductants and s/s agents using common construction equipment such as tillers and scarifiers, augers, backhoes, track mixers, or high-speed rotary mixers. Operational layout, scheduling, equipment, material, and labor logistics will be developed during the design phase based on the results of the treatability study.

All excavation and treatment activities will be conducted in a manner that provides adequate short-term protection for site workers and minimizes disruptions to local businesses and adjacent neighborhoods. Engineering controls will be implemented to reduce public health and safety concerns associated with soil removal and treatment and to manage storm water and siltation during excavation. Air monitoring, dust control technologies, and health and safety measures will be implemented to reduce risk to site workers.

Confirmation Sampling

Confirmation samples will be collected to monitor remedy effectiveness during implementation. A plan will be developed during remedial design for collecting and analyzing samples from undisturbed soil in the excavated areas to ensure that soil with concentrations of chromium (VI) exceeding the cleanup level has been treated. The plan will also address the sampling of treated soil and berm material to assess the effectiveness of the reductant, s/s, and mixing technology in meeting the cleanup level. EPA and SCHDEC will have the opportunity to review and approve the confirmation sampling work plan and the results of the sampling program.

Backfilling

Excavated soil will be replaced in its original location or at other onsite locations consistent with site redevelopment plans. Soil successfully treated by chemical reduction and s/s can be used onsite for other applications, reducing the need to use offsite borrow material. For example, the approximately 12-foot-high mound of USI berm material and the stockpiled lined impoundment berm material, both of which are undesirable features for future site reuse, will be characterized as part of the remedy and treated as required to meet the chromium (VI) cleanup level. The soil will then be used to fill excavated areas and in cut-and-fill operations for the storm water remedy. The volume of treated soil generated by the addition of reductants and s/s agents may be greater than that of excavated soil depending on the volume of reductants and stabilizing agents that must be added to reduce chromium (VI) concentrations to below the cleanup level. The increased soil volume generated by this process could also be used to achieve desired final grades onsite consistent with site reuse and storm water management plans.

Institutional Controls

One or more of the following institutional controls will be installed as part of the alternative to prohibit future residential use of the property:

- Covenant — provisions in any subsequent property transfer agreements to restrict use.

- Informational devices — tools (e.g., deed notices, state registries of hazardous waste sites, and advisories), which often rely on property record systems, used to provide public information about risks from contamination.

Monitoring Requirements

Long-term effectiveness of this alternative will be evaluated during the groundwater monitoring program discussed in Section 12.2.3.

12.2.2 Radiological Material

The goal of the selected remedy is to prevent exposure to radiation levels greater than twice the measured background concentration (12 μR/hr). The approximately 110 cubic yards of soil and debris that produce gamma radiation exceeding this cleanup level will be excavated and disposed of in a Subtitle D landfill in South Carolina. Confirmation screening with hand-held radiation detectors will be conducted to verify that materials producing gamma radiation exceeding the cleanup levels are removed. Soil and debris will be excavated using conventional excavation equipment such as a track-mounted or rubber-tire mounted backhoe and then loaded onto the appropriate haul trucks for transportation to the disposal site. The area will be backfilled using onsite borrow materials. A plan for confirmation screening will be developed during the design phase, which will also address equipment decontamination and site worker health and safety. EPA and SCDHEC will have the opportunity to review and approve of this plan.

This remedy is permanent and will require no long-term monitoring or maintenance, and the area will be available for industrial reuse.

12.2.3 Groundwater

The objective of the groundwater remedy is to prevent exposure to chromium (VI) concentrations in shallow groundwater above the maximum contaminant level (MCL) specified by the Safe Drinking Water Act for total chromium (100 μg/L) and to minimize the migration of chromium (VI) from groundwater to Shipyard Creek. The selected remedy for groundwater is enhanced in situ reduction. This treatment method permanently immobilizes or degrades contaminants in groundwater into harmless end products. Results of the RI groundwater investigation indicated that chromium (VI) reduction is favorable in the shallow aquifer. Enhanced in situ reduction will complement current reducing conditions and target groundwater with chromium (VI) concentrations exceeding the cleanup level of 100 μg/L. Reductants can be delivered passively, actively, or as a combination of the two and can address source areas, as well as provide downgradient containment.

Plumes of groundwater contaminated with chromium (VI) exceeding the cleanup levels are illustrated on Figure 5-13. These plumes are confined to the shallow aquifer and have not penetrated a clay confining layer that occurs approximately 20 feet below ground surface. The estimated volume of impacted groundwater is 45 million liters. The mass of chromium (VI) in the lake fill area, which is considered a significant groundwater contamination source, is approximately 1,270 kg. The success of this alternative depends on effectively distributing the reductant to impacted zones to permanently convert chromium (VI) to chromium (III).

The following main elements will be included in development of the selected remedy:

- Bench-and pilot-scale treatability studies.

- Delineation sampling to refine the extent of the groundwater plume near the concentrator area.

- Reductant application.

- Long-term effectiveness monitoring program.

Treatability Study

The treatability study will be initiated by bench-scale tests to evaluate the effectiveness of several reductants in reducing chromium (VI) in site groundwater to chromium (III), which is less toxic and less mobile. Site groundwater and aquifer materials will be collected to simulate site conditions in the laboratory. Criteria used to select the reductant will include:

- Estimates of reductant loading required to reduce a representative concentration of chromium (VI) to the cleanup level.
- Additional components required to sustain or augment efficacy and application of the reductant, such as pH buffering compounds.
- Handling characteristics: safety and physical properties.
- Compatibility with aquifer matrix and hydraulic properties.
- Stability, mobility, and reaction rate in groundwater and aquifer matrix.
- Long-term effectiveness and permanence.
- Cost.

Pilot studies will be implemented after the reductants eligible for continued evaluation have been determined. These studies will determine the effectiveness of several reductant delivery methods. Criteria for field evaluation of prospective reductants and delivery methodologies for this remedy will include:

- Compatibility of delivery method with aquifer hydraulic properties. Heterogeneities in the aquifer may require modifying the selected technique, or even combining techniques for efficient delivery of reductant to the targeted area.

- Radius of influence in delivery system: the effectiveness and distribution of reductant by various delivery methods such as DPT injection points, wells, or horizontal infiltration galleries in achieving thorough delivery of reductant within the aquifer interval are controlled largely by aquifer properties and distribution.

- Evaluation of injection rates, well or DPT spacing, frequency/duration of application.

- Cost per-unit volume of treated groundwater.

- Time required to complete implementation of the remedy.

- Potential hazards to site workers.

Preliminary EPA bench-scale and pilot study results indicate that a mixture of sodium dithionite and ferrous sulfate may be the most effective reductant. The delivery method used by EPA was a grid of temporary wells. Additional reductants and delivery methods will be considered during the remedial design and pilot-study phase.

Delineation Sampling

During the design phase, a work plan will be prepared to further delineate the groundwater plumes, particularly in the concentrator area where the results of one monitoring well are driving the cleanup strategy. These wells will also be used after the treatment system has been implemented to gauge treatment efficacy. EPA and SCDHEC will have the opportunity to review and approve the work plan and the delineation sampling results.

Reductant Application

Data from the treatability studies will be used to determine the layout of delivery system(s), system operating parameters, and the need for any additional controls. Process flow diagrams (if needed), mechanical requirements, and chemical demands will also be developed during full-scale design.

Potential delivery methods for evaluation include DPT point grids, temporary groundwater wells (fully penetrating, partially penetrating, and multilevel), a gallery of pipes, and surface impoundments to infiltrate the reductant. The Macalloy Site has a heterogeneous stratigraphy and the delivery system requires careful planning if it is to be effective and efficient. A conceptual layout of a chemical injection system using DPT is presented in Figure 12-1. Approximately 1,800 DPT points are estimated to address the chromium (VI) contamination (pilot testing would hone that number). The chemical reductant application strategy would be designed for one dosing based on the findings of the pilot-scale test. Although one or two reapplications could be necessary over the course of the project, each reapplication would likely use a smaller area and dose than the initial application.

An alternate design could combine enhanced in situ groundwater treatment with the soil remedy by installing an infiltration gallery in the lake fill area after the chromium (VI)-contaminated soil is excavated. Drainage aggregate or concrete rubble from site demolition could be placed in the excavation with a network of infiltration pipes connected to the surface; the remaining void would be backfilled with uncontaminated soil. The pipe network would allow for easy amendment infiltration.

Design phase activities will also include:

- Recalculation of groundwater volume exceeding 100 μg/L following additional plume delineation.

- Calculation of the quantity of reductant needed.

- Reductant distribution system layout and spacing.

- Equipment and labor required.

- Implementation schedule.

Engineering controls and health and safety measures will be established to reduce risk to site workers during remedy implementation.

Monitoring Requirements

Groundwater monitoring is required to assess chemical-based enhancement of chromium (VI) reduction. During remedy implementation, the following groundwater parameters will be measured to monitor the remedy's effectiveness:

- Key contaminants: total chromium and chromium (VI).

- Field parameters: dissolved oxygen, oxidation reduction potential, pH, temperature, and ferrous iron.

- Attenuation parameters: dissolved iron and manganese, nitrate, sulfate, sulfide, chloride, and alkalinity.

- Key cations: calcium, magnesium, sodium, and potassium.

A sampling and analysis plan for groundwater effectiveness monitoring will be prepared during remedial design. EPA and SCDHEC will have the opportunity to review and approve the work plan. Monitoring wells in the treatment area and upgradient and downgradient of the application area will be sampled every other month for 6 to 8 months using low-flow groundwater collection techniques. The sampling frequency may be reduced to quarterly, semiannually, or annually as geochemical trends become established.

In addition, the groundwater plume will be monitored semiannually for five years. Samples will be analyzed for chromium (VI) plus the following eight RCRA metals: arsenic, barium, cadmium, total chromium, lead, mercury, selenium, and silver. Potential well locations for plume monitoring are shown on Figure 12-2. However, the monitoring well network and the sampling frequency may change based on the results of delineation sampling, treatability studies, and remedial design. EPA and SCDHEC will have the opportunity to review and approve the groundwater monitoring program during remedial design. Some of the monitoring wells shown in Figure 12-2 may be abandoned during implementation of the soil remedy.

12.2.4 Sediment

The objective of the sediment remedy is to eliminate exposure to benthic organisms from unacceptable concentrations of chromium, nickel, and zinc. Based on the results of the Ecological Risk Assessment, the area of greatest ecological concern was defined as the 001 tidal creek. EPA's selected remedy is sediment removal with upland disposal. This remedy protects human health and the environment by permanently removing the risk potential associated with contaminated sediments. The top 18 inches of contaminated sediment in the 001 tidal creek (approximately 1,000 cubic yards) will be removed using hydraulic dredging equipment and transported via pump and pipeline to an onsite dewatering area that drains to onsite settling basins. Benthic organisms living in the contaminated sediments will be destroyed during implementation but will re-establish residence in the dredged areas.

EPA's sediment remedy combines the following general components:

1. Delineation sampling to refine the dredging depth.

2. Excavation of approximately 1,000 cubic yards of sediment.

3. Upland disposal of removed sediments.

4. Confirmation sampling to verify the achievement of RAOs as expressed by the range of protective levels for COCs listed on page 7-11.

5. 5-year monitoring of Zone C.

Delineation Sampling

Previous investigations indicate that contaminants concentrations are highest in the upper 6 inches of sediment. A conservative depth of 18 inches was estimated for contaminated sediment removal cost calculations. The area targeted for removal, presented in Figure 5-14, is estimated to be 1,000 cubic yards of sediment. A work plan will be prepared during remedial design to verify the depth of contamination prior to remedy implementation. Samples will be analyzed for chromium, nickel, and zinc. Based on the results, the final sediment removal volume will be estimated. EPA, SCDHEC, and the natural resource trustees will have the opportunity to review and approve the work plan and the delineation sampling results.

Excavation

Because barge access is limited due to shallow water, a self-contained portable hydraulic dredge such as the Mudcat™ and Little Monster™ may be used to remove contaminated sediment from the tidal creek. Hydraulic dredges remove and transport sediments in the form of a slurry, providing an economical means of removing large quantities of contaminated sediments. The key components of a hydraulic dredge are the dredgehead, dredgehead support, hydraulic pump, and pipeline. The Mudcat™ and Little Monster™ use a transversely mounted horizontal auger bit that conveys sediment to the center of the cutter head where the hydraulic suction pipe is located. These hydraulic dredges have removal rates ranging from 30 to 150 cubic yards/hr. The sides of the dredged tidal creek are expected to slough at a slope of approximately 4H:1V, adding another 5 or 6 feet to the width of the channel at its top. The channel will not be backfilled. Remedial design may include mechanical dredging techniques as well, especially in near shore areas that can be reached with a long-stick trackhoe.

Dredging in the tidal creek will be conducted in a manner that minimizes physical disturbance and impacts to the adjacent vegetated salt marsh. Following dredging, impacts to the adjacent salt marsh will be assessed, and damaged areas will be revegetated.

Dredging and sediment transportation system design will include:

- Configuration of dredgehead for optimum in-place sediment removal.
- Selection of the dredgehead, dredge pump, and intake suction pipeline to maintain a slurry concentration and slurry velocity that prevent sediment from settling in the discharge pipeline while reducing entrance and friction losses.
- A suction intake, pump, and discharge pipeline system that minimizes resuspension of sediments while reducing system maintenance and pump failures.
- Evaluation of the potential for collateral damage to the marsh; a dredge system design will be selected that minimizes adverse impacts on the surrounding environment.
- Evaluation of the dredge system's ability to operate in a tidal environment.
- Minimization of the time, labor, and cost required to complete dredging operations.

Silt curtains and barriers will encircle the entire dredged area to recapture and isolate resuspended sediments; additional sediment control measures (e.g., staked hay bales) will be used as needed.

During the dredging process, monitoring will be focused on sediment resuspension and removal rates. Turbidity, conductivity, and dissolved oxygen measurements will be used as real-time indicators of excessive sediment resuspension. Water samples will be collected at one location upstream and several locations downstream from the dredging site. Project-specific guidelines for interpreting monitoring results will be developed during remedial design. Removal rates will be measured to ensure that excessive material is not removed. The final quantity of dredged material may be estimated from bathymetric surveys conducted before and after the dredging, or from other measurements such as pumping rates and duration.

Upland Disposal

Dredged materials management developed during the design phase will address:

1. Dredged sediment dewatering area location and layout.
2. Slurry percent solids and water generated during the operation.
3. Engineering controls necessary to minimize sediment runoff from dewatering area.

Dewatering technologies are used in sediment remedial alternatives to reduce the amount of water, enhance material handling characteristics, and prepare the sediments for further treatment or disposal. Dredged material is traditionally dewatered in ponds or in a confined disposal facility, which relies on seepage, drainage, consolidation, and evaporation. Hydraulically dredged sediments typically range from 10% to 20% solids. Because sufficient land area is available on the Macalloy property, a combination of seepage, drainage, consolidation, evaporation, and chemical stabilization (lime/cement) will be used at Macalloy. Dredged material will be pumped to an on-shore dewatering area that will drain into a storm water settling basin. A dredged sediment sampling program will be prepared during remedial design to characterize dewatered material and outline management practices. Onsite worker health and safety concerns about the potential for increased particulates from dewatered sediment will be addressed in a health and safety plan.

As necessary, Jersey barriers or their equivalent will be used to contain the removed sediment while it drains. Water, which is not expected to contain chromium (VI), will gravity-drain through existing settling basins to Shipyard Creek. Water quality will be monitored as part of the comprehensive storm water management plan.

Sediment Disposal

Dewatered sediment will be sampled for metals and chromium (VI). Depending on the analytical results, the dredged material will be left in place or managed with the approximately 115,000 cubic yards of contaminated site soil. Offsite disposal options will be considered for sediments that cannot be treated cost-effectively for use onsite.

Confirmation Sampling

A confirmation sampling plan will be developed during remedial design to evaluate the effectiveness of the remedial action. Sediment samples will be collected from the dredged area, analyzed for chromium, nickel, and zinc, and compared to the protective risk ranges discussed in Section 7.2 and Appendix A. EPA, SCDHEC, and the natural resource trustees will have the opportunity to review and approve the work plan and the confirmation sampling results.

Zone C Monitoring

There are no long-term monitoring or institutional controls associated with the selected 001 tidal creek remedy. However, sediment in Zone C will be monitored during EPA's 5-year review period. A plan for monitoring of Zone C sediment will be prepared during remedial design and reviewed by EPA, SCDHEC, and the natural resource trustees. Monitoring activities will include sediment chemistry and toxicity testing.

12.2.5 Storm Water Management

The goal of this remedy is to mitigate discharge of contaminants into Shipyard Creek and address the substantive requirements of the Clean Water Act by implementation of a comprehensive storm water management plan. Conceptually, this plan will include construction of a series of diversions, conveyances, and settling basins to divert surface water runoff through one outfall.

The outfall will be located in the North Turning Basin of Shipyard Creek and will eliminate discharge to the perennially low-flow 002 portion of the creek.

In September 1998, the process and storm water sewer network leading to the 001 basin was plugged to eliminate process water from discharging through the 001 outfall. Furthermore, no process wastewater has been used or discharged since chromium smelting, metal recovery processes, and the groundwater pump-and-treat system at Macalloy stopped operating.

Based on available data, metals concentrations in storm water discharge appear to be coincident with elevated suspended solids. Therefore, a comprehensive Storm Water Management and Sediment Control Plan (SWMSCP) to control effluent suspended solids would be expected to reduce metals in storm water. The SWMSCP will focus on removing suspended solids from storm water runoff as a way to reduce metals concentrations in the discharge.

However, because the contaminant is highly soluble in water, reducing suspended solids alone may not reduce the concentration of chromium (VI). Remedial actions designed to meet chromium (VI) cleanup levels in soil and groundwater are expected to help the SWMSCP meet cleanup levels by reducing the availability of soluble chromium (VI). Key storm water performance standards established by EPA are listed below.

Storm Water Performance Standards

- Eliminate contributions from offsite watersheds and reduce the volume of water to manage.
- Design storm water detention basins and other conveyances to reduce suspended sediment concentrations.
- Relocate and consolidate storm water outfalls.

- Adjust site topography and construct berms and swales to manage storm water consistent with future site reuse.

Features of a conceptual SWMSCP are shown on Figure 12-3. The conceptual plan will be modified to consider future site redevelopment plans.

The site-specific SWMSCP will be developed using design standards outlined in the *South Carolina Storm Water Management and Sediment Control Handbook for Land Disturbance Activities* (August 1998), which incorporates guidance from the NPDES General Permit, the South Carolina Storm Water Management and Sediment Reduction Act, and the Coastal Zone Management Program Refinements. Design requirements from the handbook will be applied to the aforementioned storm water management concept. The Macalloy SWMSCP will include the following elements:

- **Maps and plan sheets** showing the site, drainage boundaries, existing and proposed topography, areas and sequencing of disturbances, and location of sediment control provisions.

- **Design calculations** showing pre- and post-development flow velocities, peak discharge rates, hydrographs, sediment yield, sediment removal efficiency, sediment storage volumes, runoff storage volumes, and dewatering time.

The handbook also presents design criteria for various elements of an SWMSCP. The following design criteria are expected to be an integral part of the SWMSCP for the Macalloy Site; other criteria in the handbook will be incorporated as appropriate.

- Sediment basins will be designed and constructed to accommodate the anticipated sediment loading and meet the lesser of the following: a suspended solids removal efficiency of 80% or a 0.5 milliliter per liter (ml/L) peak settleable solids concentration. This removal efficiency will be provided for disturbed conditions for the 10-year, 24-hour design storm event.

- Discharge velocities from sediment control and drainage structures will be reduced to a non-erosive velocity.

- Post-development discharge rates will not exceed pre-development rates for the 2- and 10-year frequency, 24-hour-duration storm.

- Permanent water quality ponds with a permanent pool will be designed to store and release the first 0.5 inches of runoff from the site over a 24-hour period and have a storage volume designed to accommodate at least 0.5 inches of runoff from the entire site.

- Permanent water quality ponds without a permanent pool will be designed to release the first inch of runoff from the site over a 24-hour period.

Other pertinent design criteria will be incorporated into the SWMSCP to achieve the cleanup levels as needed.

As summarized in Table 12-1, cleanup levels for this remedial action were selected to be protective of human health and the environment. The SCDHEC has established water quality criteria in Regulation 61-68 for streams and estuaries of the state. Shipyard Creek is designated for *aquatic life*. This use classification is subject to numerical criteria for toxic metals that are established as both chronic and acute criteria. Acute criteria are applicable to storm water discharges because such discharges are intermittent and have a short duration. Saltwater criteria are appropriate for establishing protective limits for storm water effluent, since Shipyard Creek is part of a tidally influenced brackish estuarine system.

Table 12-1
Macalloy Corporation Site Cleanup Levels for Storm Water

Effluent Characteristic	Cleanup Level
Flow (mgd)	report
Total suspend solids (μg/L)	110,000
Total lead (μg/L)	220
Total arsenic (μg/L)	69
Total copper (μg/L)	5.8
Total zinc (μg/L)	95
Chromium (VI) (μg/L)	1,100
Acute Whole Effluent Toxicity	report

Cleanup levels were set at established water quality criteria without allowing for mixing or an adjustment for dissolved total metals even though Regulation 61-68 allows for a storm water effluent mixing zone in which the acute criteria may be exceeded. These cleanup levels are conservative concentrations that will be evaluated and revised based upon effectiveness monitoring data and results of the SCDHEC Cooper River Total Maximum Daily Load (TMDL) study.

Mixing zone modeling to predict the length, width, and depth of the zone where the contaminants are permitted to exceed acutely toxic concentration limits and dissolved-to-totals metals translation of water quality criteria using EPA guidance adopted by South Carolina regulation were addressed in a technical memorandum (EnSafe, 2002). Though these methods were considered appropriate for the discharge, insufficient data are available for rigorous modeling until the results of the TMDL study are available.

The mixing zone model indicated that a submerged discharge pipe is capable of maintaining a mixing zone within regulatory limits. Due to the tendency of relatively fresh storm water discharge to float on the brackish receiving water of Shipyard Creek, open channel and surface discharges were not as successful. The type and construction of the discharge point will be determined during the design evaluation phase.

SWMSCP effectiveness monitoring will be based on a detailed sampling and analysis plan that will be developed during remedial design for review and approval by EPA and SCDHEC. The plan, which will outline the methods and procedures for storm water system monitoring, will be implemented for one year after remedial construction is completed. Sampling frequency and scope of the plan will be re-evaluated after the one-year monitoring period. Effluent characteristics listed in Table 12-1 will be tested to assess SWMSCP effectiveness. In addition, effluent toxicity tests will be performed quarterly on a species to be determined. South Carolina regulations recommend *Ceriodaphnia dubia* for freshwater and *Mysidopsis bahia* for saltwater. The results of the Cooper River TMDL modeling will also be reviewed to assess the applicability of adopting alternate, less conservative cleanup levels for surface water that are protective of human health and the environment.

12.3 Summary of Estimated Remedy Costs

Costs associated with the selected remedy are summarized below and detailed in Tables 12-2 to 12-6. These order-of-magnitude engineering cost estimates are based upon best available information regarding anticipated scope and technologies available, and are expected to be within +50 to -30 percent of the actual project cost. New information collected during the remedial design phase will likely result in cost changes. Major changes may be documented in the Administrative Record file, an ESD, or a ROD amendment. Costs are sensitive to the actual volume of contaminated soil and sediment, which will be refined during remedial design, the groundwater chemical reductant selected, and the application spacing, which may be subject to change based on additional bench- and pilot-scale testing.

EPA'S CLEANUP PLAN FOR THE MACALLOY SITE

Media	Alternative/Description	Total Present Worth
Soil	Alternative S2b: Onsite chemical reduction and stabilization/solidification: ex situ treatment with mechanical mixing	$ 7,883,000
Groundwater	Alternative G2b: Enhanced in situ reduction: chemical reductant	$ 2,053,000
Radiological Material	Alternative R2: Excavation with offsite disposal	$ 15,000
Sediment	Alternative M4: Removal with upland disposal	$ 492,000
	Zone C: Five-year monitoring and review	$ 20,000
Storm Water	Comprehensive storm water management plan	$ 1,256,000
	TOTAL REMEDY COST	**$ 11,719,000**

Table 12-2
Alternative S2: Onsite Chemical Reduction and Stabilization/Solidification
Ex Situ Treatment with Mechanical Mixing

Description	Quantity	Unit Cost	Total Cost
Bench- and Pilot-Scale Testing			
Treatability study	LS	$20,000	$20,000
		20% contingency	$4,000
		Bench- and Pilot-Scale Testing Subtotal	**$24,000**
Full-Scale Design and Implementation			
Delineation sampling	LS	$25,000	$25,000
Engineering design	LS	$40,000	$40,000
Mobilization/demobilization	LS	$60,000	$60,000
Engineering controls (includes dust suppression and silt fences during excavation.	LS	$100,000	$100,000
Reductant (estimated based on ferrous sulfate)	4,900 tons	$400/ton	$1,960,000
Concrete demolition	LS	$40,000	$40,000
Ex situ treatment (includes excavation, placement, soil stabilization with 5% cement, mixing, and compaction)	115,000 CY	$35/CY	$4,025,000
Ex situ confirmation sampling (assume 1 composite sample/500 CY)	LS	$13,000	$13,000
Confirmation sampling after excavation (assume 160 locations)	LS	$16,000	$16,000
Contractor oversight, engineering review, and reports	27 wks	$10,000/week	$270,000
		20% contingency	$1,310,000
		Full-Scale Design and Implementation Subtotal	**$7,859,000**
Total			
		Total Cost	**$7,883,000**

Notes:
LS = lump sum
CY = cubic yards
Soil would be sampled for chromium (VI) only.

Table 12-3
Alternative R2: Excavation and Offsite Disposal

Description	Quantity	Unit Cost	Total Cost
Engineering design, review, and reporting	LS	$2,000	$2,000
Mobilization/demobilization	LS	$1,000	$1,000
Excavation and transportation	165 tons	$10/ton	$1,700
Disposal	165 tons	$30/ton	$5,000
Backfill	110 CY	$7/CY	$800
Erosion control	400 ft	$1.50/ft	$600
Miscellaneous construction (PPE, dust control, etc.)	LS	$500	$500
Engineering oversight and confirmation screening	LS	$2,000	$2,000
		10% contingency	$1,400
		Total Cost	**$15,000**

Notes:
LS = lump sum
CY = cubic yards

Table 12-4
Alternative G2: Enhanced In Situ Reduction Costs Using a Chemical Reductant

Description		Quantity	Unit Cost	Total Cost
Bench- and Pilot-Scale Testing				
Bench- and pilot-scale testing		LS	$125,000	$125,000
			Bench- and Pilot-Scale Testing Subtotal	**$125,000**
Full-Scale Design and Implementation				
Engineering design		LS	$60,000	$60,000
Reductants (includes delivery costs)	Ferrous sulfate	85 tons	$800/ton	$68,000
	Sodium dithionite	100 tons	$3,200/ton	$320,000
Reductant handling (includes labor, tanks, mixers, etc.)		LS	$75,000	$75,000
Reductant application (includes mobilization/demobilization, DPT, pump, and associated equipment rental for 25 weeks)		LS	$250,000	$250,000
Contractor oversight, engineering review, and reporting		25 weeks	$10,000/week	$250,000
Monitoring well installation		15 wells	$2,500/well	$38,000
Well abandonment		LS	$40,000	$40,000
			20% contingency	$220,000
			Full-Scale Design and Implementation Subtotal	**$1,321,000**
Second Application (assumes strategic re-dosing)				
Engineering design		LS	$10,000	$10,000
Reductants (includes delivery costs)	Ferrous sulfate	30 tons	$800/ton	$24,000
	Sodium dithionite	35 tons	$3,200/ton	$112,000
Reductant handling		LS	$25,000	$25,000
Reductant application (includes mobilization/demobilization, DPT, pump, and associated equipment rental for 8 weeks)		LS	$80,000	$80,000
Contractor oversight, engineering review, and reporting		8 weeks	$10,000/week	$80,000
			20% contingency	$66,000
			Second Application Subtotal	**$397,000**
Annual Operation and Maintenance				
Sampling and analysis (10 samples per month, every other month)		60 samples	$300/sample	$18,000
Field technician		240 hours	$65/hour	$16,000
Engineering review and reporting		LS	$15,000	$15,000
			20% contingency	$10,000
			Annual O&M Subtotal	$59,000
			Present value subtotal at 7% discount over 2 years	**$107,000**

Table 12-4
Alternative G2: Enhanced In Situ Reduction Costs Using a Chemical Reductant

Description	Quantity	Unit Cost	Total Cost
Plume Monitoring			
Sampling and analysis (12 samples semiannually)[b]	24 samples	$150/sample	$4,000
Field technician	100 hours	$65/hour	$7,000
Engineering review and reporting	LS	$10,000	$10,000
		20% contingency	$4,000
		Annual Subtotal	**$25,000**
		Present value subtotal at 7% discount over 5 years	**$103,000**
Total			
		Total Cost	**$2,053,000**

Notes:
(a) = Metals only; sample locations shown on Figure 12-2.
LS = lump sum

Table 12-5
Alternative M4: Dredging Costs

Description	Quantity	Unit Cost	Total Cost
Full-Scale Design and Implementation			
Engineering design	LS	$60,000	$60,000
Vertical contamination delineation	LS	$20,000	$20,000
Mobilization/demobilization (includes decontamination)	LS	$15,000	$15,000
Dredging equipment and operators	20 days	$8,500/day	$170,000
Containment barriers and sediment monitoring	LS	$10,000	$10,000
Confirmation sampling	LS	$20,000	$20,000
Dewatering system (includes construction and water management)	LS	$25,000	$25,000
Sediment treatment (includes cement stabilization)	1,000 CY	$50/cubic yards	$50,000
Contractor oversight, engineering review, and reporting	4 weeks	$10,000/week	$40,000
		20% contingency	$82,000
		Total Cost	**$492,000**

Note:
Sediment sample will be analyzed for chromium, nickel, and zinc. For this cost estimate, delineation samples will be collected every 100 feet at three depths. Confirmation samples will be collected at five locations from 10 equally-spaced transects along the 1,000-foot-long creek.

Table 12-6 Storm Water Management and Sediment Control Cost Estimate			
Onsite Storm Water Work			
Topographic survey	LS	$25,000	$25,000
Engineering design	LS	$60,000	$60,000
Mobilization/demobilization	LS	$40,000	$40,000
Onsite Storm Water Work			
Engineering controls (includes dust suppression and silt fences during excavation and grading)	LS	$40,000	$40,000
Fence reconstruction	3,000 feet	$18/ft	$54,000
Compost	5,000 CY	$12/CY	$60,000
Concrete demolition	LS	$20,000	$20,000
Storm sewer modification	LS	$8,000	$8,000
Swale construction/grading, Basins 002A and 004B modification	LS	$125,000	$125,000
Soil cover	3,500 CY	$10/CY	$35,000
Basin 002B closure and 004A size reduction[1]	26,000 CY	$10/CY	$260,000
Revegetation	14 AC	$2,500/AC	$35,000
Contractor oversight, engineering review, and reports	8 weeks	$10,000/week	$80,000
		20% contingency	$168,000
		Design and Construction Subtotal	**$1,010,000**
Annual Operation and Maintenance			
Sampling labor and analysis (water quality/biota)	LS	$45,000	$45,000
Swale and basin maintenance	LS	$5,000	$5,000
		20% contingency	$10,000
		Annual O&M Subtotal	$60,000
		Present value subtotal at 7% discount over 5 years[2]	**$246,000**
Total			
		Total Cost	**$1,256,000**

Notes:
1 = Assumes use of offsite material
2 = Operation and maintenance cost assumes that cleanup levels are met and sampling is discontinued after 5 years.
LS = lump sum
AC = acre
CY = cubic yard

12.4 Expected Outcomes of the Selected Remedy

The purpose of this response action is to:

(a) Minimize the migration of chromium (VI) from soil to groundwater and surface water.

(b) Minimize exposure to debris that produces elevated levels of gamma radiation.

(c) Control risks to future site workers posed by the ingestion of chromium (VI) in groundwater and limit migration of chromium (VI) to Shipyard Creek.

(d) Mitigate the discharge of contaminated storm water to Shipyard Creek.

(e) Prevent direct exposure of benthic organisms to contaminated sediments in the 001 tidal creek.

The affected media, chemicals of concern, cleanup levels, and the basis for the cleanup level selection are presented in Table 12-7.

A series of engineering reports, specifications, and drawings will be prepared during the remedial design to detail the steps to be taken during remedial action to meet the cleanup goals established in this ROD.

Remedial Design Documents

- *Delineation Sampling Work Plan.* Outlines the sampling and analytical approach for further delineating the extent of soil, groundwater, and sediment contamination.

- *Delineation Sampling Report.* Presents the results of the delineation sampling activities and refines the volume estimates for soil, groundwater, and sediment remediation.

- *Treatability Study Work Plan.* Describe the strategy for conducting treatability studies for soil and groundwater.

- *Treatability Study Report.* Analyzes field and laboratory results, assesses the effectiveness of the systems evaluated, and makes recommendations for full-scale design.

- *Draft/Final Design.* Includes design analysis, construction drawings and specifications, and a cost estimate.

- *Health and Safety Plan.* Specifies requirements for a health and safety plan that must be followed by during remedial construction activities to protect onsite personnel and the surrounding community from physical, chemical, and/or biological hazards of the site.

- *Quality Assurance Project Plan.* Specifies sampling techniques and methods for monitoring activities at the site.

- *Operation and Maintenance Plan.* Specifies operation and maintenance requirements for the remedial systems.

As part of the remedy implementation, confirmation sampling of soil and sediment will be conducted to ensure that cleanup levels are achieved. Groundwater will be monitored semiannually for 5 years to evaluate the effectiveness of the soil and groundwater alternatives in achieving cleanup levels. Storm water will be monitored monthly (with quarterly toxicity tests) for one year after remedial construction is completed. After one year or pending the results of the state TMDL study, the frequency and scope of the storm water sampling plan will be evaluated. Sediment in Zone C will be monitored at the end of EPA's 5-year monitoring period.

EPA's selected remedies are anticipated to allow for industrial reuse of the Macalloy property and restoration of tidal creek habitat in Shipyard Creek. The site can be expected to be available for industrial reuse in approximately one year after remedial construction begins. Chromium (VI) concentrations in groundwater are expected to meet the cleanup levels in approximately 2 years after remedial construction begins. Groundwater will be available for use but not as a source of potable water.

One or more of the following institutional controls will be installed to prohibit future residential use of the property:

- Covenant — provisions in any subsequent property transfer agreements to restrict use.
- Informational devices — tools (e.g., deed notices, state registries of hazardous waste sites, and advisories), which often rely on property record systems, used to provide public information about risks from contamination.

Table 12-7
Cleanup Levels for Chemicals of Concern

Media	Chemical of Concern	Cleanup Level	Basis of Cleanup Level
Soil	chromium (VI)	23 mg/kg	calculated using leachability ratios and groundwater MCL
Debris	gamma radiation	12 micro-Roentgens/hour	2 times background
Groundwater	chromium (VI)	100 μg/L	ARAR compliance (MCL)

Table 12-7
Cleanup Levels for Chemicals of Concern

Media	Chemical of Concern	Cleanup Level	Basis of Cleanup Level
Sediment	total chromium	219 to 258 mg/kg	Appendix A
	nickel	33 to 35.7 mg/kg	Appendix A
	zinc	132 to 163 mg/kg	Appendix A
Storm Water	flow	report	ARAR compliance (Clean Water Act)
	lead	220 μg/L	ARAR compliance (Clean Water Act, Ambient Saltwater Criteria)
	arsenic	69 μg/L	ARAR compliance (Clean Water Act, Ambient Saltwater Criteria)
	chromium (VI)	1,100 μg/L	ARAR compliance (Clean Water Act, Ambient Saltwater Criteria)
	copper	5.8 μg/L	ARAR compliance (Clean Water Act, Ambient Saltwater Criteria)
	zinc	9.5 μg/L	ARAR compliance (Clean Water Act, Ambient Saltwater Criteria)
	Acute Whole Effluent Toxicity	Report	ARAR compliance (Clean Water Act)

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13.0 STATUTORY DETERMINATIONS

Under CERCLA §121 and the NCP, the lead agency must select remedies that are protective of human health and the environment, comply with ARARs (unless a statutory waiver is justified), are cost-effective, and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. In addition, CERCLA includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as a principal element and a bias against offsite disposal of untreated wastes. The following sections discuss how the Selected Remedy meets these statutory requirements.

13.1 Protection of Human Health and the Environment

Soil Alternative S2b protects human health and the environment through treatment by chemically reducing chromium (VI) to chromium (III), which is less toxic and mobile. Approximately 115,000 cubic yards of soil and berm material with chromium (VI) concentrations exceeding the cleanup level of 23 mg/kg will be excavated and treated by onsite chemical reduction and s/s using mechanical mixing techniques. Removal of these materials will address the soil-to-groundwater migration pathway that was identified as a potential human health hazard during the risk assessment process. No chemicals of concern were identified for surface soil under the future site worker (industrial) scenario.

Radiological material Alternative R2 provides protection by removing gamma radiation producing soil debris from the site and disposing of it in a landfill.

Engineering controls will be implemented to reduce public health and safety concerns associated with soil removal and/or treatment and to manage storm water and siltation during excavation. Excavation workers will be exposed to increased particulate emissions and might also have dermal contact with hazardous constituents. However, worker risk can be minimized with dust control technologies and health and safety measures, including personal protective equipment (PPE).

Groundwater Alternative G2b protects human health and the environment by chemically reducing chromium (VI) to chromium (III), which is less toxic and mobile. Because enhanced in situ reduction is expected to reduce chromium (VI) to concentrations below the MCL (100 μg/L), risk to human health and the environment would be significantly reduced. Short-term risks from inhalation and dermal contact during implementation would be minimal and would be controlled using common engineering techniques and appropriate PPE.

Sediment Alternative M4 is protective of the environment by removing contaminated sediment from the site. Short-term risks posed during implementation include elimination of benthic organisms in the application area and worker exposure to contaminated sediments during implementation. However, benthic organisms would recolonize the area, and human health risks can be controlled with common engineering techniques and PPE.

The SWMSCP, in conjunction with the soil and groundwater remedies, will reduce chromium (VI) and total suspended solids concentrations in the discharge to meet established SCDHEC water quality criteria.

13.2 Compliance with ARARs

The Selected Remedy of (1) onsite chemical reduction and stabilization/solidification of contaminated soil by mechanical mixing, (2) excavation and offsite disposal of gamma radiation-producing soil and debris, (3) enhanced in situ reduction of chromium (VI)-contaminated groundwater using a chemical reductant, (4) dredging and upland disposal of contaminated sediment, and (5) implementation of a SWMSCP complies with all ARARs. Federal and state chemical-, location-, and action-specific ARARs for the Selected Remedy are summarized in Tables 13-1 to 13-3 at the end of this section.

13.3 Cost-Effectiveness

In EPA's judgment, the Selected Remedy is cost-effective and represents a reasonable value for the money to be spent. In making the determination, the following definition was used: "A remedy shall be cost-effective if its costs are proportional to its overall effectiveness" (NCP §300.430[f][1][ii][D]). This was accomplished by evaluating the "overall effectiveness" of those alternatives that satisfied the threshold criteria (i.e., were both protective of human health and the environment and ARAR-compliant). Overall effectiveness was evaluated by assessing three of the five balancing criteria in combination (long-term effectiveness and permanence; reduction in toxicity, mobility, and volume through treatment; and short-term effectiveness). Overall effectiveness was then compared with costs to determine cost-effectiveness. The relationship of the overall effectiveness of the selected remedy was determined to be proportional to its costs and hence represents a reasonable value for the money to be spent. Tables 13-4 to 13-6 summarize cost effectiveness for all of the evaluated alternatives.

Though the selected soil remedy, onsite chemical reduction and stabilization/solidification by mechanical mixing (S2b), is approximately $1,200,000 more expensive than the asphalt cap, it offers a increase in the protection of human health and the environment because chromium (VI) is permanently converted to chromium (III) rather than just capped. As an additional benefit, the treated and stabilized materials can be used for flexible site redevelopment (e.g., site grading). Of the radiological material alternatives that are cost-effective, excavation and offsite disposal (R2) is the least expensive and will most rapidly achieve cleanup levels. It has the additional benefit of no O&M after implementation.

Though enhanced in situ treatment (G2b) is slightly more expensive than continued groundwater containment (G4), it achieves cleanup levels in only three years; the containment alternative includes O&M and monitoring for up to 30 years.

Of the cost-effective sediment alternatives, dredging and upland disposal (M4) was chosen as the selected remedy because it is the least expensive and cleanup levels are met immediately after implementation. The capping alternative (M3) only minimizes exposure and must be monitored for up to 30 years.

13.4 Utilization of Permanent Solutions and Alternative Treatment (or Resource Recovery) Technologies to the Maximum Extent Possible

The EPA has determined that the Selected Remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a practicable manner at the site. Of those alternatives that are protective of human health and the environment and comply with ARARs, the EPA has determined that the Selected Remedy provides the best balance of trade-offs in terms of the five balancing criteria, while also considering the statutory preference for treatment as a principal element and bias against offsite treatment and disposal, and considering state and community acceptance.

The Selected Remedy treats the source materials constituting principal threats at the site, achieving significant reductions in chromium (VI) concentrations in soil and groundwater. The Selected Remedy satisfies the criteria for long-term effectiveness by removing, treating, and stabilizing chromium (VI) contamination from soil and sediment and treating chromium (VI)-contaminated groundwater in situ within three years. The SWMSCP will minimize discharges of surface water runoff that contain COC concentrations above the SCDHEC ambient water quality criteria.

The Selected Remedy does not present short-term risks different from the other treatment alternatives. There are no special implementability issues that set the Selected Remedy apart from any of the other alternatives evaluated.

13.5 Preference for Treatment as a Principal Element

By treating chromium (VI)-contaminated soil with chemical reduction and s/s and groundwater using enhanced in situ reduction, the Selected Remedy addresses principal threats posed by site constituents through the use of treatment technologies. Utilizing treatment as a significant portion of the remedy satisfies the statutory preference for remedies that employ treatment as a principal element.

13.6 Five-Year Review Requirements

Because this remedy will result in hazardous substances, pollutants, or contaminants remaining onsite above levels that allow for unlimited use and unrestricted exposure, a statutory review will be conducted within five years after initiation of remedial action to ensure that the remedy is, or will be, protective of human health and the environment.

Table 13-1
Summary of Potential Chemical-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
Federal Requirements			
Safe Drinking Water Act MCLs *40 CFR 141.11 - 141.16*	Relevant and Appropriate	MCLs have been set for toxic compounds as enforceable standards for public drinking water systems. SMCLs are unenforceable goals regulating the aesthetic quality of drinking water.	Available data indicate that shallow aquifer water quality does not meet the primary and secondary drinking water standards promulgated under the SDWA. However, South Carolina Water Classifications and Standards, SC R.61-68, classify all groundwater as GB (a potential underground source of drinking water).
Safe Drinking Water Act MCLGs *40 CFR 141.50-141.51*	Relevant and Appropriate	MCLGs are unenforceable goals under the SDWA.	Available data indicate that shallow aquifer water quality does not meet the primary and secondary drinking water standards promulgated under the SDWA. However, South Carolina Water Classifications and Standards, R.61-68, classify all groundwater as GB (a potential underground source of drinking water).
Clean Water Act Federal Water Quality Criteria *51 Federal Register 43665*	Applicable	Effluent limitations must meet Best Achievable Technology. Ambient Water Quality Criteria (AWQC) are provided for toxic chemicals.	Discharges to water bodies during remedial activities would have AWQC as potential goals.

Table 13-1
Summary of Potential Chemical-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
State Requirements			
South Carolina Drinking Water Regulations *SC R.61-58.5*	Relevant and Appropriate	Establishes primary and secondary MCLs as well as sampling and analytical requirements.	Available data indicate that shallow aquifer water quality does not meet the primary and secondary drinking water standards promulgated under the SDWA. However, South Carolina Water Classifications and Standards, SC R.61-68, classify all groundwater as GB (a potential underground source of drinking water).
South Carolina Water Classification and Standards *SC R.61-68*	Applicable	Establishes a system and rules for managing and protecting the quality of South Carolina surface water and groundwater.	Remedial objectives require protection of surface water and groundwater.

Table 13-2
Summary of Potential Location-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
Federal Requirements			
CERCLA *104, 106, 107, 120, 121, 122*	Applicable	Regulations controlling inactive hazardous waste sites.	Applicable as some form of remedial action is likely required at Macalloy.
National Environmental Policy Act *40 CFR Part 6, Appendix A*	Applicable	Sets forth USEPA policy carrying out the provisions of Executive Order 11988, Flood Plain Management Policy, and Executive Order 11990, Wetlands Protection Policy.	The Macalloy site is located within a 100-year floodplain and abuts wetlands areas.
Fish and Wildlife Coordination Act (16 U.S.C. 661 et seq.) *33 CFR Part 320 to Part 330* *40 CFR 6.302*	Applicable	Fish and wildlife must be protected from actions modifying streams or areas affecting streams.	Construction activities, particularly storm/surface water management strategy modifications, must meet these requirements.
RCRA Location Requirements *40 CFR 264.18*	Relevant and Appropriate	Sets forth minimum requirements for design, construction, and operation of a facility where treatment, storage, or disposal of hazardous waste will be within a 100-year floodplain.	If treatment of hazardous waste is required onsite, and treatment occurs within the 100-year floodplain, RCRA location requirements may be relevant and appropriate.

Table 13-2
Summary of Potential Location-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
State Requirements			
Ocean and Coastal Resource Management *SC R 30*	Applicable	Serves to protect and enhance the state's coastal resources.	Remediation activities and storm water must be managed in accordance with these requirements.
Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities: Location Standards *SC R 61-79*.264.18	Relevant and Appropriate	Sets forth minimum requirements for design, construction, and operation of a facility where treatment, storage, or disposal of hazardous waste will be within a 100-year floodplain.	Relevant and appropriate if hazardous wastes are treated onsite.
Hazardous Waste Management Location Standards *SC R.61-104*	Relevant and Appropriate	This regulation creates requirements for the location of hazardous waste treatment, storage, or disposal facilities.	Macalloy remediation system(s) should be limited to those areas where there will be minimal impact to human health and the environment.

Table 13-3
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
Federal Requirements			
CERCLA *121 (d)(3)*	Applicable	CERCLA wastes can only be transferred to facilities that are in compliance with RCRA, the Toxic Substance and Control Act, or other applicable federal and state requirements.	Applicable if hazardous wastes are generated onsite.
Occupational Safety and Health Administration (OSHA) Hazardous Waste Operations and Emergency Responses Standard and OSHA General Safety and Health Standards *29 CFR 1910.120* *29 CFR Part 1926*	Applicable	Sets limits on exposure to workers on hazardous sites or emergency responses, sets forth minimum health and safety requirements such as personal protection and training, and establishes reporting requirements.	All activities taking place at Macalloy including remediation, construction, and monitoring are subject to OSHA health and safety regulations.
Clean Air Act Permits Regulation *40 CFR 72*	Applicable	Establishes requirements for major source permitting and operation.	Applies to any remedial action with a major source air emission.
CWA National Pollutant Discharge Elimination System (NPDES) *40 CFR 122, 125, 129, 136*	Applicable	Prohibits unpermitted discharge of any pollutant or combination of pollutants. Standards and limitations are established for discharges to waters of the U.S. from any point source.	Remedial actions may include the discharge of treated groundwater, runoff, or other flows to surface water.
CWA Wetlands Regulations Part 404 *40 CFR 230*	Applicable	Controls the discharge of dredged or fill materials into waters of the U.S. such that the physical and biological integrity is maintained.	Remedial actions may include capping or dredging sediment in wetlands.

Table 13-3
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
Federal Requirements (continued)			
RCRA Identification of Hazardous Waste *40 CFR 261*	Applicable	Criteria for identifying those solid wastes subject to regulation as hazardous wastes under RCRA.	Applicable if solid wastes meeting the requirements of RCRA hazardous waste are generated onsite during remedial actions.
RCRA Generator Standards *40 CFR 262*	Relevant and Appropriate	Establishes standards for generators of RCRA hazardous waste(s).	Relevant and appropriate if solid wastes meeting the requirements of RCRA hazardous waste are generated onsite during remedial actions.
RCRA Facility Standards *40 CFR 264 and 265*	Relevant and Appropriate	Establishes standards for the management and storage of RCRA hazardous waste(s).	Relevant and appropriate if solid wastes meeting the requirements of RCRA hazardous waste are generated onsite during remedial actions.
RCRA Land Disposal Restrictions (LDRs) *40 CFR 268*	Applicable	Certain classes of waste are restricted from land disposal without acceptable treatment.	If hazardous wastes are generated during remedial activities, they will require treatment to comply with LDRs before disposed in a permitted landfill.
National Contingency Plan *40 CFR 300*	Applicable	Governs all actions at CERCLA sites.	Applicable because remedial action is likely required at Macalloy.

Table 13-3
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
Federal Requirements (continued)			
Department of Transportation Rules for the Transport of Hazardous Substances *49 CFR Parts 107 and 171-179*	Applicable	Regulates the labeling, packaging, placarding, and transportation of solid and hazardous wastes offsite.	Applicable if offsite transport and disposal of solid and hazardous wastes are necessary.
State Requirements			
General Rules and Standards for the National Pollutant Discharge Elimination System *SC R.61-68*	Applicable	Establishes design and performance standards and permit requirements for discharge facilities.	Remedial actions may include the discharge of runoff, or other flows to surface water.
Air Pollution Control Regulations and Standards: Control of Fugitive Particulate Matter *SC R.61-62.6*	Applicable	Establishes guidelines for dust suppression during construction activities in attainment and non-attainment areas.	Charleston is in an attainment area as of January 2001.
Licensing of Naturally Occurring Radioactive Material (NORM) *SC R.61-63 Part IX*	Applicable	This part establishes radiation protection standards for the possession, use, transfer, transport, and/or storage of NORM or the recycling of NORM-contaminated materials not subject to regulation under the Atomic Energy Act of 1954, as amended.	NORM may be managed as part of remediation activities at Macalloy.

Table 13-3
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
State Requirements (continued)			
Well Standards *SC R.61-71*	Applicable	Establishes local criteria for design, installation, and abandonment of monitoring wells.	Installation of monitoring wells will be a necessary part of site remediation. Existing wells may be abandoned.
Identification and Listing of Hazardous Waste *SC R.61-79.261*	Applicable	Criteria for identifying those solid wastes subject to regulation as hazardous waste under RCRA.	Applicable if solid wastes meeting the requirements of RCRA hazardous waste are generated onsite during remedial actions.
Standards Applicable to Generators of Hazardous Waste *SC R.61-79.262*	Relevant and Appropriate	Establishes standards for generators of RCRA hazardous waste(s).	Relevant and appropriate if solid wastes meeting the requirements of RCRA hazardous waste are generated onsite during remedial actions.
Hazardous Waste Management Regulations *SC R.61-79.264*	Applicable	The purpose of this part is to establish minimum State standards that define the acceptable management of hazardous waste. The standards in this part apply to owners and operators of all facilities which treat, store, or dispose of hazardous waste, except where noted otherwise.	Applicable if solid wastes meeting the requirements of RCRA hazardous waste are generated onsite during remedial actions.
Land Disposal Restrictions *SC R.61-79.268*	Applicable	Certain classes of waste are restricted from land disposal without acceptable treatment.	If hazardous wastes are generated during remedial activities, they will require treatment to comply with LDRs before disposed in a permitted landfill.

Table 13-3
Summary of Potential Action-Specific ARARs

Requirements	Status	Requirement Synopsis	Application to the Selected Remedy
State Requirements (continued)			
Proper Closeout of Wastewater Treatment Facilities *SC R 61-82*	Applicable	These regulations outline proper closeout of wastewater treatment lagoons.	The storm water management plan may include the closeout of onsite lagoons.
Underground Injection Control Regulations *SC R.61-87*	Relevant and Appropriate	These regulations set forth the specific requirements for controlling underground injection in SC and include provisions for the following: classification and regulation of injection wells; prohibiting unauthorized injection; protecting underground sources of drinking water from injection; classifying underground sources of drinking water; and requirements for abandonment, monitoring, and reporting for existing injection wells used to inject wastes or contaminants.	Injection of amendments to stimulate contaminant reduction must meet the requirements of this regulation.

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Table 13-4
Soil Alternatives Cost and Effectiveness Summary

Relevant Soil Alternative Considerations
Chromium (VI) cleanup level for soil: 23 mg/kg
Remedial quantities (cubic yards): USI berm material (40,000); lined-impoundment berm material (15,000); casting bay/ESP dust storage and treatment area (18,500); lake fill area (40,000); isolated areas (1,500)

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
No action (S1)	C: $0 A: $10 every 5 years P: $22	Contaminated soil volume and chromium (VI) concentrations would remain unchanged, except for intrinsic attenuation. No controls over remaining contamination. No reliability.	None.	Offers no additional community protection. No risk to workers. Cleanup levels not met.
Hot-mix asphalt cap (S4) ★	C: $6,259 A: $422 P: $6,681	Will minimize leaching of chromium (VI) to groundwater and surface water. Though reliable, maintenance will be required to ensure effectiveness of the cap because contaminated soil remains onsite.	Some treatment of berm material for use in cap.	Minor increase in dust during construction activities. Worker risk would be minimized with PPE. Engineering controls are required to minimize environmental impacts. Construction complete in 5 months; monitoring required for 30 years.
Onsite chemical reduction and stabilization/ solidification (S2) ★	C: $7,883 A: $0 P: $7,883	Demonstrated treatment technology. Long-term effectiveness expected. Reoxidation of chromium (III) to chromium (VI) is not expected.	Toxicity and mobility are significantly reduced by chemical reduction and s/s. Soil volume may increase.	Increase in dust during construction activities. Worker risk would be minimized with PPE. Engineering controls are required to minimize environmental impacts. Treatment complete in 7 months.

Table 13-4
Soil Alternatives Cost and Effectiveness Summary

Relevant Soil Alternative Considerations
Chromium (VI) cleanup level for soil: 23 mg/kg
Remedial quantities (cubic yards): USI berm material (40,000); lined-impoundment berm material (15,000); casting bay/ESP dust storage and treatment area (18,500); lake fill area (40,000); isolated areas (1,500)

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
Excavation with offsite disposal (S3) ★	C: $8,872 A: $0 P: $8,872	No risk would remain after contaminated soil is removed. Though landfill disposal would be extremely reliable, future liability could be incurred.	Some pretreatment may occur prior to disposal.	Minor increase in dust during excavation activities. Worker risk would be minimized with PPE. Engineering controls are required to minimize environmental impacts. Implementation complete in 6 months.

Cost-Effectiveness Summary
Alternative S1 is not considered cost-effective.
Alternative S2, S3, and S4 are considered cost-effective.
Though S4 is less expensive than S2, S2 permanently converts Chromium (VI) to chromium (III); S4 only provides exposure mitigation for 30 years.

Key
TMV: toxicity, mobility, and volume; ★: considered cost-effective; C: capital costs; A: annual costs (present worth); P: total present worth cost

Table 13-5
Radiological Materials Alternatives Cost and Effectiveness Summary

Relevant Radiological Material Alternative Considerations
Approximately 2,000 ft^2 of radioactive material.
110 cubic yards requires excavation.
Average levels of gamma radiation ranged from background (6 μR/hr) to 70 μR/hr at waist level during site screening. Cleanup level is 12 μR/hr.

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
No action (R1)	C: $0 A: $5 every 5 years P: $11	Source not addressed. Existing risk remains. No controls over remaining radioactive materials. No reliability.	None.	Offers no additional community protection. No risk to workers. Cleanup levels not met.
Excavation with offsite disposal (R2) ★	C: $15 A: $0 P: $15	No risk would remain after radioactive soil and debris are removed. Though landfill disposal would be extremely reliable, future liability could be incurred.	None.	Minor increase in dust during construction activities. Worker risk would be minimized with dust suppression and radiation monitoring. Minimal environmental risk. Cleanup levels achieved in one week.
Soil cover (R3) ★	C: $24 A: $17 P: $41	Risk reduced as long as cap is adequately maintained. A maintained cap would adequately and reliably control exposure to radioactive soil and debris.	None.	Minor increase in dust during construction activities. Worker risk would be minimized with dust suppression and radiation monitoring. Minimal environmental risk. Cleanup levels achieved in one week. Long-term monitoring required.

Cost-Effectiveness Summary
Alternative R1 is not considered cost-effective.
Alternatives R2 and R3 are considered cost-effective.
R2 is the most cost effective because R2 removes the radioactive materials from the site, is the least costly alternative, and requires no monitoring.

Key
TMV: toxicity, mobility, and volume; ★: considered cost-effective; C: capital costs; A: annual costs (present worth); P: total present worth cost

Table 13-6
Groundwater Alternatives Cost and Effectiveness Summary

Relevant Groundwater Alternative Considerations
5 distinct plumes identified during the RI/FS
44,600,000 L of chromium (VI)-contaminated groundwater exceeding 100 μg/L
dissolved-phase chromium (VI) mass: 215 kg
saturated soil chromium (VI) mass: 1,270 kg

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
No action (G1)	C: $40 A: $39 P: $79	Contaminated groundwater volume and chromium (VI) concentrations would remain unchanged except for intrinsic attenuation. No controls over remaining contamination. No reliability.	None.	Offers no additional community protection. No risk to workers. Cleanup levels not met.
Groundwater containment ★ (G4)	C: $655 A: $1,228 P: $1,883	Groundwater contaminant migration is expected to be arrested by the containment system. Risk minimized by containing chromium (VI) migration. Groundwater collection, pump, and treat is a reliable containment technology.	Chromium (VI) mobility would be reduced via containment. Minimal toxicity and volume reductions because source area would be unaffected.	Minor increase in dust during construction activities. No short-term risks are anticipated with proper PPE and health and safety procedures. No open-trench hazards associated with one-pass trencher. Minimal impact to the environment. Containment required for at least 30 years.
Enhanced in situ reduction ★ (G2)	C: $1,843 A: $210 P: $2,053	Risk reduction and long-term effectiveness are expected to be exceptional, particularly if source materials are removed or targeted in the design. Re-oxidation of chromium (III) to chromium (VI) is not expected.	Toxicity, mobility, and volume would be reduced by enhancing already occurring natural attenuation processes.	Minor increase in dust during construction activities. No short-term risks are anticipated with proper PPE and health and safety procedures. Minimal impact to the environment. Treatment complete in three years.

Table 13-6
Groundwater Alternatives Cost and Effectiveness Summary

Relevant Groundwater Alternative Considerations
5 distinct plumes identified during the RI/FS
44,600,000 L of chromium (VI)-contaminated groundwater exceeding 100 μg/L
dissolved-phase chromium (VI) mass: 215 kg
saturated soil chromium (VI) mass: 1,270 kg

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
ZVI-PRB with enhanced in situ reduction (G3) ★	C: $1,958 A: $633 P: $2,591	Reactive media are expected to have long-term treatment capacity. Risk minimized by containing chromium (VI) migration. Demonstrated treatment technology. Reactive media rejuvenation may be necessary. Reoxidation of chromium (III) to chromium (VI) is not expected.	Chromium (VI) mobility would be reduced via containment. Minimal toxicity and volume reductions because source area would be unaffected.	Minor increase in dust during construction activities. No short-term risks are anticipated with proper PPE and health and safety procedures. No open-trench hazards associated with one-pass trencher. Minimal impact to the environment. Containment required for at least 30 years.

Cost-Effectiveness Summary
Alternative G1 is not considered cost-effective.
Alternatives G2, G3, and G4 are considered cost-effective.
Though G3 is less expensive than G2, G2 achieves cleanup levels in 3 years; G3 and G4 only provide containment for 30 years.

Key
TMV: *toxicity, mobility, and volume;* ★: *considered cost-effective;* C: *capital costs;* A: *annual costs (present worth);* P: *total present worth cost*

Table 13-7
Sediment Alternatives Cost and Effectiveness Summary

Relevant Sediment Alternative Considerations
Depth of contaminated sediment is conservatively assumed to be 18 inches.
Volume of contaminated sediment to be remediated is estimated to be 1,000 cubic yards.
COCs: chromium, nickel, and zinc

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
No action (M1)	C: $0 A: $12 every 5 years P: $26	Contaminated sediment volume and COC concentrations would remain unchanged except for natural sedimentation. No controls over remaining contamination. No reliability. Existing risk remains.	None.	Offers no additional community protection. No risk to workers. Cleanup levels not met.
Removal with upland disposal (M4) ★	C: $492 A: $0 P: $492	Excavation and disposal eliminates risk effectively and permanently. Very reliable because contaminated sediment is removed, treated if needed, and placed in a secure area.	None.	No short-term risks are anticipated with proper PPE and health and safety procedures. Implementation could result in short-term elimination of benthic organisms. It will also impact the tidal creek ecological habitat. Four weeks are required to implement design.
Cap (M3) ★	C: $498 A: $61 P: $559	Effective at minimizing exposure to contaminated sediments. Because contaminated sediment may remain onsite, maintenance will be required to ensure effectiveness. Caps are reliable controls but require long-term maintenance to ensure effectiveness.	None.	No short-term risks are anticipated with proper PPE and health and safety procedures. Implementation could result in short-term elimination of benthic organisms. It will also impact the tidal creek ecological habitat. Four weeks are required to implement design.

Table 13-7
Sediment Alternatives Cost and Effectiveness Summary

Relevant Sediment Alternative Considerations
Depth of contaminated sediment is conservatively assumed to be 18 inches.
Volume of contaminated sediment to be remediated is estimated to be 1,000 cubic yards.
COCs: chromium, nickel, and zinc

Alternative	Costs (x1,000)	Long-Term Effectiveness and Permanence	Reduction of TMV Through Treatment	Short-Term Effectiveness
Enhanced monitored natural recovery (M2) ★	C: $50 A: $576 P: $626	Effective by enhanced sedimentation. Additional monitoring is provided so that another alternative can be selected if the cleanup levels are not met.	None.	Minimal risk to workers. Not enough data to predict when cleanup levels would be met.

Cost-Effectiveness Summary
Alternative M1 is not considered cost-effective.
Alternatives M3 and M4 are considered cost-effective. Alternative M2 is less cost-effective.
M4 is the least expensive of these and eliminates the contaminated sediment from the tidal creek without long-term controls.

Key
TMV: toxicity, mobility, and volume; ★: considered cost-effective; C: capital costs; A: annual costs (present worth); P: total present worth cost

14

14.0 DOCUMENTATION OF SIGNIFICANT CHANGES FROM THE PREFERRED ALTERNATIVE OF THE PROPOSED PLAN

The Proposed Plan for the Macalloy Site was released for public comment on April 11, 2002. The Proposed Plan identified Alternative S2b (Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with Mechanical Mixing) for vadose zone soil; Alternative R2 (Excavation and Disposal) for radiological materials; Alternative G2b (Enhanced In Situ Reduction: Chemical Reductant) for shallow groundwater; Alternative M4 (Removal with Upland Disposal) for sediment; and a comprehensive storm water management plan for storm water. EPA received comments on the draft Proposed Plan from NOAA and SCDHEC. EPA received written comments from five entities during the 60 day Proposed Plan public comment period which ran from April 11 to June 10, 2002. EPA reviewed and fully considered written comments from the Honorable Keith Summey (Mayor of North Charleston), the Macalloy Corporation, the South Carolina Department of Natural Resources, SCDHEC's Office of Ocean and Coastal Resource Management, and CSX Transportation. No significant or fundamental changes to the remedy, as originally identified in the Proposed Plan, were necessary or appropriate. EPA's individual responses to specific comments received are provided in the Responsiveness Summary, which is Part III of this ROD.

59

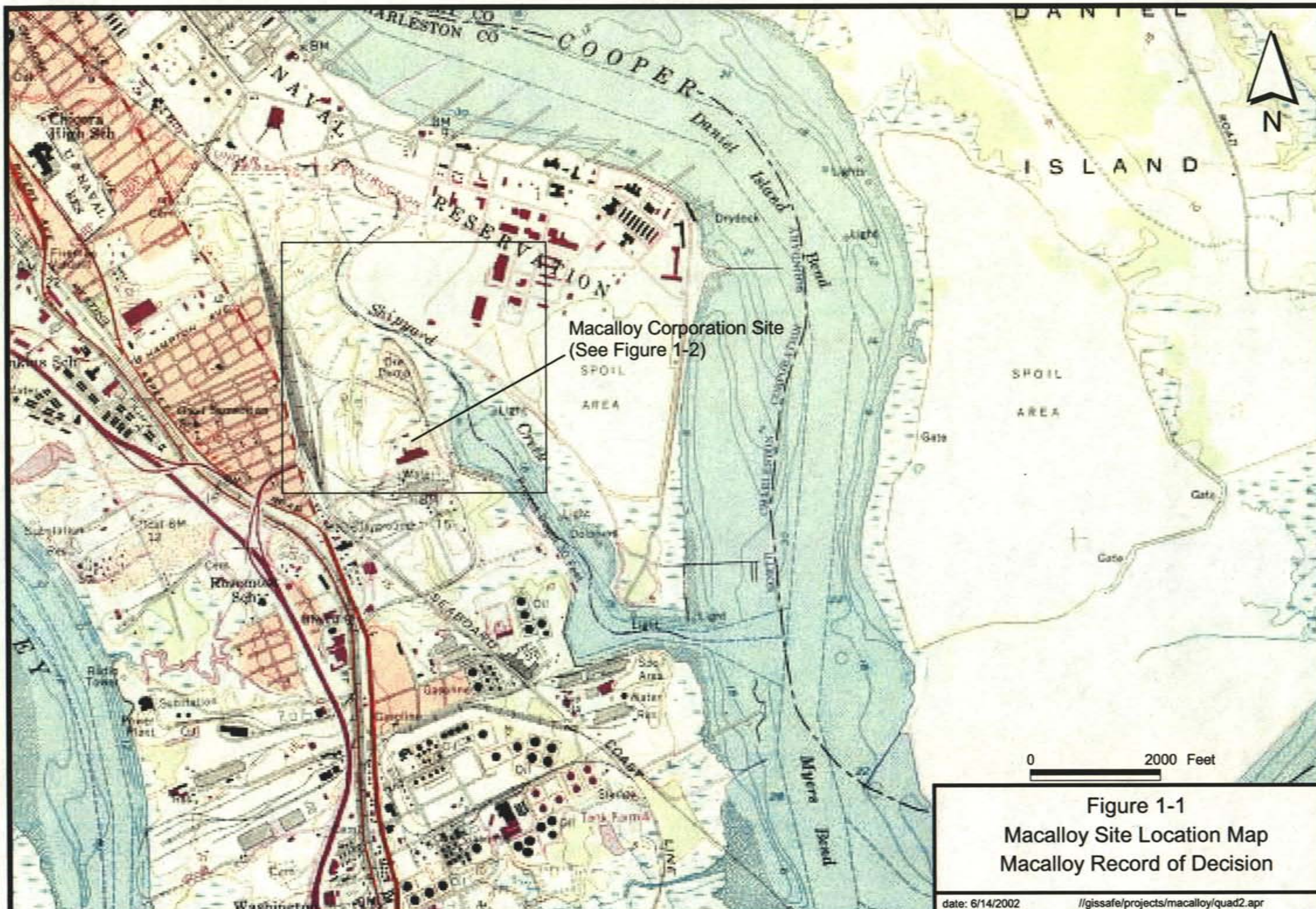


Figure 1-1
Macalloy Site Location Map
Macalloy Record of Decision

date: 6/14/2002 //gissafe/projects/macalloy/quad2.apr

59 212

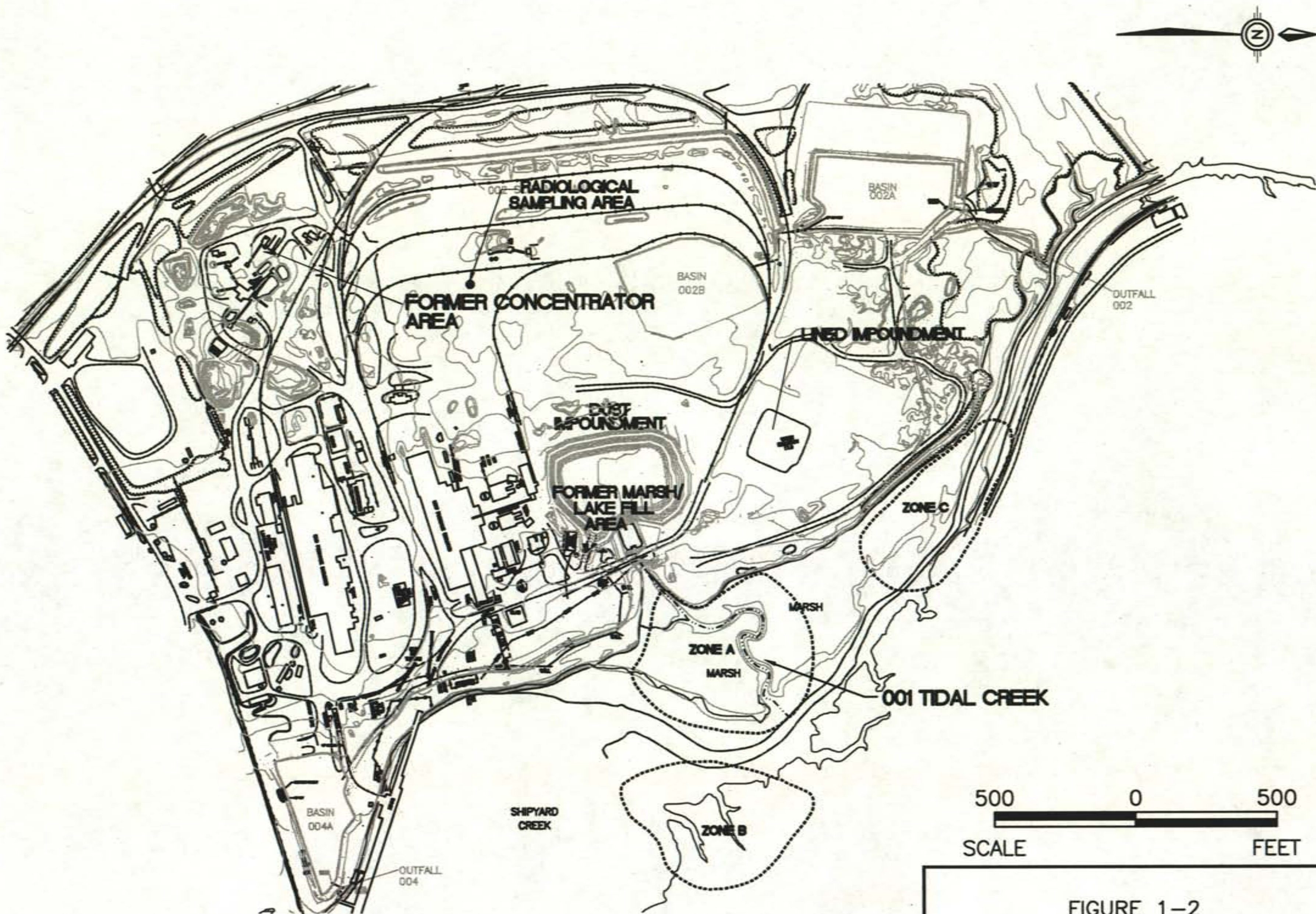


FIGURE 1–2
MACALLOY CORPORATION SITE
MACALLOY RECORD OF DECISION

DWG DATE: 06/14/02	NAME: 2417021W024

59 213

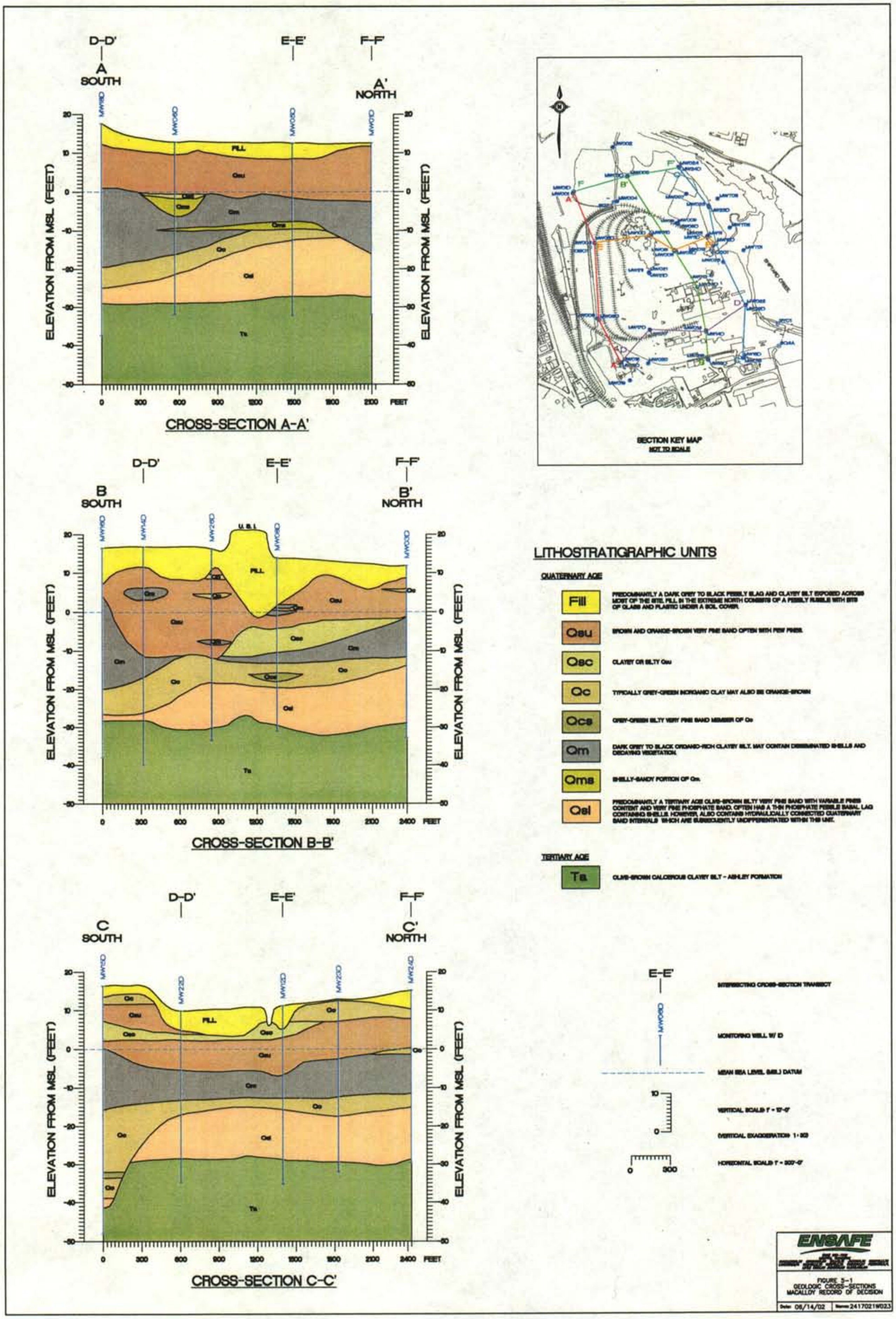
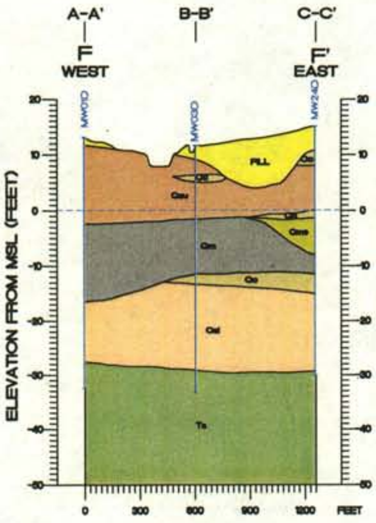
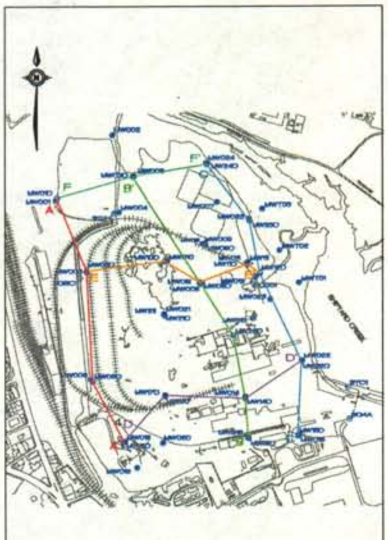
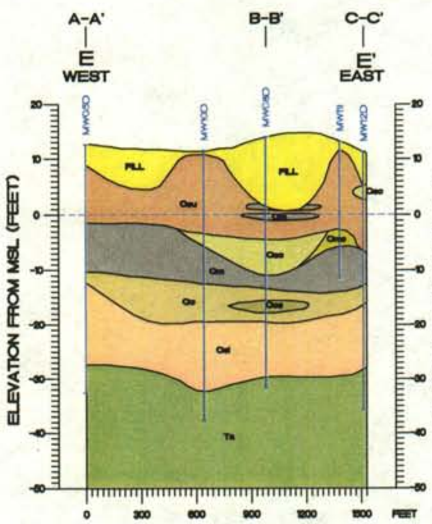


FIGURE 3-1
GEOLOGIC CROSS-SECTIONS
MACALLOY RECORD OF DECISION

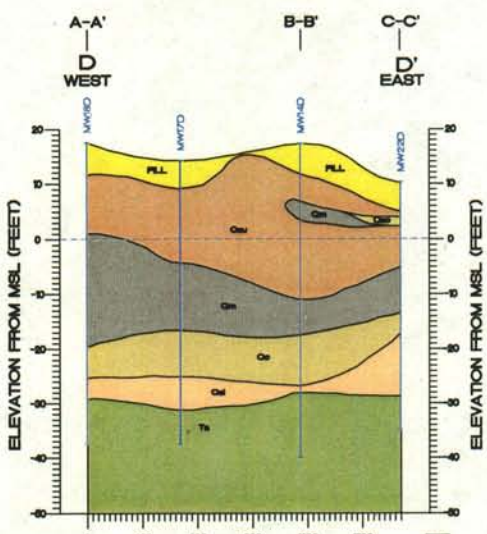


CROSS-SECTION F-F'





CROSS-SECTION E-E'



CROSS-SECTION D-D'

LITHOSTRATIGRAPHIC UNITS

QUATERNARY AGE

Fill	PREDOMINANTLY A DARK GREY TO BLACK PEBBLY SLAG AND CLAYEY SILT EXPOSED ACROSS MOST OF THE SITE. FILL IN THE EXTREME NORTH CONSISTS OF A PEBBLY RUBBLE WITH BITS OF GLASS AND PLASTIC UNDER A SOIL COVER.
Qsu	BROWN AND ORANGE-BROWN VERY FINE SAND OFTEN WITH FEW FINES.
Qsc	CLAYEY OR SILTY Qsu
Qc	TYPICALLY GREY-GREEN INORGANIC CLAY MAY ALSO BE ORANGE-BROWN
Qcs	GREY-GREEN SILTY VERY FINE SAND MEMBER OF Qc
Qm	DARK GREY TO BLACK ORGANIC-RICH CLAYEY SILT. MAY CONTAIN DISSEMINATED SHELLS AND DECAYING VEGETATION.
Qms	SHELLY-SANDY PORTION OF Qm.
Qsl	PREDOMINANTLY A TERTIARY AGE OLIVE-BROWN SILTY VERY FINE SAND WITH VARIABLE FINES CONTENT AND VERY FINE PHOSPHATE SAND. OFTEN HAS A THIN PHOSPHATE PEBBLE BASAL LAG CONTAINING SHELLS. HOWEVER, ALSO CONTAINS HYDRAULICALLY CONNECTED QUATERNARY SAND INTERVALS WHICH ARE SUBSEQUENTLY UNDIFFERENTIATED WITHIN THIS UNIT.

TERTIARY AGE

Ta	OLIVE-BROWN CALCEROUS CLAYEY SILT - ASHLEY FORMATION

B-B' — INTERSECTING CROSS-SECTION TRANSECT

MW03D — MONITORING WELL W/ ID

MEAN SEA LEVEL (MSL) DATUM

VERTICAL SCALE 1" = 10'-0"

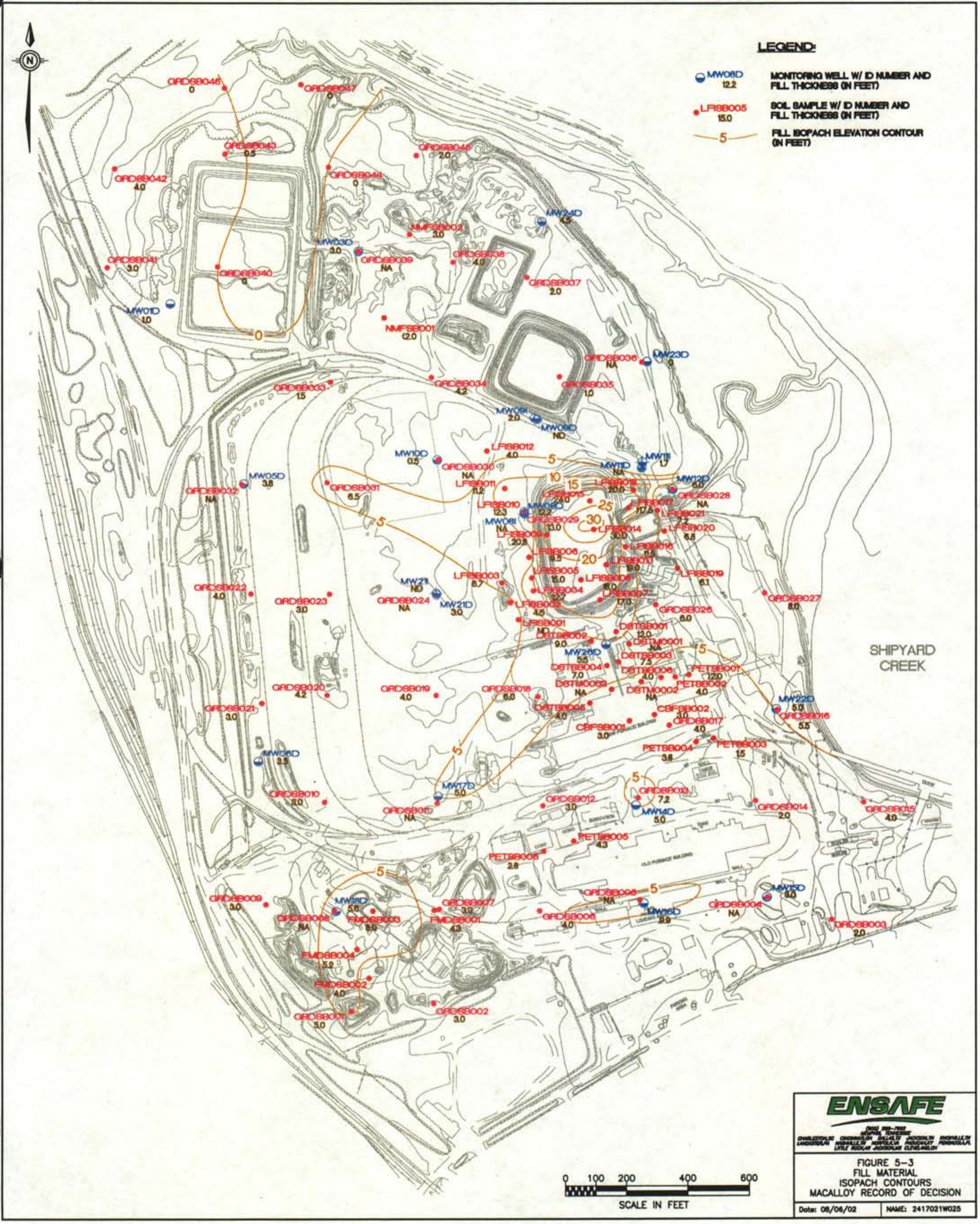
(VERTICAL EXAGGERATION 1:30)

HORIZONTAL SCALE 1" = 300'-0"

ENSAFE

FIGURE 5-2
GEOLOGIC CROSS-SECTIONS
MACALLOY RECORD OF DECISION

Date: 08/14/02 | Name: 2417021W022


LEGEND:
MW08D 12.2 MONITORING WELL W/ ID NUMBER AND FILL THICKNESS (IN FEET)
LFSB005 15.0 SOIL SAMPLE W/ ID NUMBER AND FILL THICKNESS (IN FEET)
5 FILL ISOPACH ELEVATION CONTOUR (IN FEET)
SHIPYARD CREEK
0 100 200 400 600
SCALE IN FEET
ENSAFE
FIGURE 5-3
FILL MATERIAL
ISOPACH CONTOURS
MACALLOY RECORD OF DECISION
Date: 08/06/02
NAME: 2417021W025

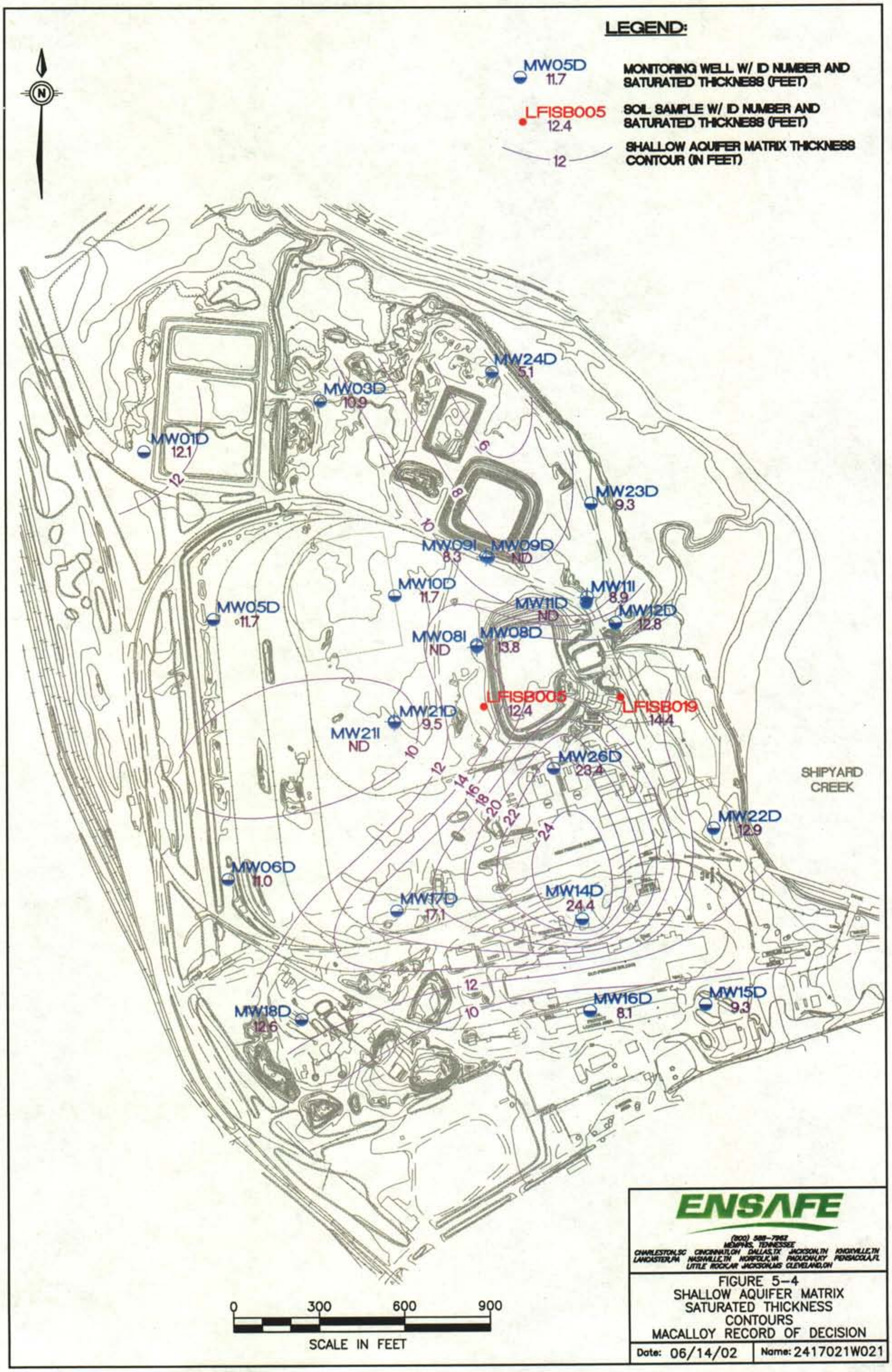
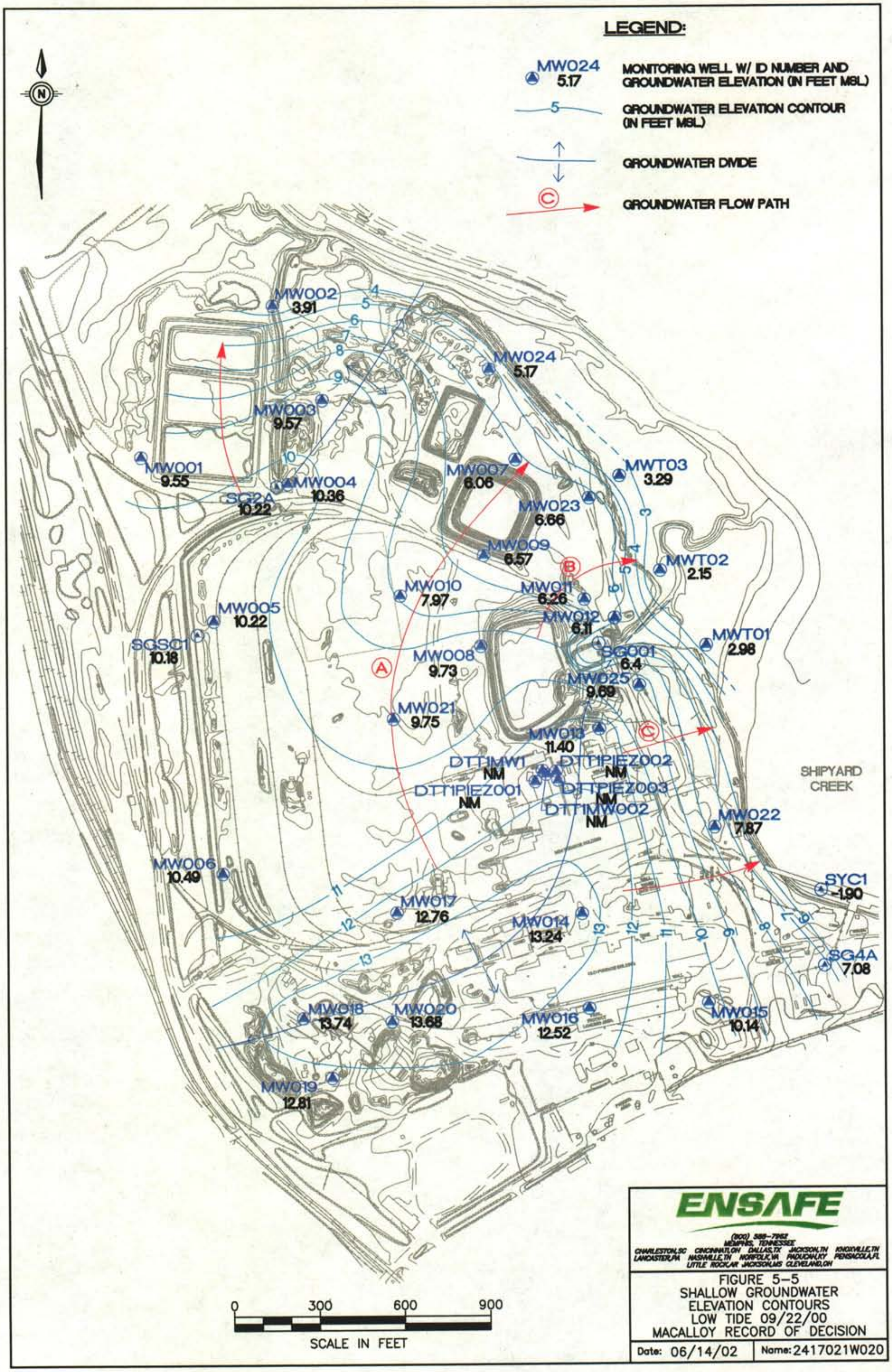
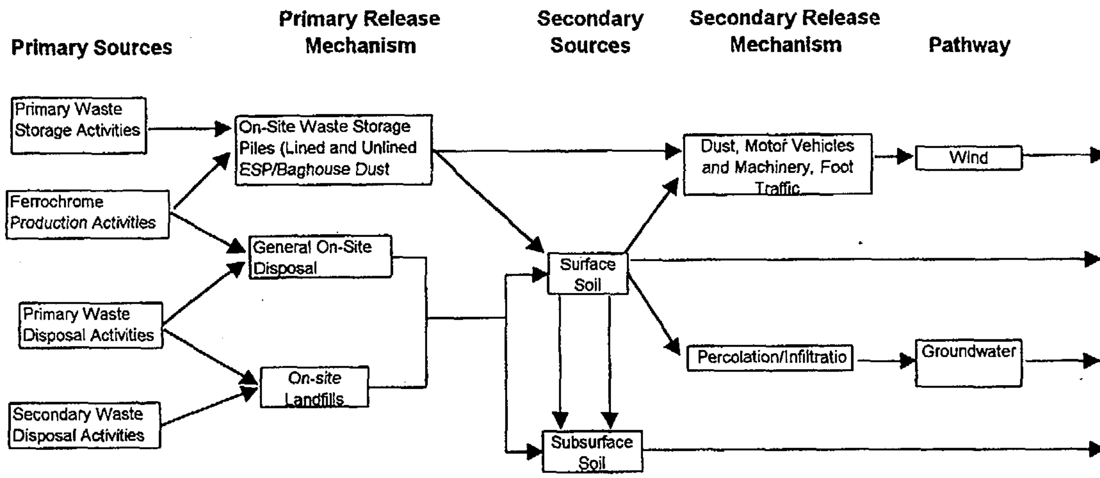


FIGURE 5-4
SHALLOW AQUIFER MATRIX SATURATED THICKNESS CONTOURS
MACALLOY RECORD OF DECISION

Date: 06/14/02 Name: 2417021W021


LEGEND:
MW024 5.17 MONITORING WELL W/ ID NUMBER AND GROUNDWATER ELEVATION (IN FEET MSL)
GROUNDWATER ELEVATION CONTOUR (IN FEET MSL)
GROUNDWATER DIVIDE
GROUNDWATER FLOW PATH
MW002 3.91
MW024 5.17
MW003 9.57
MW001 9.55
MW004 10.36
SG2A 10.22
MW007 6.06
MWT03 3.29
MW023 6.66
MW009 6.57
MWT02 2.15
MW010 7.97
MW011 6.26
MW005 10.22
MW012 6.11
SGSC1 10.18
MWT01 2.98
MW008 9.73
SG001 6.4
MW025 9.69
MW021 9.75
MW013 11.40
DTTIMW1 NM
DTTIPIEZ002 NM
DTTIPIEZ001 NM
DTTPIEZ003 NM
DTTIMW002 NM
SHIPYARD CREEK
MW022 7.87
MW006 10.49
SYC1 -1.90
MW017 12.76
MW014 13.24
SG4A 7.08
MW018 13.74
MW020 13.68
MW016 12.52
MW015 10.14
MW019 12.81
0 300 600 900
SCALE IN FEET
ENSAFE
FIGURE 5-5
SHALLOW GROUNDWATER
ELEVATION CONTOURS
LOW TIDE 09/22/00
MACALLOY RECORD OF DECISION
Date: 06/14/02
Name: 2417021W020



EXPOSURE ROUTE	HUMAN RECEPTOR: Site Residents	Industrial Workers	Trespasser/ Visitor	Construction Worker
Ingestion				
Inhalation	✔	✔		
Dermal Contact				
Ingestion	✔	✔		
Inhalation				
Dermal Contact	✔	✔		
Ingestion	✔	✔		
Inhalation				
Dermal Contact				
Ingestion	✚	✚	✚	✚
Inhalation	✚	✚	✚	✚
Dermal Contact	✚	✚	✚	✚

ENSAFE
Figure 5-6: Conceptual Site Model
Macalloy Corporation
North Charleston, South Carolina
Date: 03/26/2001 Conceptualmodel.xls

Notes:
✔ Denotes a pathway evaluated quantitatively in this Risk Assessment
✚ Denotes an Incomplete Pathway
Rational for the Selection and Exclusion of Pathways is Provided in Section 7-2 of the RI/FS report.

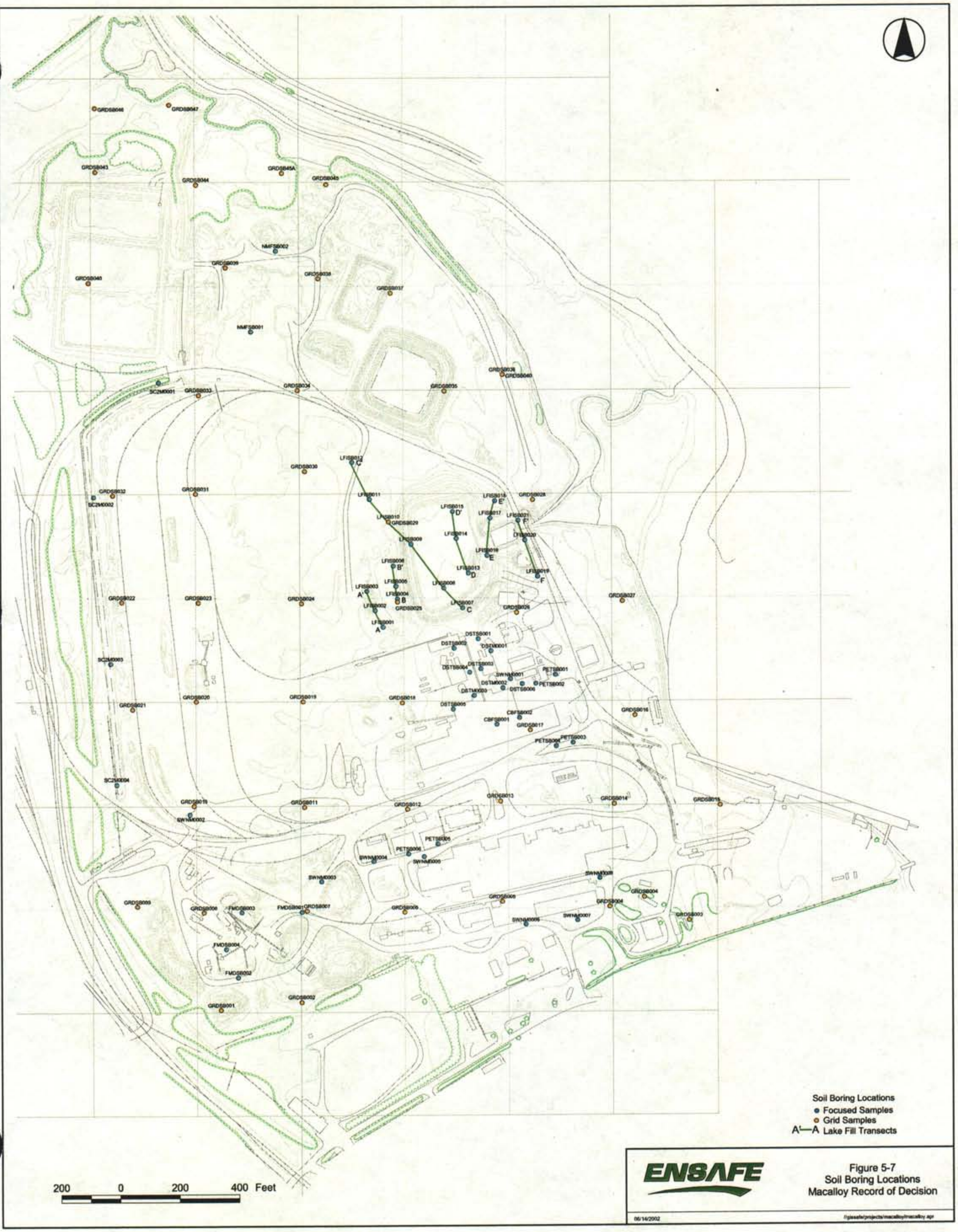


Figure 5-7
Soil Boring Locations
Macalloy Record of Decision

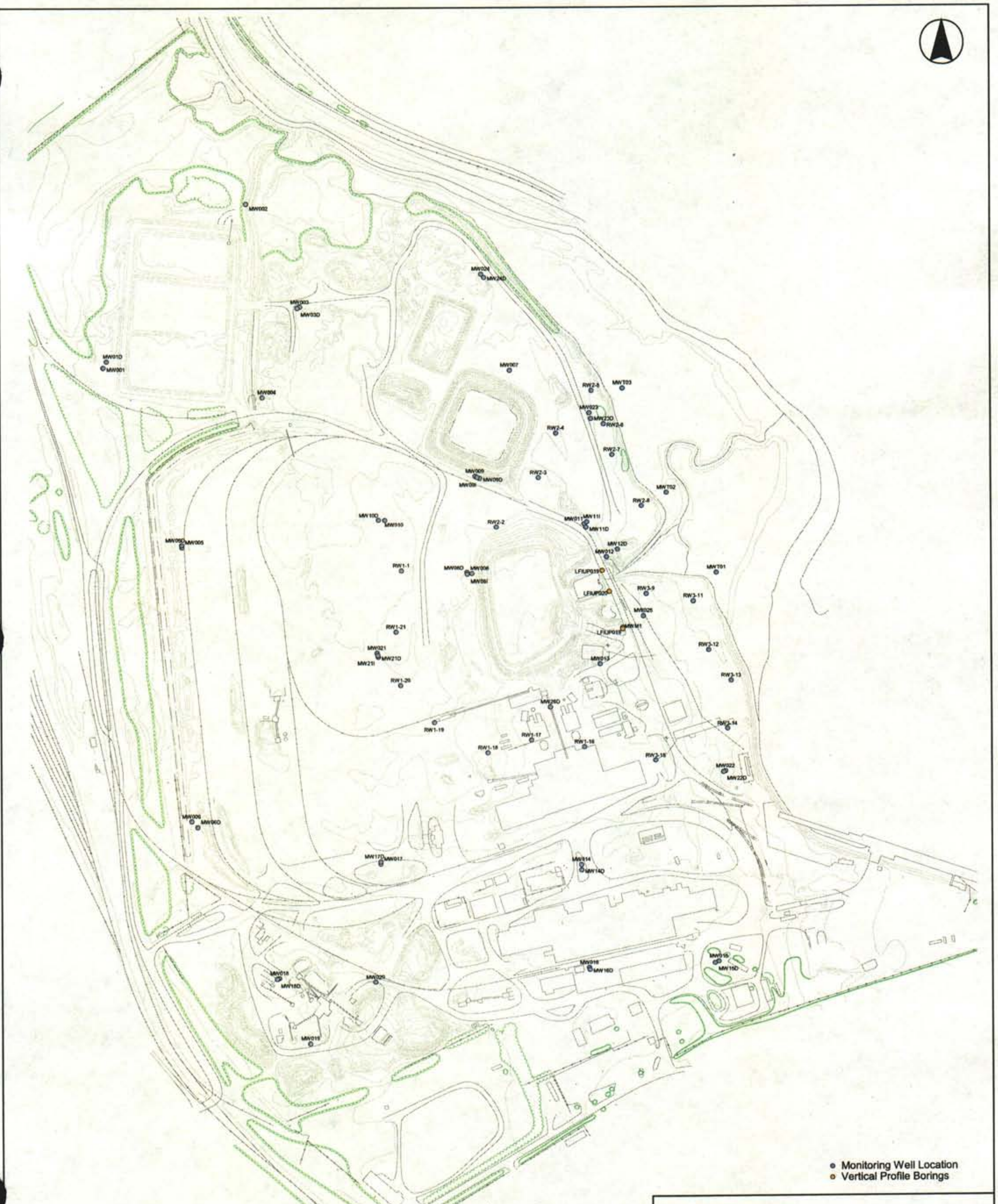


Figure 5-8
Well Locations
Macalloy Record of Decision

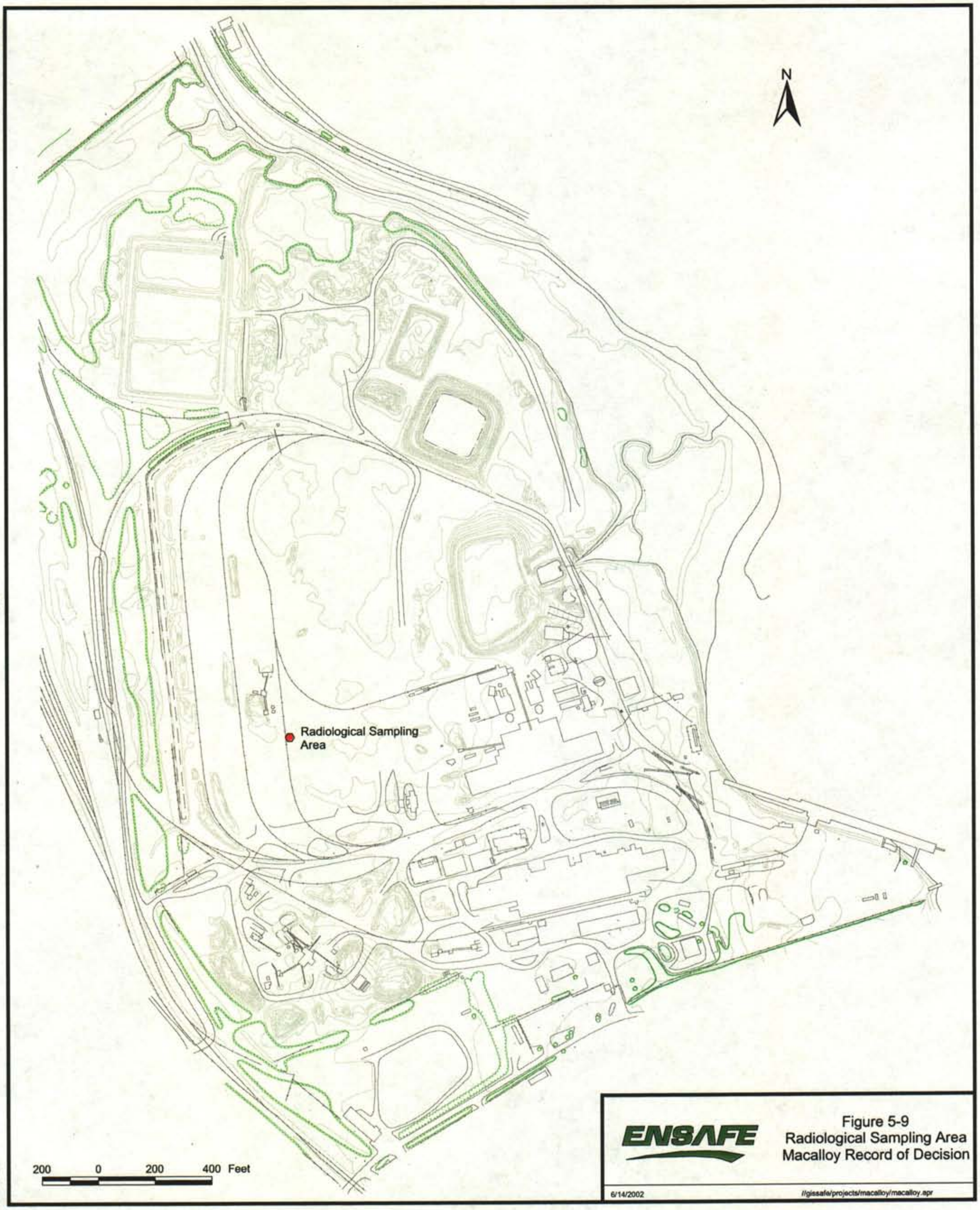


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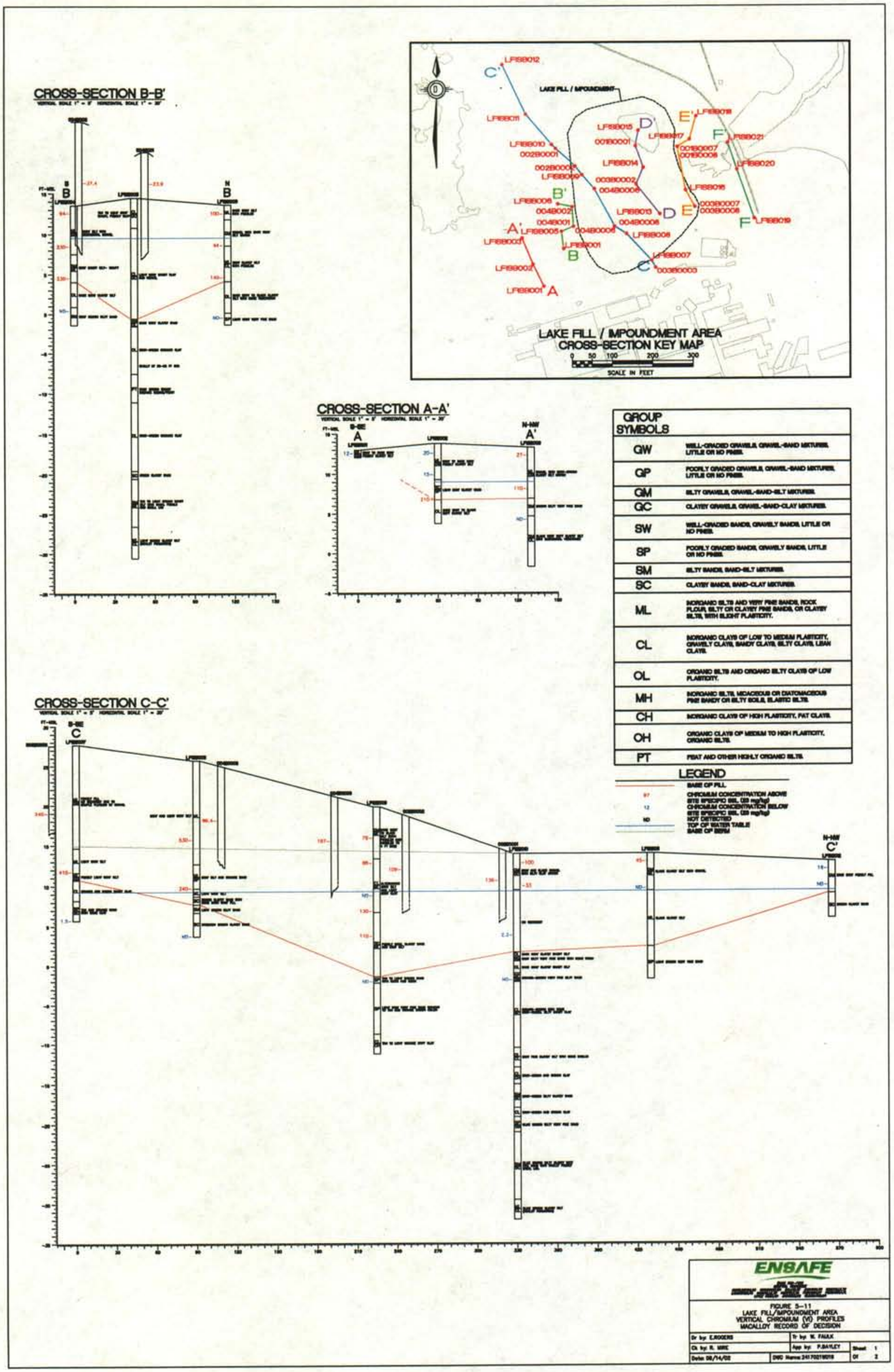
Figure 5-9
Radiological Sampling Area
Macalloy Record of Decision

6/14/2002

//gissafe/projects/macalloy/macalloy.apr

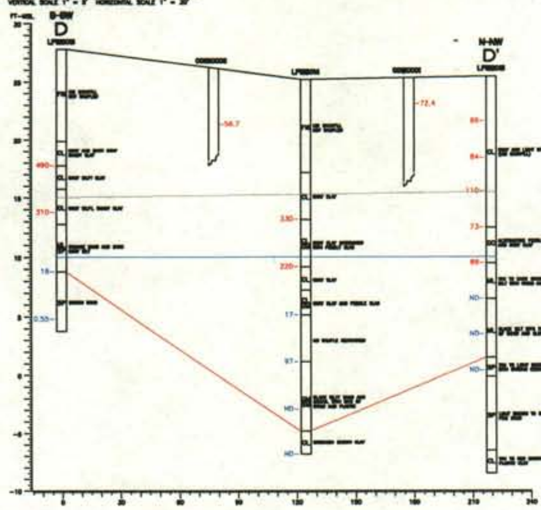
Figure 5-10
RG Exceedances in Soil
Macalloy Record of Decision



GROUP SYMBOLS	
GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.
GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.
SW	WELL-GRADED SANDS, GRAVELY SANDS, LITTLE OR NO FINES.
SP	POORLY GRADED SANDS, GRAVELY SANDS, LITTLE OR NO FINES.
SM	SILTY SANDS, SAND-SILT MIXTURES.
SC	CLAYEY SANDS, SAND-CLAY MIXTURES.
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS, WITH SLIGHT PLASTICITY.
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
PT	PEAT AND OTHER HIGHLY ORGANIC SILTS.

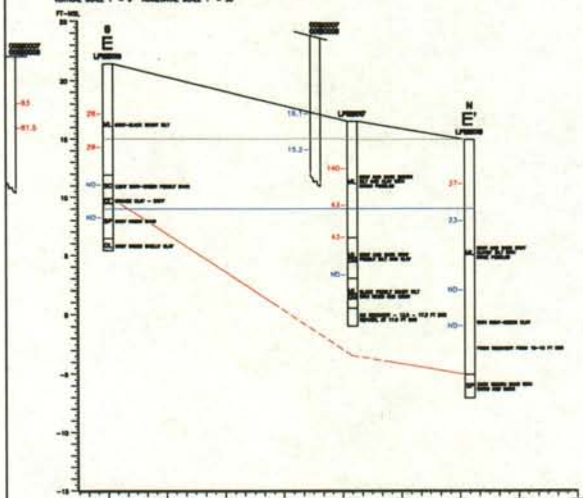
CROSS-SECTION D-D'

VERTICAL SCALE 1" = 5' HORIZONTAL SCALE 1" = 20'



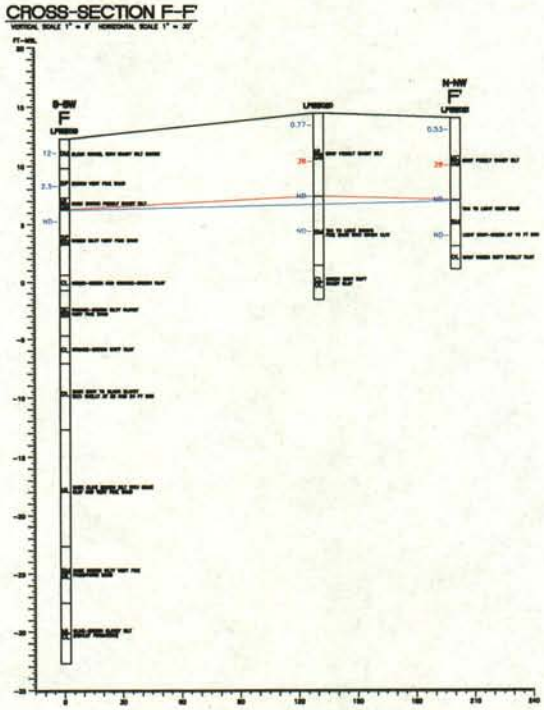
CROSS-SECTION E-E'

VERTICAL SCALE 1" = 5' HORIZONTAL SCALE 1" = 20'



CROSS-SECTION F-F'

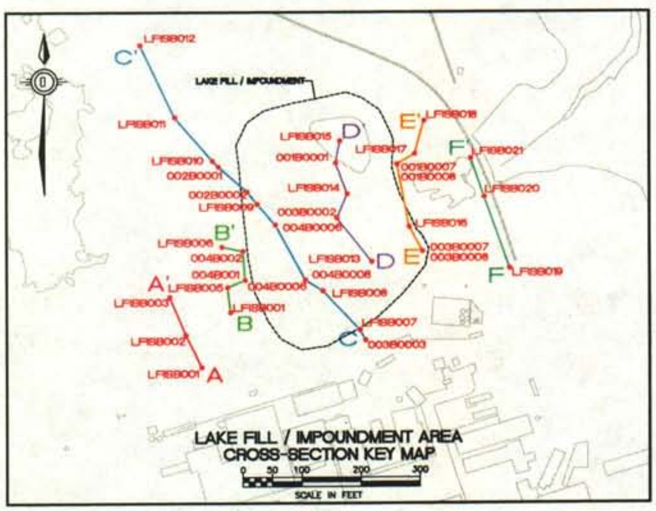
VERTICAL SCALE 1" = 5' HORIZONTAL SCALE 1" = 20'



GROUP SYMBOLS	
GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
GP	POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES.
GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES.
GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES.
SW	WELL-GRADED SANDS, GRAVELY SANDS, LITTLE OR NO FINES.
SP	POORLY GRADED SANDS, GRAVELY SANDS, LITTLE OR NO FINES.
SM	SILTY SANDS, SAND-SILT MIXTURES.
SC	CLAYEY SANDS, SAND-CLAY MIXTURES.
ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS, OR CLAYEY SILTS, WITH SLIGHT PLASTICITY.
CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS.
OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY.
MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SANDY OR SILTY SOILS, ELASTIC SILTS.
CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS.
OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS.
PT	PEAT AND OTHER HIGHLY ORGANIC SILTS.

LEGEND

(red line)	BASE OF FILL
97	CHROMIUM CONCENTRATION ABOVE SITE SPECIFIC SSL [illegible]
12	CHROMIUM CONCENTRATION BELOW SITE SPECIFIC SSL [illegible]
ND	NOT DETECTED
(blue line)	TOP OF WATER TABLE
(grey line)	BASE OF BERM



ENSAFE

FIGURE 5-12
LAKEFILL/IMPOUNDMENT AREA
VERTICAL CHROMIUM (VI) PROFILES
MACALLOY RECORD OF DECISION

Dr by: E.ROGERS	Tr by: W. FAULK	
Ck by: R. MIRE	App by: P.BAYLEY	Sheet 2
Date: 08/14/02	DWG Name: 2417021801B	Of 2

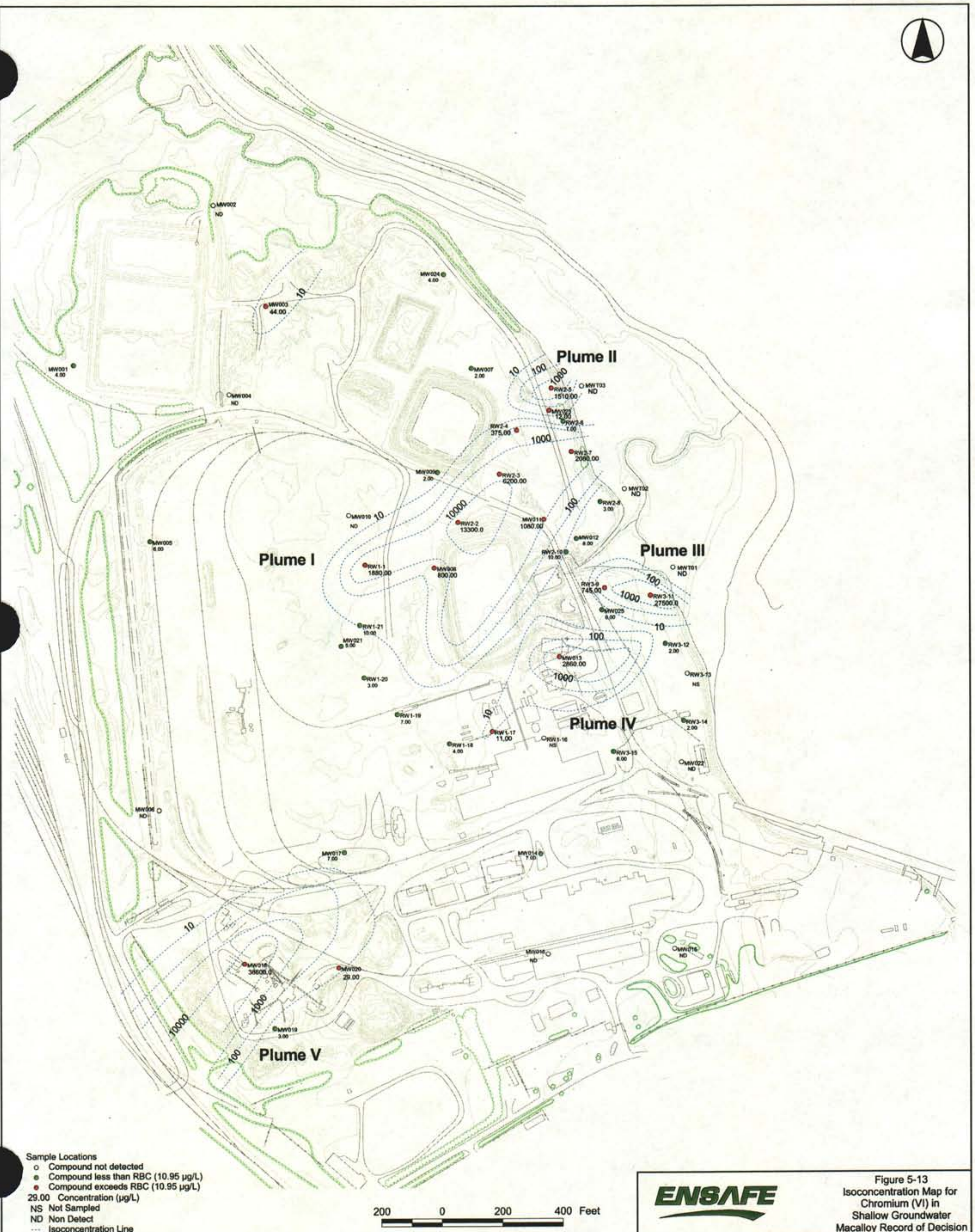


Figure 5-13
Isoconcentration Map for Chromium (VI) in Shallow Groundwater
Macalloy Record of Decision

Plant Communities Associated with Shipyard Creek

SM /Salt Marsh - This emergent or intertidal plant community grows in salt water along the outer coastal plain and barrier islands. It is mostly dominated by Spartina alterniflora; often in virtual monocultures with tall, medium, and short growth forms; with Spartina patens and Distichlis spicata as common associates. These often cover large expanses of the estuaries.

HM / High Marsh - This is a hyper-saline plant community that is flooded only by the highest tides. It is commonly dominated by saltgrass (Distichlis spicata) and glasswort (Salicornia virginica) with Suaeda linearis, Limonium carolinianum, Chenopodium berlandieri, Atriplex patula, Aster tenuifolius, Sporobolus virginicus, and Spartina spp.

EW / Estuarine Water - Open water with a high salt content that is closely associated with the Atlantic Ocean (in South Carolina) and follow its tidal cycles. It lies between the marine waters of the Atlantic Ocean and the the brackish and fresh waters farther upstream.

IM / Intertidal Mud Flats - The intertidal mud flats are areas of Shipyard Creek that are flooded at high tide and not flooded at low tide. The flats are rich in mud algae but contain no vascular plants. These flats are populated by permanent benthic consumers and temporary consumers in its water column when the tide is in.

SC / Shipping Channel - The shipping channel and turning basin has been dredged in Shipyard Creek to make it deep enough for ship traffic. The channel's benthic community is low in oxygen and is likely reduced. Its water column is estuarine water and has most of its population of consumers. Most of the subtidal community in Shipyard Creek is in this Shipping Channel.

001 Tidal Creek

NOTE: Basemap provided by BDY, Environmental Consultants.

Area	Poly name
6,400 sq. ft.	lower
4,100 sq. ft.	upper
7,300 sq. ft.	middle

50 0 50 100 Feet

ENSAFE

Figure 5-14
001 Tidal Creek
Macalloy Record of Decision

gmsafe/figure_5.41/tidal_creek.apr

5 9 227

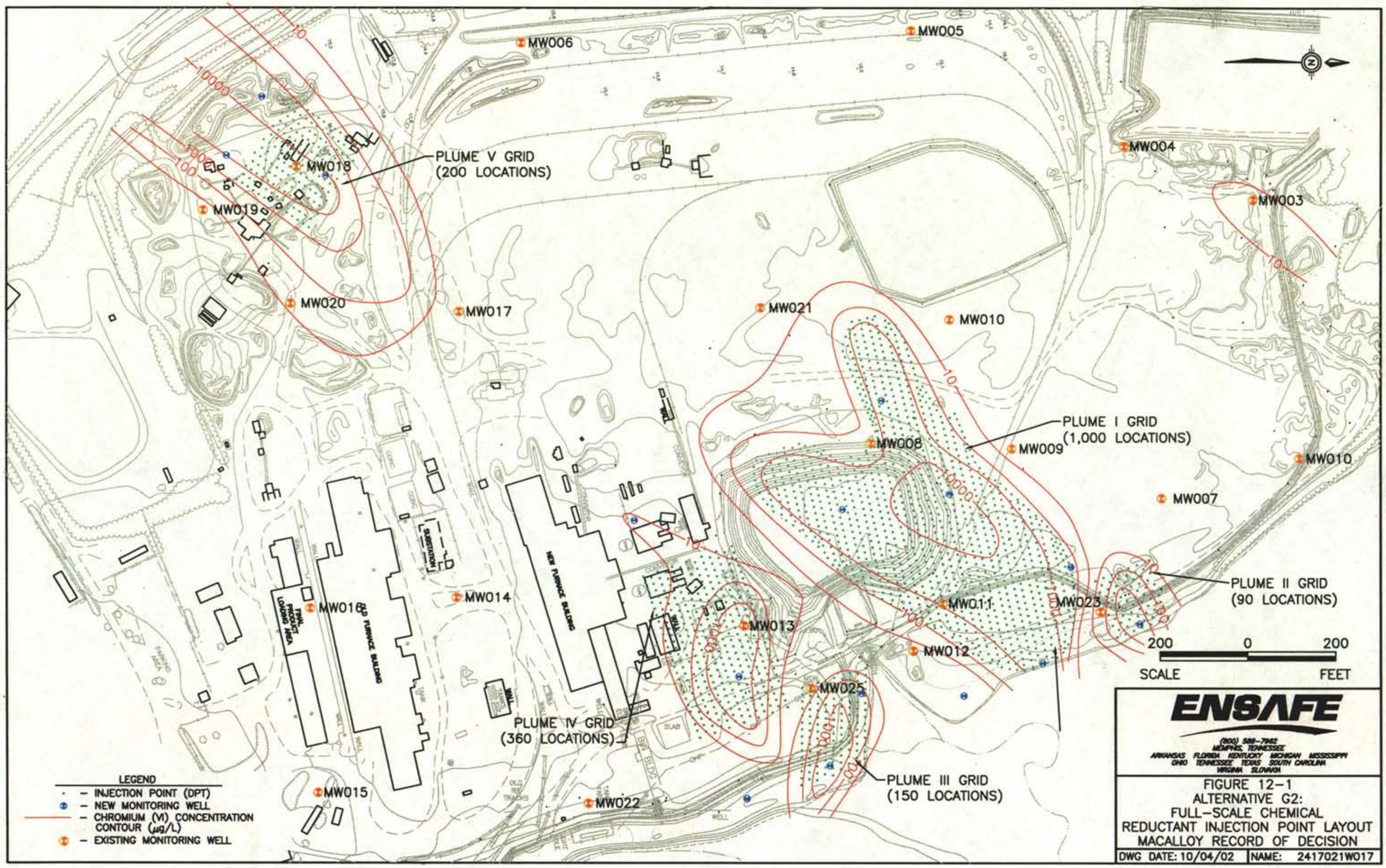


FIGURE 12-1
ALTERNATIVE G2:
FULL-SCALE CHEMICAL
REDUCTANT INJECTION POINT LAYOUT
MACALLOY RECORD OF DECISION

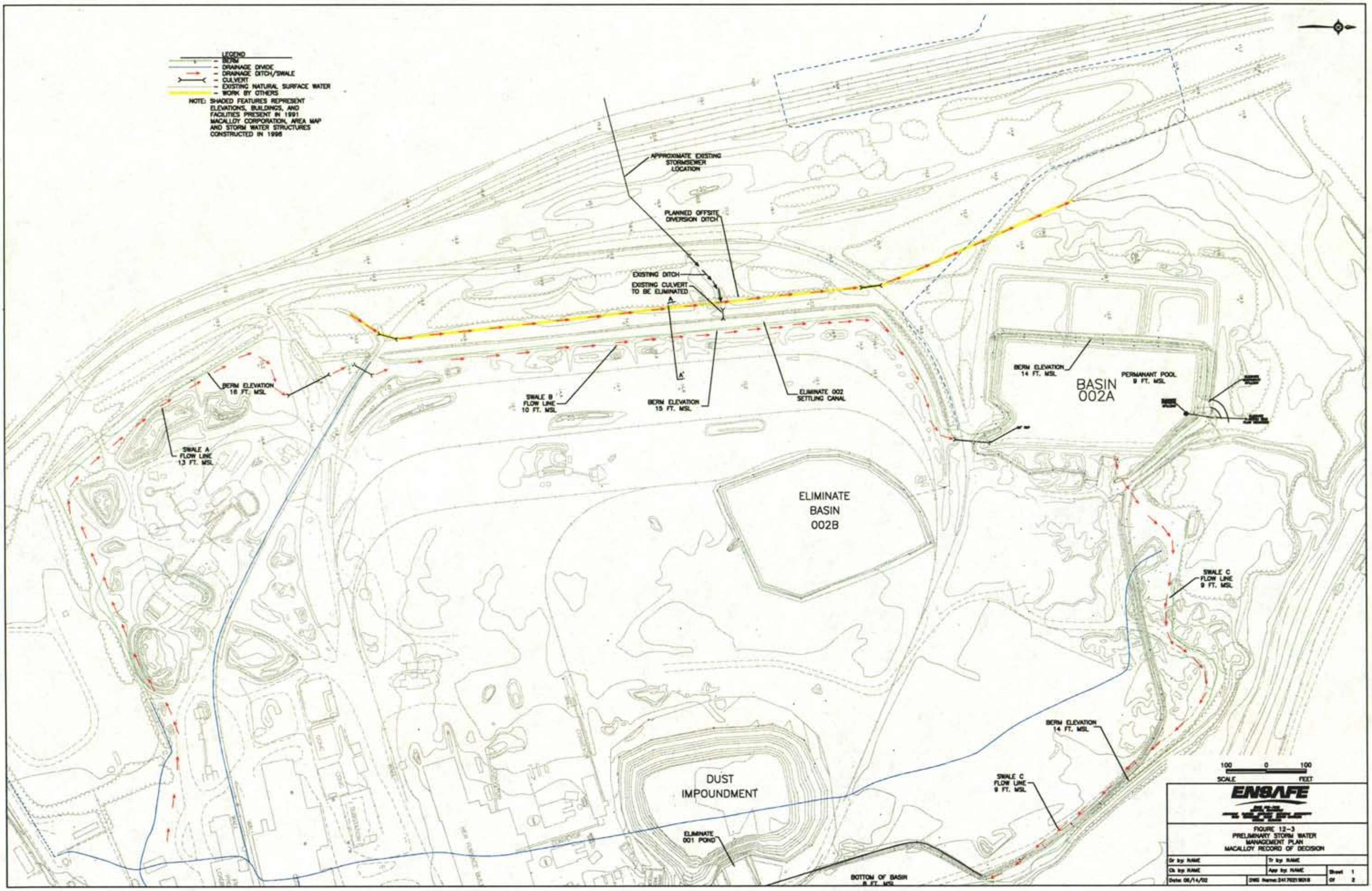
DWG DATE: 10/04/02 | NAME: 2417021W017

59 228

ENSAFE

Figure 12-2
Shallow Monitoring
Well Designations for
Groundwater Remediation
Macalloy Record of Decision

14 June, 2002



LEGEND
- BERM
- DRAINAGE DIVIDE
- DRAINAGE DITCH/SWALE
- CULVERT
- EXISTING NATURAL SURFACE WATER
- WORK BY OTHERS
NOTE: SHADED FEATURES REPRESENT ELEVATIONS, BUILDINGS, AND FACILITIES PRESENT IN 1991 MACALLOY CORPORATION, AREA MAP AND STORM WATER STRUCTURES CONSTRUCTED IN 1998
APPROXIMATE EXISTING STORMSEWER LOCATION
PLANNED OFFSITE DIVERSION DITCH
EXISTING DITCH
EXISTING CULVERT TO BE ELIMINATED
BERM ELEVATION 16 FT. MSL
SWALE A FLOW LINE 13 FT. MSL
SWALE B FLOW LINE 10 FT. MSL
BERM ELEVATION 15 FT. MSL
ELIMINATE 002 SETTLING CANAL
BERM ELEVATION 14 FT. MSL
BASIN 002A
PERMANANT POOL 9 FT. MSL
ELIMINATE BASIN 002B
SWALE C FLOW LINE 9 FT. MSL
BERM ELEVATION 14 FT. MSL
SWALE C FLOW LINE 9 FT. MSL
DUST IMPOUNDMENT
ELIMINATE 001 POND
BOTTOM OF BASIN
100 0 100
SCALE FEET
ENSAFE
FIGURE 12-3
PRELIMINARY STORM WATER MANAGEMENT PLAN
MACALLOY RECORD OF DECISION
Dr by: NAME
Tr by: NAME
Ck by: NAME
App by: NAME
Sheet 1 Of 2
Date: 00/14/02
DWG Name: 241702180I8

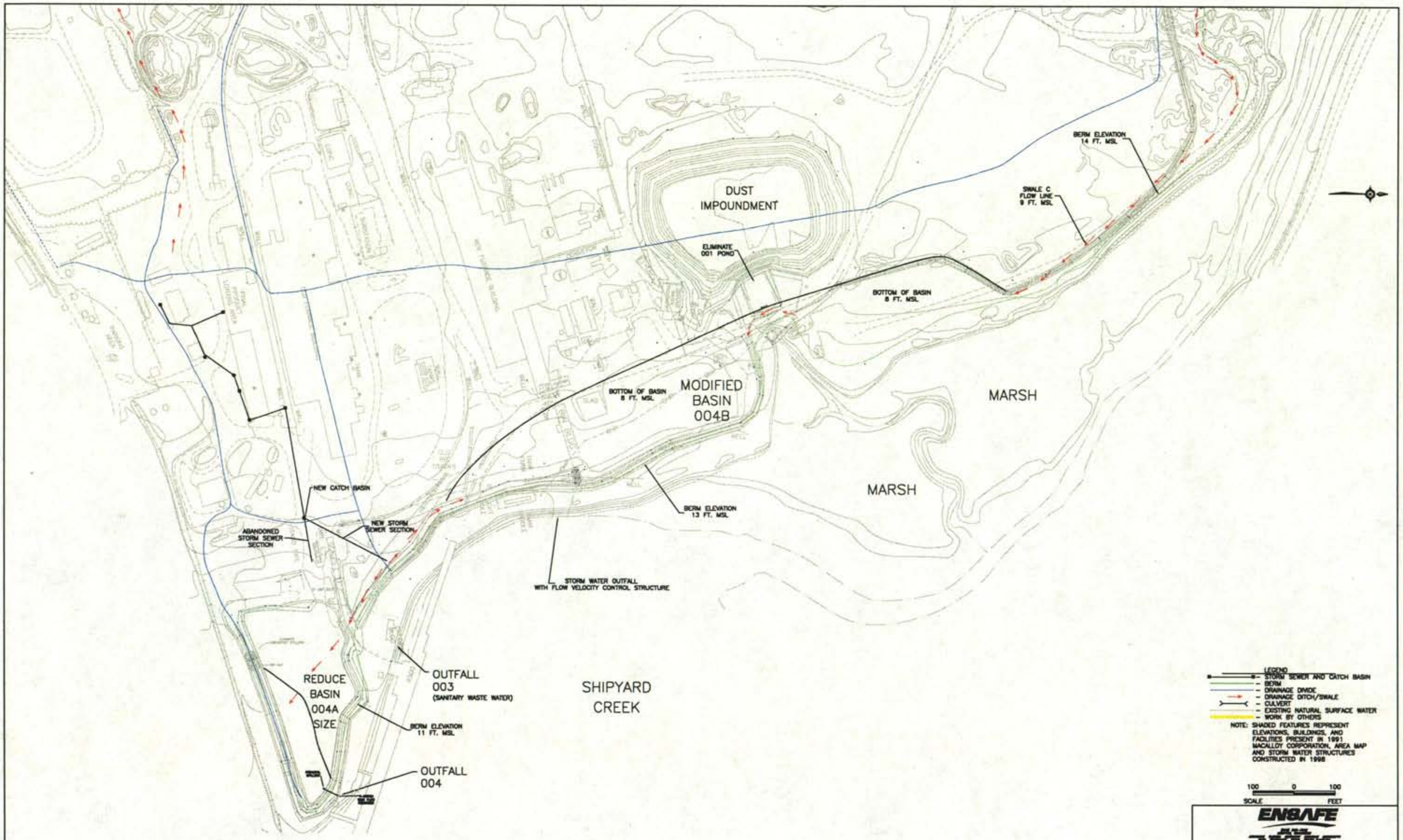


FIGURE 12-3
PRELIMINARY STORM WATER
MANAGEMENT PLAN
MACALLOY RECORD OF DECISION

Dr by: NAME	Tr by: NAME	
Ck by: NAME	App by: NAME	Sheet 2
Date: 08/14/02	DWG Name: 24170218018	Of 2

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Appendix A

Sediment Protective Ranges

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION 4

61 Forsyth Street, S.W.
Atlanta, Georgia 30303-3104

August 13, 2002

4WD-OTS

MEMORANDUM

SUBJECT: Risk review comments on ecological issues, Macalloy Corporation Site, Charleston, South Carolina

FROM: Lynn H. Wellman, Life Scientist/ETAG Coordinator
Office of Technical Services
Waste Management Division

TO: Craig Zeller, Remedial Project Manager
North Site Management Branch
Waste Management Division

Per your request, I have evaluated the information contained in the **Baseline Ecological Risk Assessment Report** for the **Macalloy Corporation Site and Shipyard Creek** to derive protective levels for the chemicals of potential concern for the benthic community assessment endpoint. The derivation of protective levels is required by our guidance. These protective levels are applicable only for this site because of the influence of the myriad factors which affect the bioavailability of these contaminants. The data and information used to derive these protective levels are based on the site-specific investigation (in this case whole-phase sediment toxicity testing with grass shrimp, *Palaemonetes pugia*) of the Shipyard Creek system.

The grass shrimp bioassy procedure is described in Lee, 2001, and is briefly described here. Three groups (replicates) of 20 juvenile grass shrimp (*Palaemonetes pugio*) were exposed to sediments collected from the eight Shipyard Creek study stations, two reference locations (Rathall Creek and Foster Creek), and reference test location (Skidaway River). Each group was observed every five days to determine the number of dead grass shrimp, the number of females with mature ovaries, and the number of females with attached embryos. Ten to twenty stage 7 embryos were collected to assess DNA strand damage by the comet analysis. Stage 9 embryos were removed from three females (unless there were less than three females that produced embryos) and were placed in 24-well polystyrene plates, two embryos per well, for the determination of embryo hatching success.

Ten to twenty embryos were used in the DNA strand damage analysis. Embryos were homogenized and separated by centrifugation and treated to promote DNA strand unwinding. Fifty randomly selected cells per slide were analyzed from each samples and the tail moment (amount of DNA in tail by tail length) was determined by a computerized image analysis system.

Positive control samples were subjected to various concentrations of 2,4-nitroquinoline-4-oxide (NQO), a chemical agent known to damage DNA and effect grass shrimp embryo hatching.

Mortality and sub-lethal endpoints of the grass shrimp (*Palaemonetes pugio*) toxicity test (Table 1) are compared to chemical concentrations (Table 2) to determine the relationship of effects or responses to the contaminant concentration gradient representing exposure. The contaminants of potential concern (COPCs) as determined in the Problem Formulation step which were evaluated are: Cadmium, Chromium, Hexavalent Chromium, Copper, Lead, Manganese, Mercury, Nickel, Selanium, Vanadium, and Zinc. The endpoints evaluated were mortality, and the sub-lethal endpoints: reproduction (percent females developing mature ovaries), embryo production (percent females which produced embryos), embryo hatching (percent embryos hatching into zoea stage), and DNA strand damage in embryos (DNA tail moment). A significant higher difference in the mortality of stations Zone A Upper (AU) and Lower (AL); Zone C Middle (CM); and Rathall Creek.(RC) was shown as compared to the reference test location (Skidaway River). The percent of females forming mature ovaries was significantly lower for stations AU, Zone A Middle (AM), and AL; and Zone C Upper (CU), when compared to the reference test location. The percent of females which produced embryos was significantly lower for stations AU, AM, AL; Zone B Upper (BU) and Lower (BL); CU, CM, and Zone C Lower (CL); and Foster Creek (FC) (all stations except RC) than the reference test location. The percent of embryos hatching into the zoae stage were significantly lower for stations AU, AM, and AL; and CM and CL, than the reference test location. The DNA tail moments were significantly higher for stations AU, AM, and AL; and CM when compared to the reference test location.

In summary, stations AU and AL showed significant differences from the reference test location for the lethal endpoint and all four sublethal endpoints. Station AM showed significant differences from the reference test location for all four sublethal endpoints. Station CM showed significant differences from the reference test location for the lethal endpoint and three out of four sublethal endpoints. Stations CU and CL showed significant differences for two of the four sublethal endpoints. Stations BU, BL, RC, and FC showed a significant difference from the reference test location for one endpoint (RC for the lethal endpoint, and the other stations for one of the four sublethal endpoints).

Memorandum to Craig Zeller
Macalloy Corporation Site, Charleston, South Carolina
August 13, 2002

Cadmium

The correlation coefficients between increasing cadmium concentrations and the test endpoints are as follows: Mortality Test (0.31), Reproduction Test (-0.36), Embryo Production Test (-.41), Embryo Hatching Test (-0.28), and DNA Damage Test (0.21) (Table 3). Given the lack of a relationship between increasing cadmium concentrations and test results it appears that cadmium is not a toxicity driver and no protective levels will be derived (See Figures 1-5).

Chromium

Correlation coefficients between increasing chromium concentrations and the test endpoints are as follows: Mortality Test (0.31), Reproduction Test (-0.95), Embryo Production Test (-0.84), Embryo Hatching Test(-0.95), DNA Damage Test (0.94) (Table 4).

Mortality

The five stations with the lowest chromium concentrations are grouped in the middle of the right side of the distribution (13 - 219 ppm)(Figure 6). The sixth station, CU with a chromium concentration of 258 ppm showed 23 % mortality (the first five stations showed mortality of: FC, 12%, RC 20%, BL 12%, BU 12%, and CL, 15%). The protective range of chromium concentrations for the lethal endpoint is 219 - 258 ppm.

Reproduction Test

The relationship between the percent of females developing mature ovaries against chromium concentrations is shown in Figure 7. The five stations with the lowest concentrations (FC - 13 ppm, RC - 40.1 ppm, BL - 79.7, BU - 91 ppm, CL - 219 ppm) show a clumped distribution in the upper left corner of the plot. Stations CU - 258 ppm, and AL - 1780 ppm, AM - 2980 ppm, and AU - 3070 ppm showed significantly lower percent of females developing mature ovaries than the reference test station. Station CM - 317 ppm showed a lower percent of females with mature ovaries (53 %) than the next lowest station, CU (chromium concentration of 258 ppm and 63 % of females with mature ovaries). The lack of significance for this station may be due to a higher variability among the replicates (the Standard Deviation [SD] for CM was 10, equal to that of AU and AL, but lower than AM, SD - 14, all other stations had SDs lower than 10) . The protective range of chromium concentrations for the percent of females developing ovaries endpoint would be 219 - 258 ppm.

Embryo Production Test

The relationship between the percent females producing embryos and chromium concentrations is shown in Figure 8. All stations except RC - 40.1 ppm (including FC - 13 ppm) showed a significantly lower percentage of females producing embryos. The six stations with the lowest concentrations are grouped in the upper left corner of the plot (FC - 13 ppm to CU - 258). CU (258 ppm) showed 37 percent of females produced embryos. CM (317 ppm) showed a reduction in the percent females which produced embryos to 13 %. The protective range of chromium concentrations for the percent of females producing embryos endpoint would be 258 - 317 ppm.

Embryo Hatching Test

The relationship between the percent of embryos hatching and the chromium concentration is shown in Figure 9. Five stations (AU - 3020 ppm, AM - 2980 ppm, AL - 1780 ppm; and CM - 317 ppm, and CL 219 ppm) showed significantly lower percent of embryos hatching than the test control location (Skidaway Rvier). Six stations show embryo hatching rates above 69 % (FC, 92 %, RC, 93 %, BL, 82 %, BU, 86 %, CL, 69 %, and CU, 88%) with corresponding chromium levels ranging from 13 to 2588 ppm (FC, 13 ppm, RC, 40.1 ppm, BL, 79.7 ppm, BU, 91 ppm, CL, 219 ppm, and CU, 258 ppm). CM which has the next highest chromium concentration (317 ppm) shows a hatching percent of 64 %, while AL (1780 ppm) shows a hatching percent of 25 %. The chromium concentrations which are protective of the embryo hatching test endpoint would be 258 - 317 ppm.

DNA Strand Damage in Embryos

The relationship between the DNA tail moment and chromium concentration is shown in Figure 10. Four stations showed significantly higher tail moments indicating more DNA fragmentation (CM - 317 ppm; AL - 1780 ppm, AM - 2980 ppm, and AU - 3070 ppm). Figure 10 shows a separation between the six stations with lower chromium concentrations (FC - 13 ppm, RC - 40.1 ppm, BL - 79.7 ppm and BU - 91 ppm, and CL - 219 ppm, and CU - 258 ppm) with a tail moments ranging from 1.2 to 2, and CM - 317 ppm, with a tail moment of 3.8. The chromium concentrations which are protective of the DNA strand damage in embryos endpoint is 258 - 317 ppm.

Three endpoints showed a protective range for chromium concentrations between 258 - 317 ppm. One endpoint (percent females which developed ovaries) showed protective range for chromium concentrations between 219 - 258 ppm. Therefore the protective range for chromium concentrations is 219 -258 ppm.

Hexavalent Chromium

There were no detected concentrations of hexavalent chromium in the sediment samples.

Therefore no protective ranges for hexavalent chromium will be dervied.

Copper

The correlation coefficients between increasing copper concentrations and the toxicity test results ranged as follows: Mortality Test (0.59), Reproduction Test (-0.79), Embryo Production Test (-0.68), Embryo Hatching Test (-0.70), and DNA Damage Test (0.65) (Table 5). The relationship between copper concentrations and percent females developing mature ovaries will be the only endpoint discussed (Figures 11 - 15).

Reproduction Test

The four stations with the highest copper concentrations (AL - 39.7 ppm, AU - 47.9 ppm, and AM - 63.9 ppm, and CU - 52.9 ppm) showed a significantly lower percent of females which developed mature ovaries (Figure 12). The lowest five stations (FC - 6.2 ppm to BL - 28.4 ppm) show similar percentages of females developing mature ovaries (72 - 80 %). CM (28.5 ppm) shows 53 % of the females with ovaries, although CU (52.9 ppm) shows 63 % of the females developing mature ovaries. The protective range of copper concentrations for this endpoint is 28.4 - 28.5 ppm.

Lead

The correlation coefficients between sediment lead concentrations and the endpoints are: Mortality Test (0.45), Reproduction Test (-0.88), Embryo Production Test (-0.76), Embryo Hatching Test (-0.91), and DNA Damage Test (0.85) (Table 6). Only the results of the sublethal endpoints will be discussed below (Figures 16 - 20)

Reproduction Test

The relationship between lead concentrations and percent females developing mature ovaries is shown in Figure 17. Significantly lower percent of females developing mature ovaries were shown in stations CU, AL, AU, and AM. Station CL showed a similar percent of females developing mature ovaries as stations BU and RC (77 %), although the lead concentration was higher at CL (77.5 ppm) than station CU (56.3 ppm) which showed a significantly lower percentage of females developing mature ovaries (63 %), and station CM (37.3 ppm) which showed an even lower pecentage of females developing mature ovaries (53 %), although this value was not significantly different from the reference test location. These results weaken the relationship between the response to increasing sediment lead concentrations, however based on this information the protective range of sediment lead concentrations for this endpoint is 77.5 - 147 ppm.

Memorandum to Craig Zeller
Macalloy Corporation Site, Charleston, South Carolina
August 13, 2002

Embryo Production Test

The relationship between the sediment lead concentrations and percent females which produce embryos is shown in Figure 18. All stations except RC (57 %) show an significantly lower percentage of females producing embryos than the reference test location. The station (CM) with the fifth highest sediment lead concentration (37.3 ppm) also showed the fourth lowest percentage of females producing embryos (13 %). Stations CU and CL showed higher sediment lead levels (56.3 ppm and 77.5 ppm, respectively) and greater percentage of embryo production (37 % and 43 %, respectively). The station with the next highest sediment lead level is station AL (189 ppm) which showed 8 % of the females producing embryos. The protective sediment lead concentration range for this endpoint is 77.5 ppm to 147 ppm.

Embryo Hatching Test

The relationship between the sediment lead concentrations and the percentage of embryos hatching is shown in Figure 19. Stations CM, CL, AL, AU, and AM showed a significantly lower percentage of embryos hatching than the reference test location. Station CU showed the third highest percentage of embryos hatching (88 %) and the sixth highest sediment lead concentration (56.3 ppm). The station (CL) with the next highest lead concentration (77.5 ppm) showed a significantly lower embryo hatching percent of 69 %, which was close to the significantly lower embryo hatching percent of 64 % at a sediment lead concentration of 37.3 ppm. The protective sediment lead concentration range is 77.5 ppm to 147 ppm.

DNA Damage Test

The relationship between the sediment lead concentration gradient and DNA strand damage in embryos as measured by tail moment is shown in Figure 20. Stations CM, AL, AU, and AM showed significantly greater tail moments from the reference test location.

Stations CU and CL showed the lowest (1.2) and tied for the second lowest (1.4) tail moments, respectively, with the sixth (56.3 ppm) and seventh (77.5 ppm) sediment lead concentrations. Station CM showed a significantly higher tail moment (3.8) when compared to the reference test location at a lower sediment lead concentration (37.3 ppm). The three stations (AL, AU, and AM) with the highest sediment lead concentrations (147 ppm, 189 ppm, and 310 ppm, respectively) showed the three significantly highest tail moments (6.9, 7.1, and 7.1, respectively). The protective sediment lead concentration range for this endpoint is 77.5 ppm to 147 ppm.

The protective sediment lead concentration range for the four sublethal endpoints is 77.5 ppm to 147 ppm.

Manganese

The correlation coefficients between increasing manganese concentrations and the result of the toxicity test are: Mortality Test (0.50), Reproduction Test (-0.89), Embryo Production Test (-0.73), Embryo Hatching Test (-0.88), and DNA Damage Test (0.87) (Table 7). Only the results of three of the sublethal endpoints will be discussed (Figures 21 - 25).

Reproduction Test

The relationship between the sediment manganese concentration gradient and the percent females developing mature ovaries is shown in Figure 22. Stations CU, AL, AU, and AM showed significantly lower percentage of females developing mature ovaries. Station RC showed a percentage of females developing mature ovaries (77 %) which tied as the second highest with the seventh highest sediment manganese concentration (238 ppm). Station CU showed a significantly lower percent of females developing mature ovaries (37 %) at a lower sediment manganese concentration (161 ppm). The station (AL) with the next highest manganese concentration (377 ppm) to RC showed a significantly lower percentage of females developing mature ovaries (23 %). The protective sediment manganese concentration range for this endpoint is 238 ppm to 377 ppm.

Embryo Hatching Test

The relationship between the sediment manganese concentration gradient and the percent of embryos hatching is shown in Figure 24. Stations CM, CL, AL, AU, and AM showed a significantly lower percentage of embryos hatching into the zoae stage than the reference test location (Skidaway River).

Stations CM and CL showed significantly lower embryo hatching percentages (64 % and 69 %, respectively). The sediment manganese concentrations at stations CM and CL (105 ppm and 116 ppm, respectively) are lower than stations CU and RC (161ppm and 238 ppm, repestively) which the highest (RC - 93 %) and third highest (CU - 88 %) percentage of embryo hatching. The three stations with higher sediment manganese concentrations; AL, AU, and AM (377 ppm, 682 ppm, and 747 ppm, respectively) showed embryo hatching percentages of 25 %, 20 %, and 17 %, respectively. The protective sediment manganese concentration range for this endpoint is 238 ppm to 377 ppm.

DNA Damage Test

The relationship between the sediment manganese concentration gradient and DNA strand damage in embryos is shown in Figure 25. Stations CM, AL, AU, and AM showed significantly higher tail moments than the reference test location.

Station CM showed a significantly higher tail moment of 3.8. The sediment manganese concentration at CM (105 ppm) is lower than the sediment manganese concentrations at stations CL, CU, and RC (116 ppm, 161 ppm, and 238 ppm, respectively), alhtough the tail moments were the lowest (CU - 1.2), tied for the second lowest (CL - 1.4) and tied for the fourth lowest (Rathall Creek - 1.4). Stations AL, AU, and AM (sediment manganese concentrations of 377 ppm, 682 ppm, and 747 ppm, respectively) showed significantly higher tail moments (6.9, 7.1, and 7.1, respectively). The protective sediment manganese concentration range for this endpoint is 238 ppm to 377 ppm.

Mercury

The correlation coefficients between increasing sediment mercury concentrations and the results of the toxicity tests are: Mortality Test (0.52), Reproduction Test (-0.42), Embryo Production Test (-0.44), Embryo Hatching Test (-0.31), and DNA Damage Test (0.26) (Table 8). Figures 26 -30 show the relationships between the sediment mercury concentration gradient and the toxicity test response by endpoint. It appears that mercury's contribution to toxicity is minor or insignificant due to the lack of relationship between the response and concentration gradient.

Nickel

The correlation coefficients between increasing sediment nickel concentratoins and the results of the toxicity tests are: Mortality Test (0.48), Reproduction Test (-0.95), Embryo Production Test (-0.84), Embryo Hatching Test (-0.94), and DNA Damage Test (0.94)(Table 9). The relationship between the endpoint responses and the sediment nickel concentration gradient is shown in Figures 31 - 35.

Mortality Test

The relationship between the percent mortality and the sediment nickel concentration gradient is shown in Figure 31. Significantly higher mortality was shown for stations RC, CM, AL, and AU. The RC station (10.9 ppm) shows a significantly higher mortality of 20 %. Stations BU, BL, CL, and CU shows non-significant percent mortality tied for the lowest (BU and BL - 12 %), the (next) fourth highest (CL - 15 %), and the fifth highest (CU - 23 %) at the higher concentrations (19.4 ppm, 28.6 ppm, 33 ppm, and 35.7 ppm, respectively). The remaining stations, CM - 40.7 ppm, AL - 373 ppm, AM - 474 ppm, and AU - 606 ppm, show levels of percent mortality of 32 %, 23 %, 23 %, 27 %, respectively (stations CU, AL, and AM showed the same level of mortality - 23 % , but only station AL showed significant differences from the reference test location). Based this information, and Figure 31, the protective sediment nickel concentration range for this endpoint is 33 - 35.7 ppm.

Reproduction Test

The relationship between the percentage of females that developed mature ovaries and the sediment nickel concentration gradient is shown in Figure 32. Stations CU, AL, AM, and AU showed significantly lower percentages of females developing mature ovaries. Figure 32 shows the five stations with the lowest nickel concentrations (3.4 - 33 ppm) grouped between 70 - 80 %. The next station, CU, is the location with the lowest nickel concentration showing a significantly lower percent of females developing ovaries. The protective sediment nickel concentration range for this endpoint is 33 - 35.7 ppm.

Embryo Production Test

The relationship between the percent females producing embryos and the sediment nickel concentration gradient is shown in Figure 33. All stations except RC showed a significantly lower percentage of females producing embryos.

The six stations (FC, RC, BU, BL, CL, and CU) with the lowest sediment nickel concentrations (3.4 ppm, 10.9 ppm, 19.4 ppm, 8.6 ppm, 33 ppm, 35.7 ppm, respectively) showed 37 -57 % of the females produced embryos (40 %, 57 %, 45 %, 37 %, 43 %, and 37 %, respectively). The remaining stations (CM - 40.7 ppm, AL - 373 ppm, AM - 474 ppm, and AU - 606 ppm) showed embryo production percentages between 2 - 13 % (CM - 13 %, AL - 8 %, AM - 5 %, and AU - 2 %). The protective sediment nickel concentration range for this endpoint is 35.7 - 40.7 ppm.

Embryos Hatching Test

The relationship between the percentage of embryos hatching and the sediment nickel concentration gradient is shown in Figure 34. Stations CL, CM, AL, AM, and AU showed significant lower percentages of embryo hatching into the zoae stage. The four stations with the lowest sediment nickel concentrations (FC - 3.4 ppm, RC - 10.9 ppm, BU - 19.4 ppm, and BL - 28.6 ppm) showed embryo hatching percentages between 82 and 93 % (FC - 92 %, RC - 93 %, BU - 86 %, and BL - 82 %). Station CL showed a significant lower hatching percent (69%) at a nickel concentration of 35.7 ppm. Station CU showed the third highest (non-significant) hatching rate of 88 % at a nickel concentration of 35.7 ppm. The remaining four stations (CM, AL, AM, and AU) show significantly lower hatching rates (64 %, 25 %, 17 %, and 20 %, respectively) at higher nickel concentrations (40.7 ppm, 373 ppm, 474 ppm, and 606 ppm). The protective sediment nickel concentration range for this endpoint is 35.7 ppm to 40.7 ppm.

DNA Damage Test

The relationship between the tail moment and sediment nickel concentration gradient is shown in Figure 35. Stations CM, AL, AM, and AU show significantly higher tail moments from the reference test location. The stations showing non-significant differences from the reference test location (FC - 1.4, RC - 1.8, BU - 2, BL - 1.8, and CL - 1.2) had nickel concentrations ranging from 3.4 ppm to 35.7 ppm. The four stations with significantly higher tail moments (CM - 3.8, AL - 6.9, AM - 7.1 and AU - 7.1) had nickel concentrations ranging from 40. 7 ppm to 606 ppm. The protective sediment nickel concentration range for this endpoint is from 35. 7 ppm to 40.7 ppm.

Two endpoints (mortality and reproduction) showed protective sediment nickel concentration range from 33 ppm to 35.7 ppm. Three endpoints (embryo production, embryo hatching, and DNA damage) showed protective sediment nickel concentration range from 35.7 ppm to 40.7 ppm. Therefore the protective range for nickel concentrations is 33 ppm to 35.7 ppm.

Selenium

There were no detected concentrations of selenium. Detection limits ranged from 1.5 ppm to 13 ppm. No protective ranges for selenium will be derived.

Vanadium

The correlation coefficients between the endpoint response of the toxicity test and the sediment vanadium concentration gradient are: Mortality Test (0.77), Reproduction Test (-0.56), Embryo Production Test (-0.34), Embryo Hatching Test (-0.49), and DNA DamageTest (0.48) (Table 10). The figures showing the relationships between the toxicity test endpoint responses and the sediment vanadium concentration are shown in Figures 36 through 40. It appears that vanadium is not a major contributor to the responses based on these figures, therefore no protective levels will be derived for vanadium.

Zinc

The correlation coefficients between the endpoint response of the toxicity test and the sediment zinc concentration gradient are: Mortality Test (0.48), Reproduction Test (-0.94), Embryo Production Test (-0.82), Embryo Hatching Test (-0.93), and the DNA Damage Test (0.92) (Table 11). The relationship between the response for the toxicity test endpoints and the sediment zinc concentration gradient are shown in Figures 41 through 45.

Mortality Test

The relationship between the percent mortality and the sediment zinc concentration gradient is shown in Figure 41. Stations RC, CM, AL, and AU showed significantly higher mortality than the reference test location. The five stations with the lowest zinc concentratons (FC - 22.7 ppm, BU - 55.9 ppm, RC - 60.5 ppm, BL - 98.4 ppm, and CL - 132 ppm) showed percent mortalities of 20 % or less (RC showed a 20 % per cent mortality which was significantly higher than the reference location station). The station with the next highest zinc concentration (CM - 163 ppm) showed the highest percent mortality (32 %) which was significantly higher than the reference test location. Percent mortalities are the four stations with higher zinc concentrations (CU - 227 ppm, AL - 847 ppm, AU - 1330 ppm, and AM - 1640 ppm) showed percent mortalities between 23 - 27 % (CU - 23 %, AL - 23 %, AU - 27 %, and AM - 23 %, although the results for stations CU and AM are not considered significantly higher than the reference test location). The protective sediment zinc concentration range for this endpoint is 132 ppm to 163 ppm..

Reproduction Test

The relationship between the percent females developing mature ovaries and the sediment zinc concentration gradient is shown the Figure 42. Stations CU, AL, AU, and AM showed significantly lower percentage of females developing mature ovaries.

The five stations with the lowest zinc concentrations (FC - 22.7 ppm, BU - 55.9 ppm, RC - 60.5 ppm, BL - 98.4 ppm, and CL - 132 ppm) showed percentages of females which developed mature ovaries ranging between 77 - 80 %. The station with the next highest zinc concentration, CM (163 ppm), showed a non-significantly lower percent of females developing mature ovaries of 53 %. The next four stations (Cu, AL, AU, and AM) showed significantly lower percentages of females developing mature embryos, although station CU showing a higher value (63 %) than station CM (53 %) which was not statistical significantly different from the reference test location. The protective sediment zinc concentration range for this endpoint is 132 ppm to 163 ppm..

Embryo Production Test

The relationship between the percent females producing embryos and the sediment zinc concentration is shown in Figure 43. All stations except RC showed significantly lower percentage of females producing embryos from the reference test location.

The stations (FC, BU, RC, BL, and CL) with the five lowest zinc concentrations showed percentages of females producing embryos ranging from 37 - 57 %. The station with the next highest zinc concentration (CM - 163 ppm) showed 13 % of the females producing embryos. The percent of females producing embryos return to 37 % for the station with the next highest zinc concentration (CU - 227 ppm). The remaining stations (AL, AU, and AM) showed percentage of females producing embryos ranging from 2 - 8 %. The protective sediment zinc concentration ranges for this endpoint are 227 ppm to 847 ppm.

Embryo Hatching Test

The relationship between the percent of embryos hatching to the sediment zinc concentration gradient is shown in Figure 44. Stations CL, CM, AL, AU, and AM showed significantly lower percentages of embryos hatching.

The four stations with the lowest zinc concentrations (stations FC - 22.7 ppm, BU - 55.9 ppm, RC - 60.5 ppm, and BL - 98.4) showed the range of percent of embryos hatching to be 82 - 93 %. Stations CL (132 ppm) and CM (163 ppm) showed significantly lower embryo hatching success of 69 % and 64 %, respectively. The station with the next highest zinc concentration, CU (227 ppm) showed 88 % of the embryos hatching into the zoae stage. The remaining three stations (AL, AU, and AM) showed significantly lower percentages of embryos hatching ranging from 17 - 25 %. The protective sediment zinc concentration range for this endpoint is 227 ppm to 847 ppm.

DNA Damage Test

The relationship between the tail moment indicating DNA strand damage in embryos and the sediment zinc concentration gradient is shown in Figure 45. Stations CM, AL, AU, and AM showed significantly higher tail moments when compared to the reference test location.

The four stations with the lowest zinc concentrations (FC, BU , RC, and BL) showed tail moments ranging from 1.4 to 2. The station with the next highest zinc concentration CL (132 ppm) showed a significantly higher tail moment of 3.8. Station CU with a zinc concentration of 227 ppm showed a tail moment (1.2) falling in the range of the first four stations. The remaining stations (AL, AU, and AM) showed significantly higher tail moments ranging from 6.9 - 7.1. The protective sediment zinc concentration range for this endpoint ranges from 227 ppm to 847 ppm.

Summary of Protective Ranges

The protective ranges are summarized in Table 12. These protective ranges are compared to sediment concentrations indicative of possible and probable effects to the macrobenthic community, and reference location sediment COPC concentrations (Rathall Creek and Foster Creek). The threshold effect levels (TELs) which are indicative of the onset of the possible effects range, and the probable effects levels (PELs) which are indicative of the onset of the probable effects were obtained from the Florida Sediment Quality Assessment Guidelines. The effects range low (ER-L), which is indicative of the onset of the possible effects range, and the effects range medium (ER-M), which are indicative of the onset of probable effects range were obtained from NOAA's Sediment Guidelines.

Chromium

The chromium protective sediment concentration range, 219 ppm to 258 ppm, is above both possible effects levels (TEL - 52.3 ppm and ER-L- 81 ppm) and above the PEL (160 ppm) but below the ER-M (370 ppm). The protective range is well above the sediment concentrations found at the reference locations (13 ppm and 40 ppm). Protective levels were derived for all five endpoints of the toxicity test and the relationship between sediment chromium concentrations and the results from the toxicity test provides strong evidence that chromium is a likely driver of toxicity test results.

Copper

The copper protective sediment concentration range, 28.4 ppm to 28.5 ppm, is above the TEL (18.7 ppm) but below the ER-L (34 ppm). The protective range is below both probable effects levels (PEL - 108 ppm and ER-M - 270 ppm), and above the sediment concentrations found at the reference locations (6 ppm and 18 ppm). Protective levels were derived for one of the five endpoints of the toxicity test. The evidence identifying copper as a toxicity driver is weakest of all the COPCs.

Lead

The lead protective sediment concentration range, 77.5 ppm to 147 ppm, is above both possible effects levels (TEL - 30.2 ppm and ER-L - 47 ppm), includes the PEL (112 ppm), and below the ER-M (218 ppm). The protective range is above the concentrations found at the reference locations (8 ppm and 20 ppm). Protective ranges were derived for four of the five endpoints of the toxicity test. The evidence identifying lead as a toxicity driver is weaker than that for chromium, nickel, and zinc, both stronger than that for copper and manganese.

Manganese

The protective sediment concentration range, 238 ppm to 377 ppm, is above one of the reference location (Foster Creek - 45 ppm). The sediment concentration at the other reference location (Rathall Creek - 238 ppm) serves as the lower bound of the protective concentration range. There are no possible or probable effects levels for manganese. Protective levels were derived for three of the five endpoints of the toxicity test. The evidence identifying manganese as a toxicity driver is weaker than chromium, nickel, zinc, and lead but stronger than that for copper.

Nickel

The protective sediment concentration range, 33 ppm to 33.7 ppm, is above both possible effects levels (TEL - 15.9 ppm and ER-L - 21 ppm) and below both probable effects levels (PEL - 42.8 ppm and ER-M - 52 ppm). The protective concentration range is above both reference locations (3 ppm and 11 ppm). Protective levels were derived for all five endpoints of the toxicity test. The evidence identifying nickel as a toxicity driver is strong.

Zinc

The protective sediment concentration range, 132 ppm to 163 ppm, is above the TEL (124 ppm) and includes the ER-L (150 ppm). The protective range is below both probable effects levels (PEL - 271 ppm and ER-M - 410 ppm). The protective range is above both reference locations (23 ppm and 60 ppm). Protective ranges were derived for all five endpoints of the toxicity test. The evidence identifying zinc as a driver of toxicity is strong.

In summary the evidence identifying those contaminants most likely to be responsible for the adverse effects shown in the grass shrimp toxicity test is strongest for chromium, nickel, and zinc. Lead is the next likely toxicity driver, followed by manganese. The evidence identifying copper as a driver of toxicity is the weakest of all the COPCs.

References

Lee, Richard F. 2001. Final Report. Toxicity, Ovary Formation, Embryo Production, Embryo Hatching and DNA Strand Damage Tests in Grass Shrimp (*Palaemonetes pugio*) Exposed to Sediments from Charleston Harbor Estuary.

cc: Elmer Akin, Chief, OTS
Tom Dillon, NOAA CRC
Diane Duncan, USFWS Charleston Field Office
Priscilla Went, SCDNR/MRD/OEM

Table 1. s Shrimp (*Palaemonetes pugio*) Toxicity Test Results

Endpoint	AL	AM	AU	BL	BU	CL	CM	CU	Foster Creek	Rathall Creek	Lab Control
Percent Mortality	23*	23	27*	12	12	15	32*	23	12	20*	8
Percent Females Developing Mature Ovaries	23*	18*	17*	72	77	77	53	63*	80	77	83
Percent Females Producing Embryos	8*	5*	2*	37*	45*	43*	13*	37*	40*	57	72
Percent Embryos Hatching	25*	17*	20*	82	86	69*	64*	88	92	93	93
DNA Strand Damage (Tail Moment)	6.9*	7.1*	7.1*	1.8	2	1.4	3.8*	1.2	1.4	1.8	1
* Results significantly different from the reference test location (Skidaway River)											

Table 2. .. Concentrations by Station Location at Macalloy NPL Site, Charleston, SC, June _001

Contaminant (mg/kg)	AL		AM		AU		BL		BU		CL		CM		CU		Foster Creek		Rathall Creek	
Aluminum	13800		21300		13900		3030		7650		14600		14900		21100		5510		18600	
Antimony	1.7	UJ	2.6	UJ	1.6	UJ	13.6	UJ	1.6	UJ	2.1	UJ	2.2	UJ	2.9	UJ	1.7	UJ	2.2	UJ
Arsenic	13.1		19.3		11.8		16.3	J	7.1		10.7		11.1		14.8		4.2		13.5	
Barium	32.3	J	55.5	J	54.4	J	19	J	15.4	J	23.3	J	26.5	J	35	J	13.8	J	22.9	J
Beryllium	0.61	J	0.89	J	0.58	J	1	J	0.5	J	0.74	J	0.75	J	0.97	J	0.29	J	0.88	J
Cadmium*	0.63	J	0.82	J	0.54	J	1.8	U	0.5	J	0.5	J	0.71	J	1	J	0.23	U	0.29	U
Calcium	11600		10100		7090		118000		47700		59100		54300		54300		1730	J	11100	
Chromium*	1780	J	2980	J	3070	J	79.7	J	91	J	219	J	317	J	258	J	13	J	40.1	J
Hexavalent Chromium*	4.5	U	6.2	U	4.3	U	3	U	3.6	U	5.1	U	5.9	U	6.5	U	3.8	U	5.4	U
Cobalt	14.3	J	20.4	J	21.1		3	J	2	J	3.8	J	4.1	J	5.7	J	1.7	J	5.2	J
Copper*	39.7	J	63.9	J	47.9	J	28.4	J	12.4	J	24.5	J	28.5	J	52.9	J	6.2	J	18.4	J
Iron	20000		29600		21600		9730		7190		14000		14700		22300		7750		23800	
Lead*	147	J	310	J	189	J	6.4	J	11.8	J	77.5	J	37.3	J	56.3	J	7.6	J	20.2	J
Magnesium	43500		61100		72200		2610	J	3500		7350		7850		8710		2090		6530	
Manganese*	377		747		682		84.4		55.3		116		105		161		44.8		238	
Mercury*	0.12		0.22		0.13		0.062	J	0.087		0.12		0.17		0.3	J	0.062	J	0.016	
Nickel*	373		474		606		28.6	J	19.4		33		40.7		35.7		3.4	J	10.9	J
Potassium	1890	J	3220		1680	J	977	J	1150	J	2020	J	2030	J	2830	J	1080	J	2940	
Selenium*	1.6	U	2.4	U	1.5	U	13	U	1.5	U	2	U	2.1	U	2.8	U	1.6	U	2.1	U
Silver	0.3	U	0.46	J	0.54	J	2.4	U	0.29	U	0.37	U	0.39	U	0.52	U	0.3	U	0.39	U
Sodium	9420		15600		9150		4910	J	5850		10400		10700		14100		6660		16300	
Thallium	1.9	U	2.8	U	1.7	U	14.8	U	1.8	U	2.8	J	2.4	U	3.3	J	1.8	U	2.4	U
Vanadium*	38.8	J	66.1	J	40.4	J	19.1	J	19.5	J	34	J	32.5	J	49	J	15.7	J	51.2	J
Zinc*	847	J	1640	J	1330	J	98.4	J	55.9	J	132	J	163	J	227	J	22.7	J	60.5	J
Fraction Organic Carbon	0.036		0.013		0.021		0.044		0.043		0.018		0.038		0.039		0.065		0.052	
%Silt and Clay	55.9		88.5		78.4		7.9		22.9		47		49.5		53.9		23.3		70.2	

* Chemical of Potential Concern (COPC)

Data Qualifiers

UJ = Analyte was not detected and the detection limit reported is a quantitatvie estimate

J = Analyte concentration detected but the concentration is an estimate

U = Analyte was not detected at the quantitation limit

Table ;elation Coefficients between Cadmium Concentrations and Grass S. .p (*Palaemonetes pugio*) Toxicity Test Results

Station	Cadmium ppm	Mortality %		Females Developing Matrure Ovaries %		Females Producing Embryos %		Embryos Hatching %		DNA Damge Tail Moment	
Foster Creek	0.115	12		80		40	*	92		1.4	
Rathall Creek	0.145	20	*	77		57		93		1.8	
BU	0.5	12		77		45	*	86		2	
CL	0.5	15		77		43	*	69	*	1.4	
AU	0.54	27		18	*	2	*	20	*	7.1	*
AL	0.63	23	*	23	*	8	*	25	*	6.9	*
CM	0.71	32	*	53		13	*	64	*	3.8	*
AM	0.82	23	*	18	*	5	*	17	*	7.1	*
BL	0.9	12		72		37	*	82		1.8	
CU	1	23		63	*	37	*	88		1.2	
Lab Control		8		83		72		93		1	
R Squared		0.305143403		-0.364110629		-0.414846783		-0.284959171		0.209630676	

Cadmium was not detected for Foster Creek, Rathall Creek, and Station BL locations.
The reported cadmium concentrations for these three stations represent one-half the reported sample detection limit.
* Results were significantly different from the reference test location (Skidaway River)

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Figure 1. Cadmium Concentrations vs. Percent Mortality

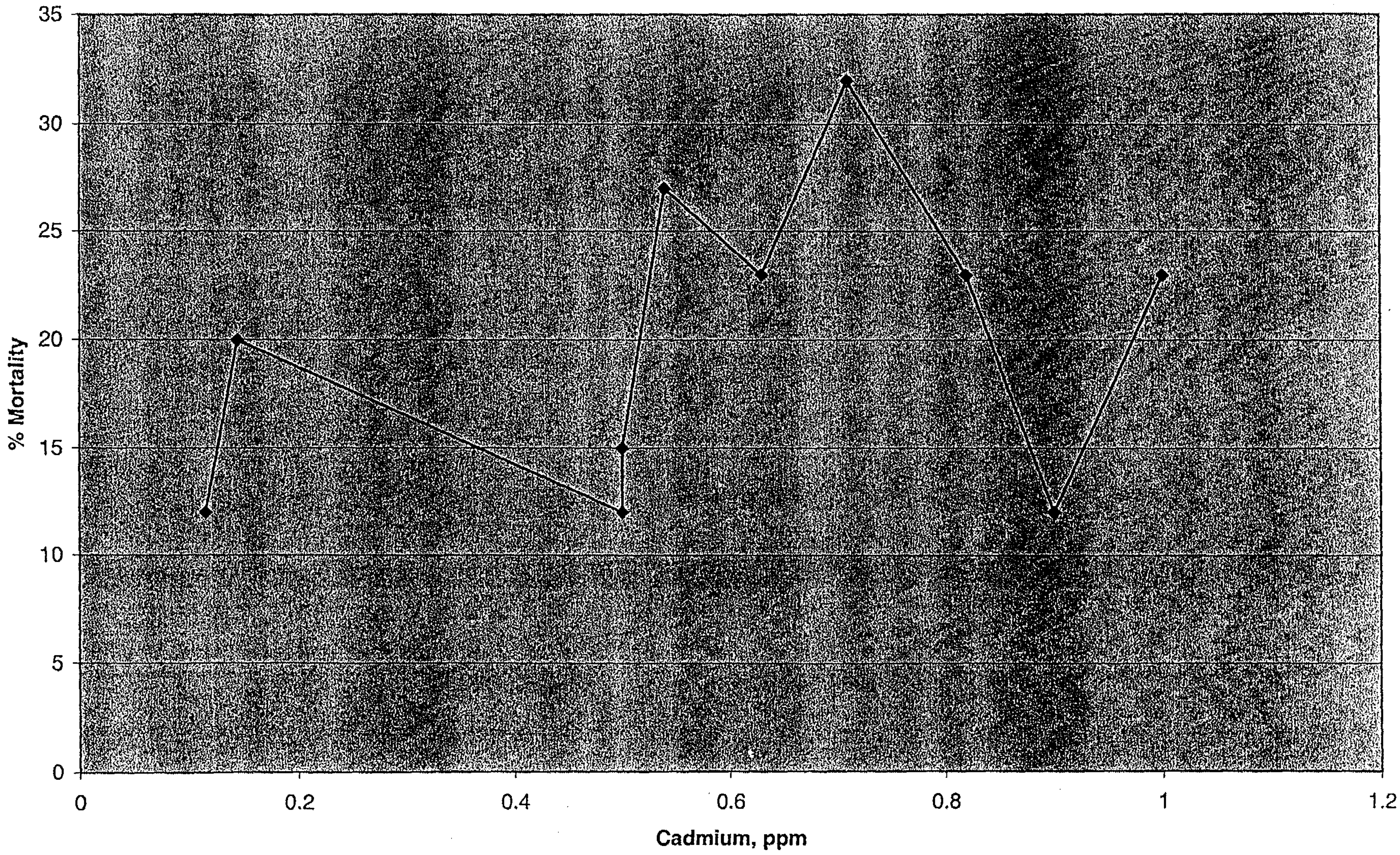

Figure 2. Cadmium Concentrations vs. Percent Females Developing Matrure Ovaries

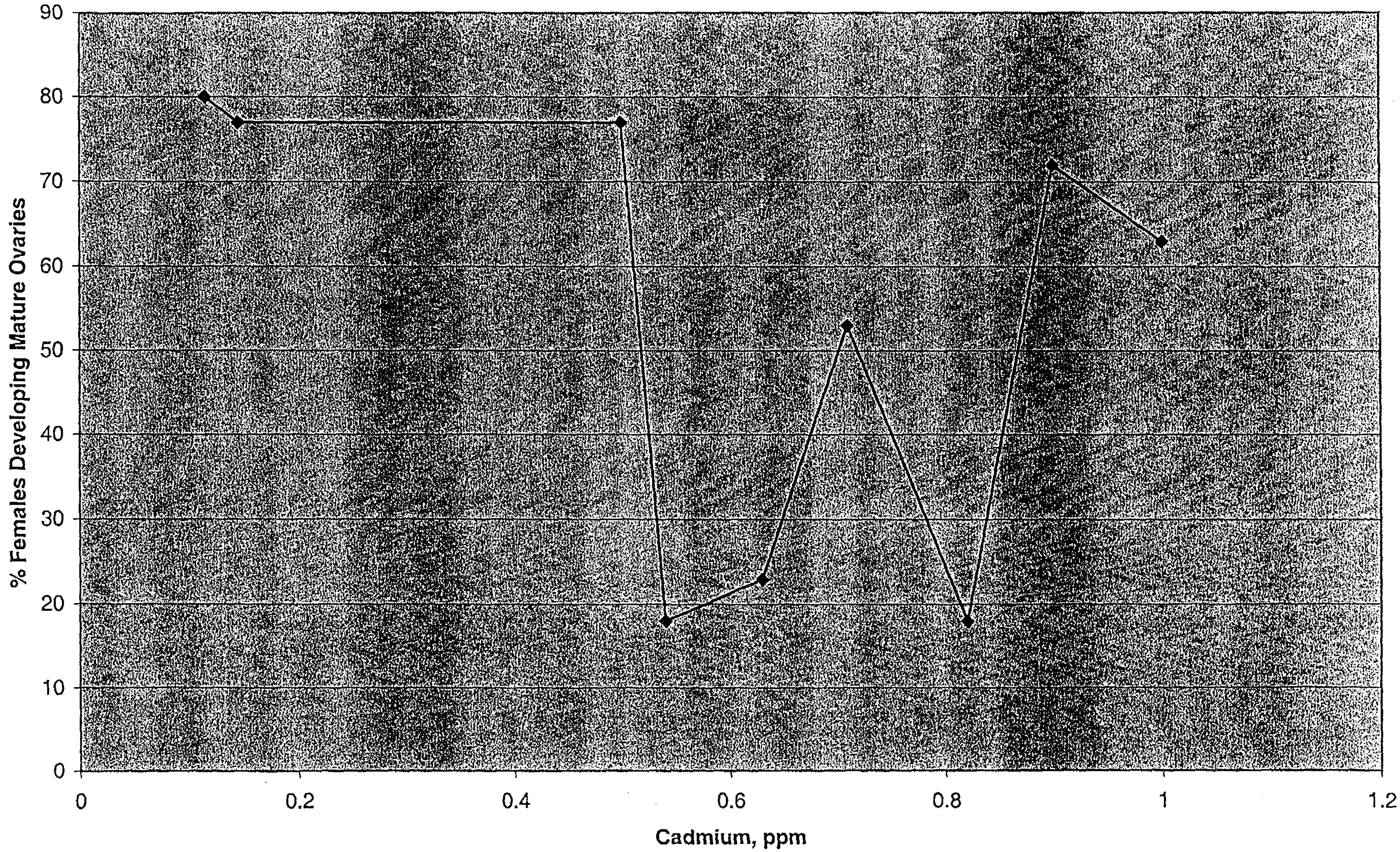

Figure 3. Cadmium Concentrations vs. Females Producing Embryos

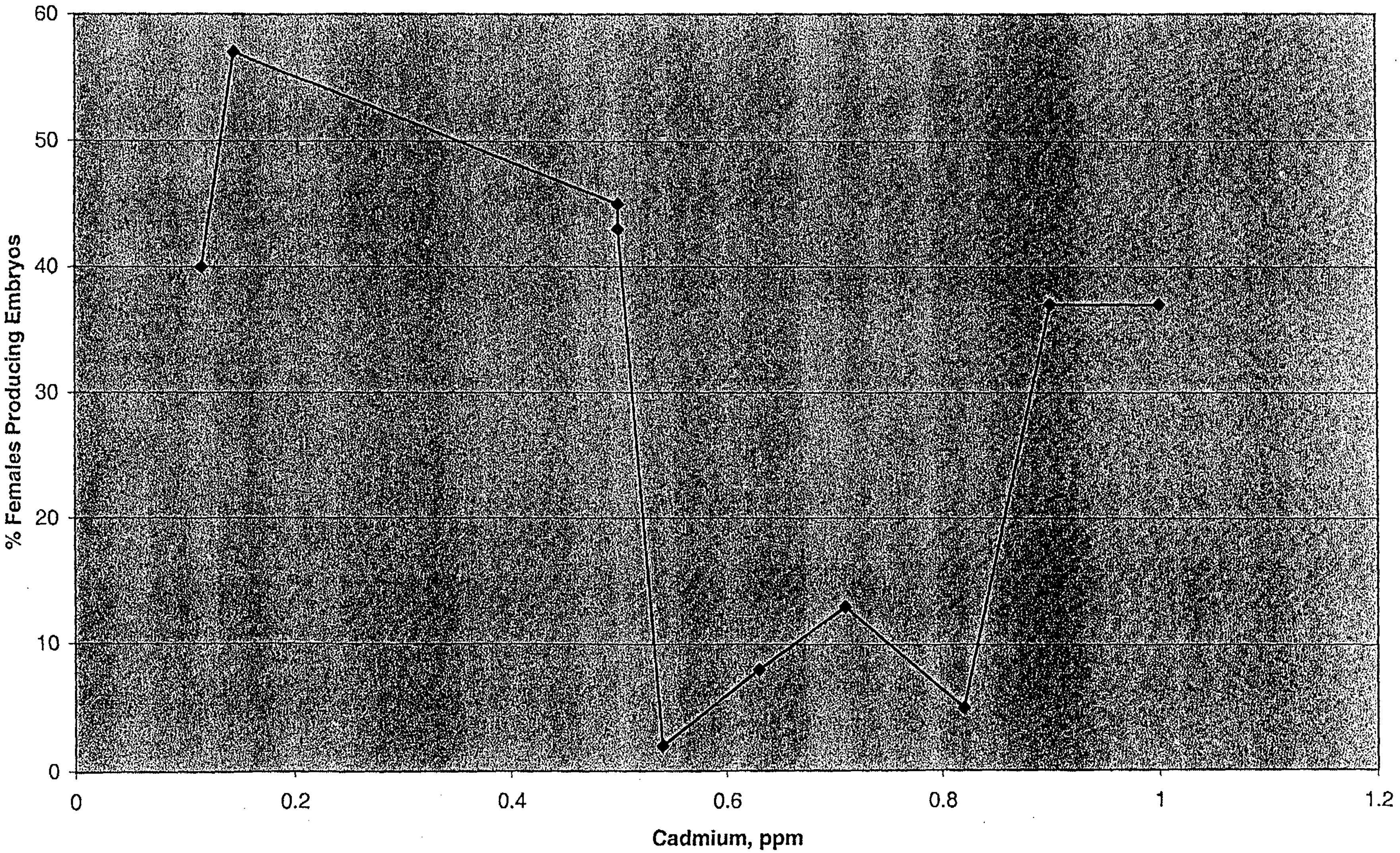

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Figure 4. Cadmium Concentrations vs. Percent Embryos Hatching

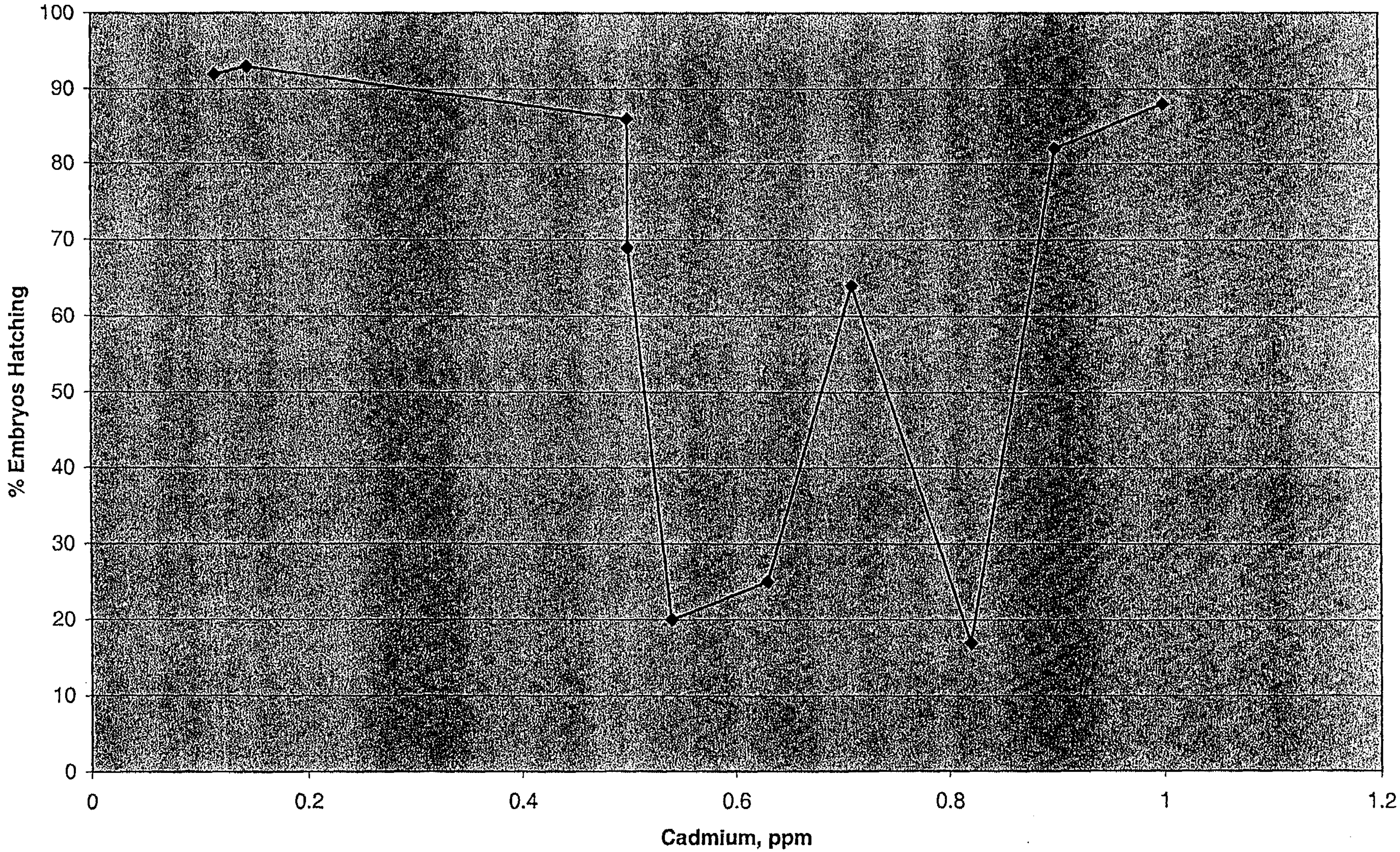

Figure 5. Cadmium Concentrations vs. DNA Strand Damage in Embryos

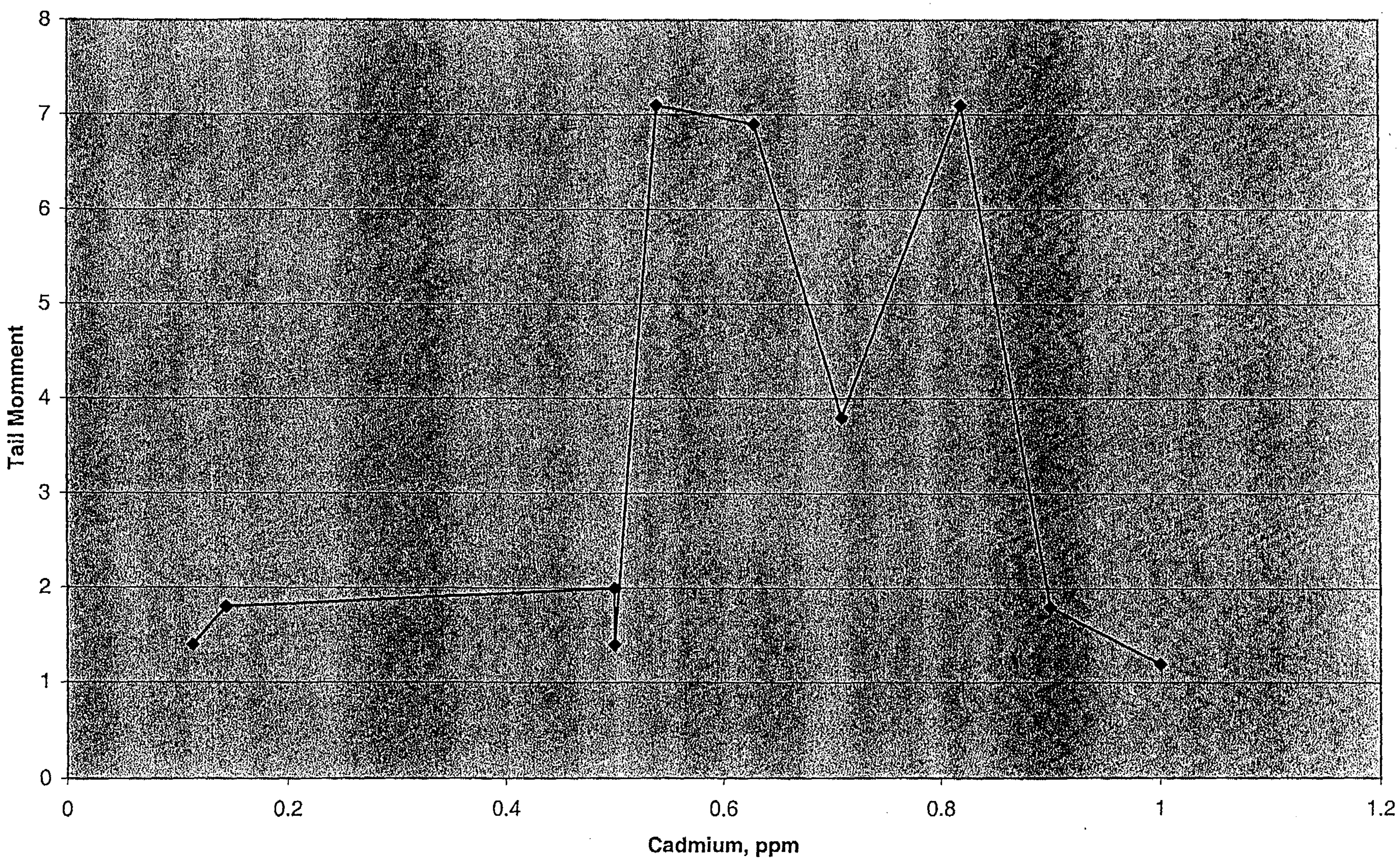

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Table ▪ ,relation Coefficients between Chromium Concentrations and Grass Shr.. (*Palaemonetes pugio*) Toxicity Test Results

Station	Chromium	Mortality		Females Developing Mature Ovaries		Females Producing Embryos		Perecnt Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
Foster Creek	13	12		80		40	*	92		1.4	
Rathall Creek	40.1	20	*	77		57		93		1.8	
BL	79.7	12		72		37	*	82		1.8	
BU	91	12		77		45	*	86		2	
CL	219	15		77		43	*	69	*	1.4	
CU	258	23		63	*	37	*	88		1.2	
CM	317	32	*	53		13	*	64	*	3.8	*
AL	1780	23	*	23	*	8	*	25	*	6.9	*
AM	2980	23		18	*	5	*	17	*	7.1	*
AU	3070	27	*	17	*	2	*	20	*	7.1	*
Lab Control		8		83		72		93		1	
R Squared		0.496613534		-0.947039362		-0.844385035		-0.946299996		0.936400305	
* Results were significantly different from the reference test location (Skidaway River)											

Figure 6. Chromium Concentrations vs. Percent Mortality

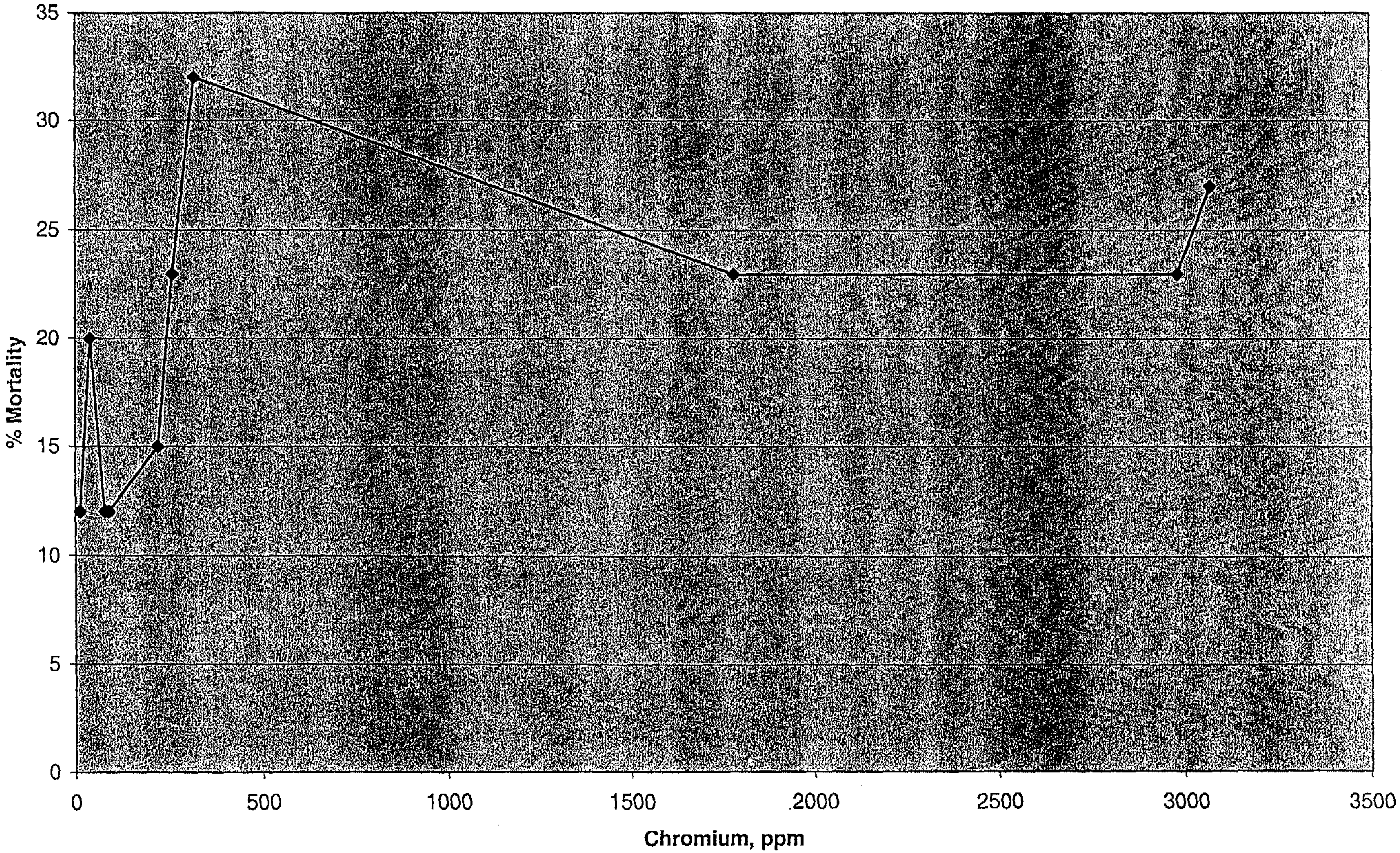

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Figure 7. Chromium Concentration vs. Percent Females Developing Mature Ovaries

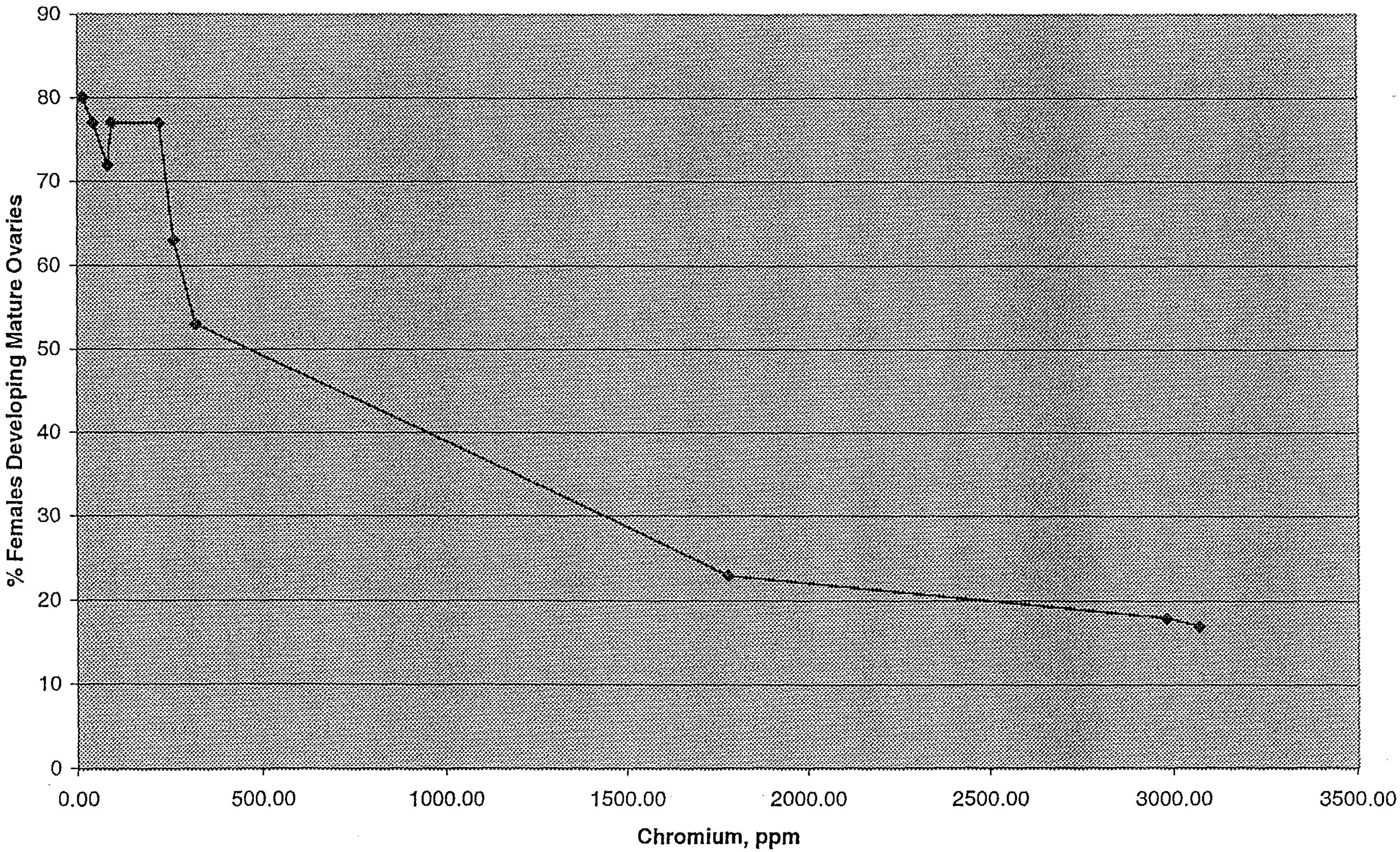

Figure 8. Chromium Concentration vs. Percent Females Producing Embryos

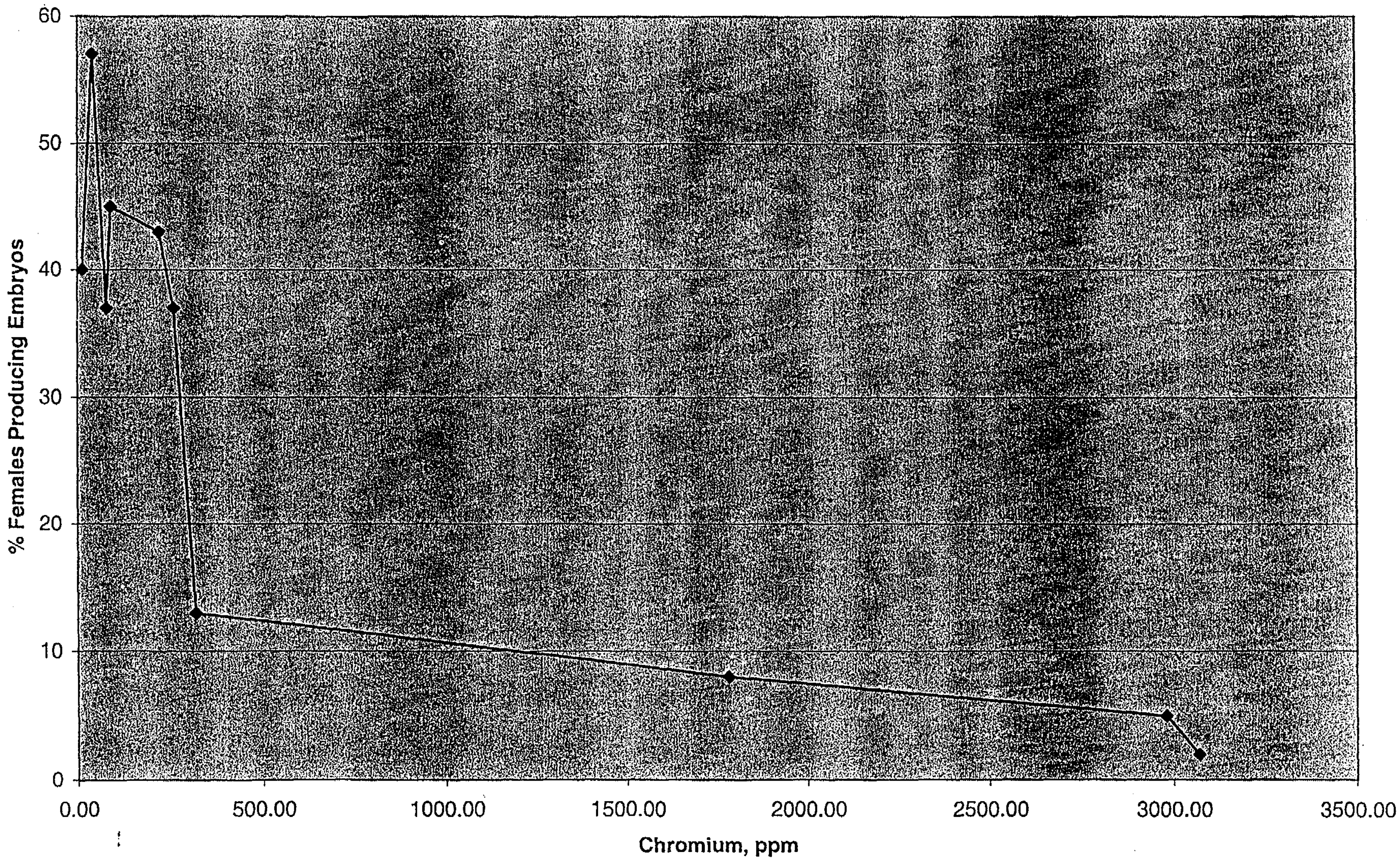

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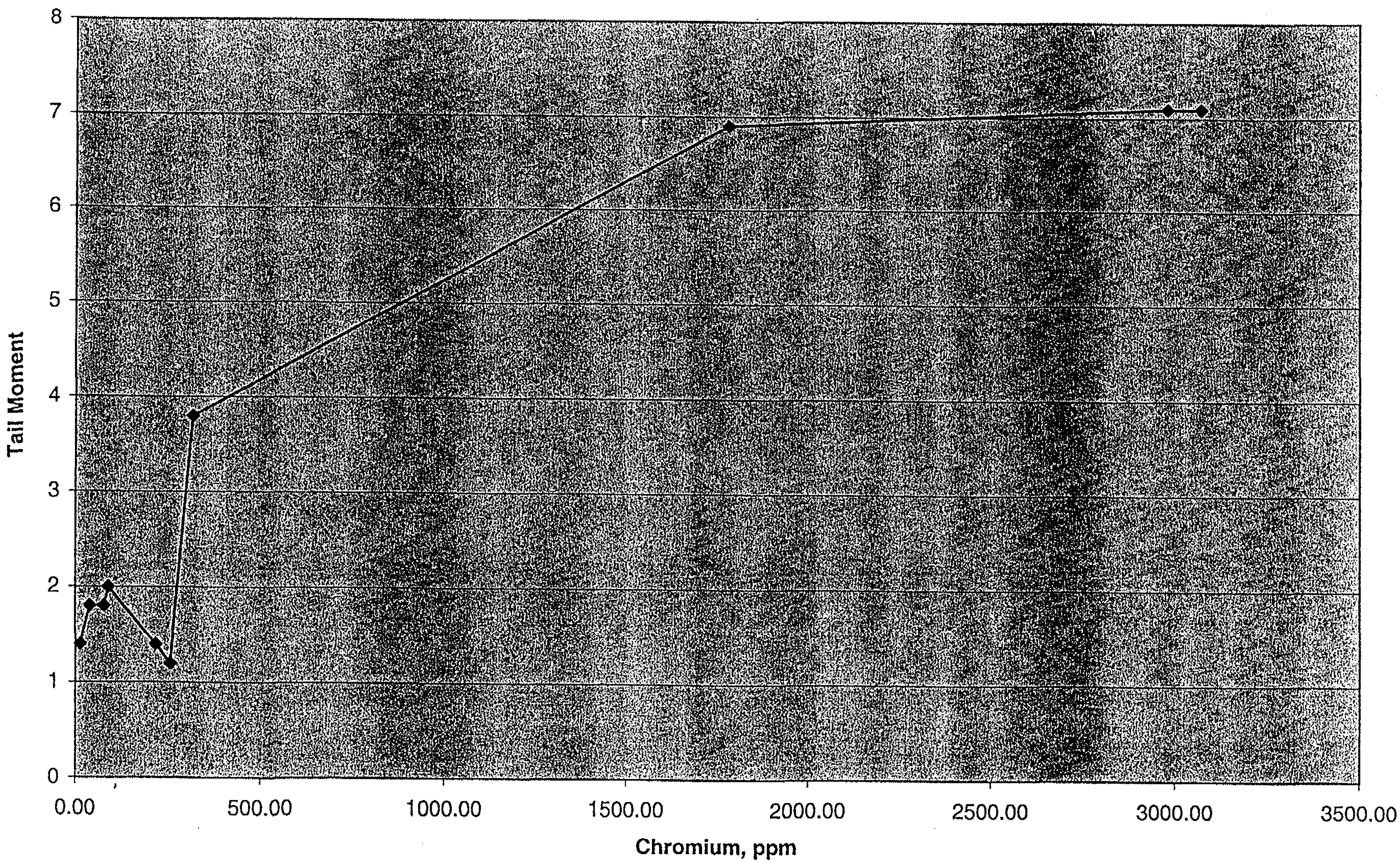
Figure 10. Chromium Concentrations vs. DNA Strand Damage in Embryos



Tabl orrelation Coefficients between Copper Concentrations and Gra hrimp (*Palaemonetes pugio*) Toxicity Test Results

Station	Copper	Mortality		Females Developing Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
Foster Creek	6.2	12		80		40	*	92		1.4	
BU	12.4	12		77		45	*	86		2	
Rathall Creek	18.4	20	*	77		57		93		1.8	
CL	24.5	15		77		43	*	69	*	1.4	
BL	28.4	12		72		37	*	82		1.8	
CM	28.5	32	*	53		13	*	64	*	3.8	*
AL	39.7	23	*	23	*	8	*	25	*	6.9	*
AU	47.9	27	*	17	*	2	*	20	*	7.1	*
CU	52.9	23		63	*	37	*	88		1.2	
AM	63.9	23		18	*	5	*	17	*	7.1	*
Lab Control		8		83		72		93		1	
R Squared		0.586509		-0.787402618		-0.684775292		-0.704330767		0.647835265	
* Results were significantly different from the reference test location (Skidaway River)											

Figure 11. Copper Concentrations vs. Percent Mortality

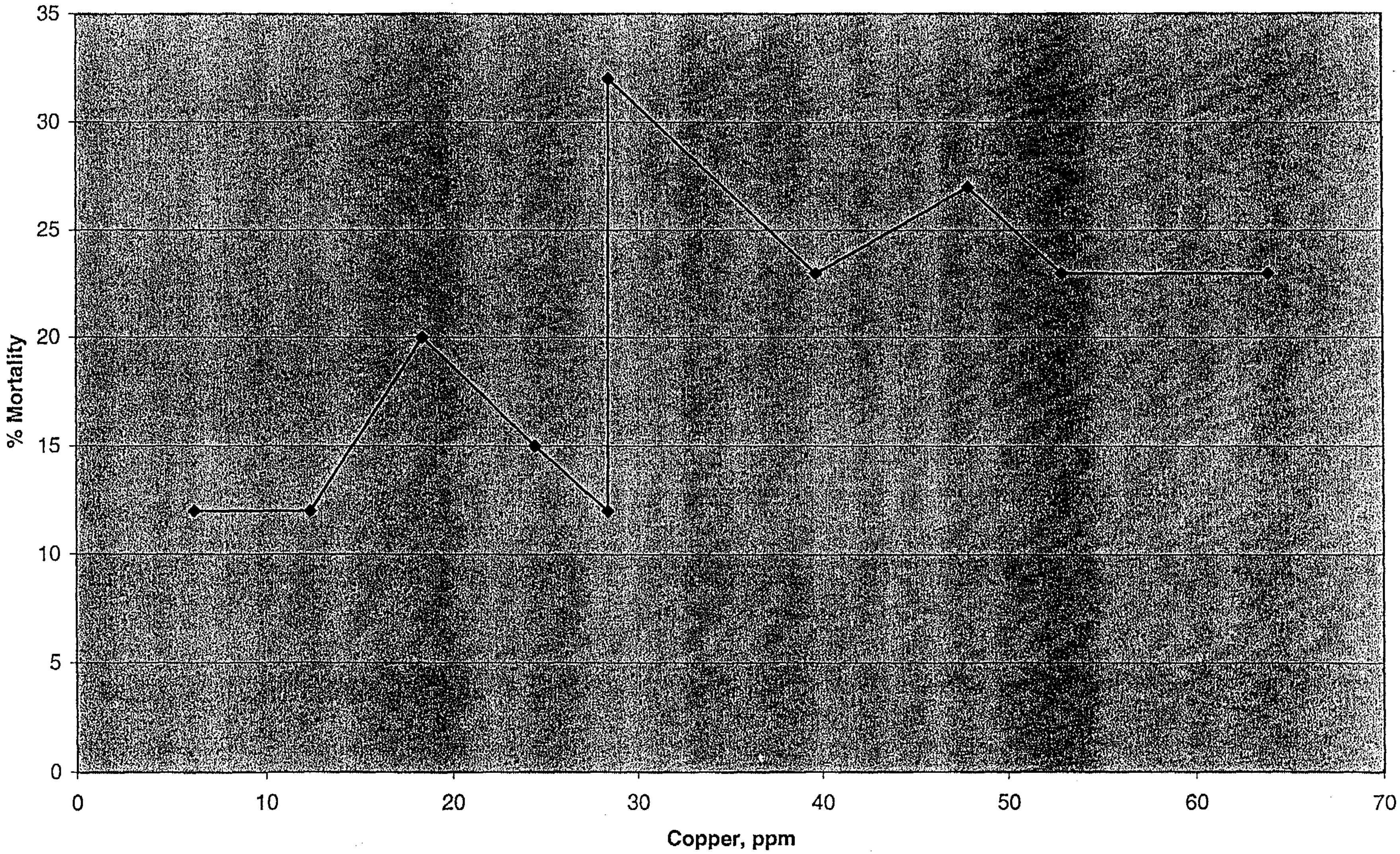


Figure 12. Copper Concentrations vs. Percent Females Developing Mature Ovaries

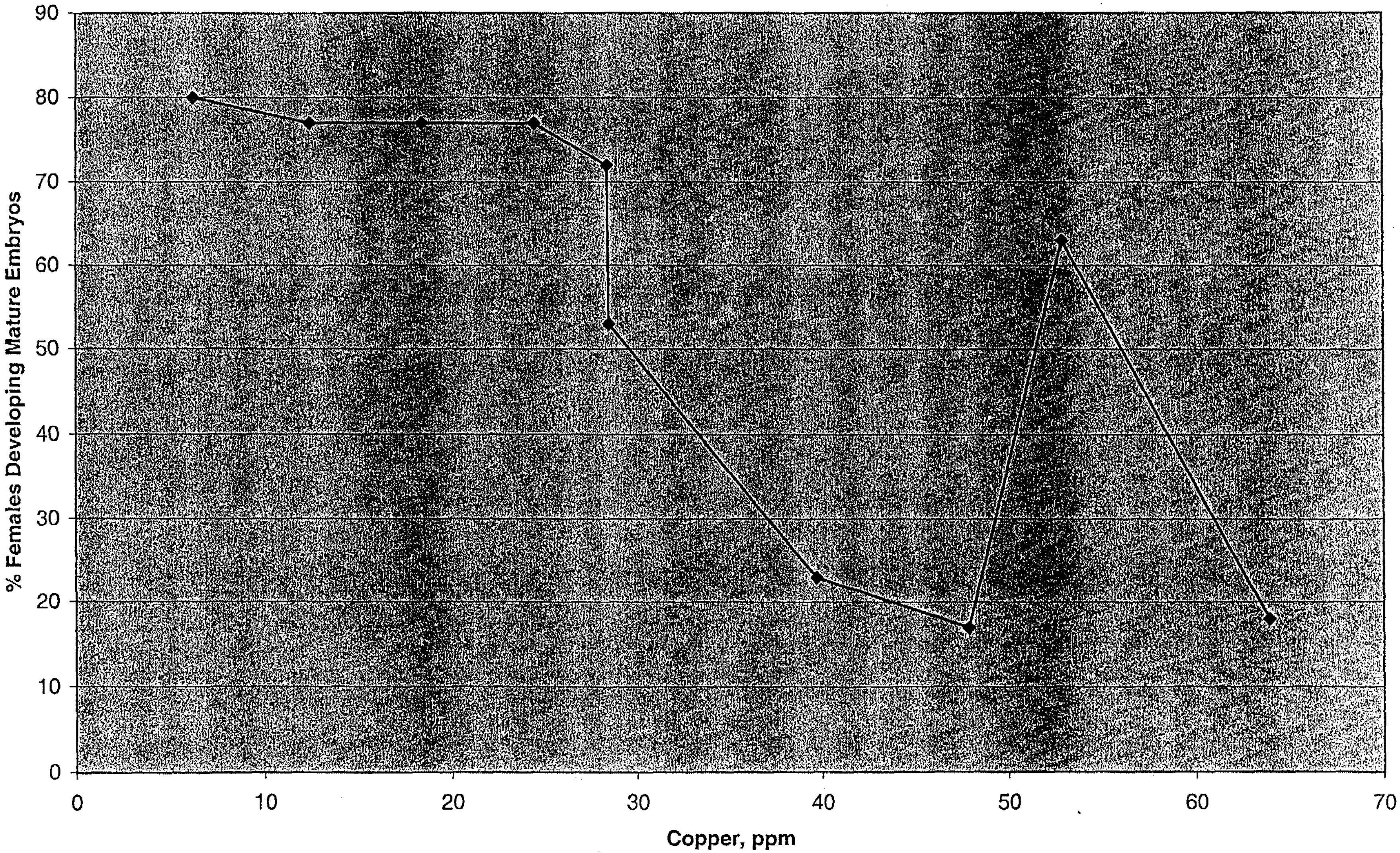


Figure 13. Copper Concentrations vs. Females Producing Embryos

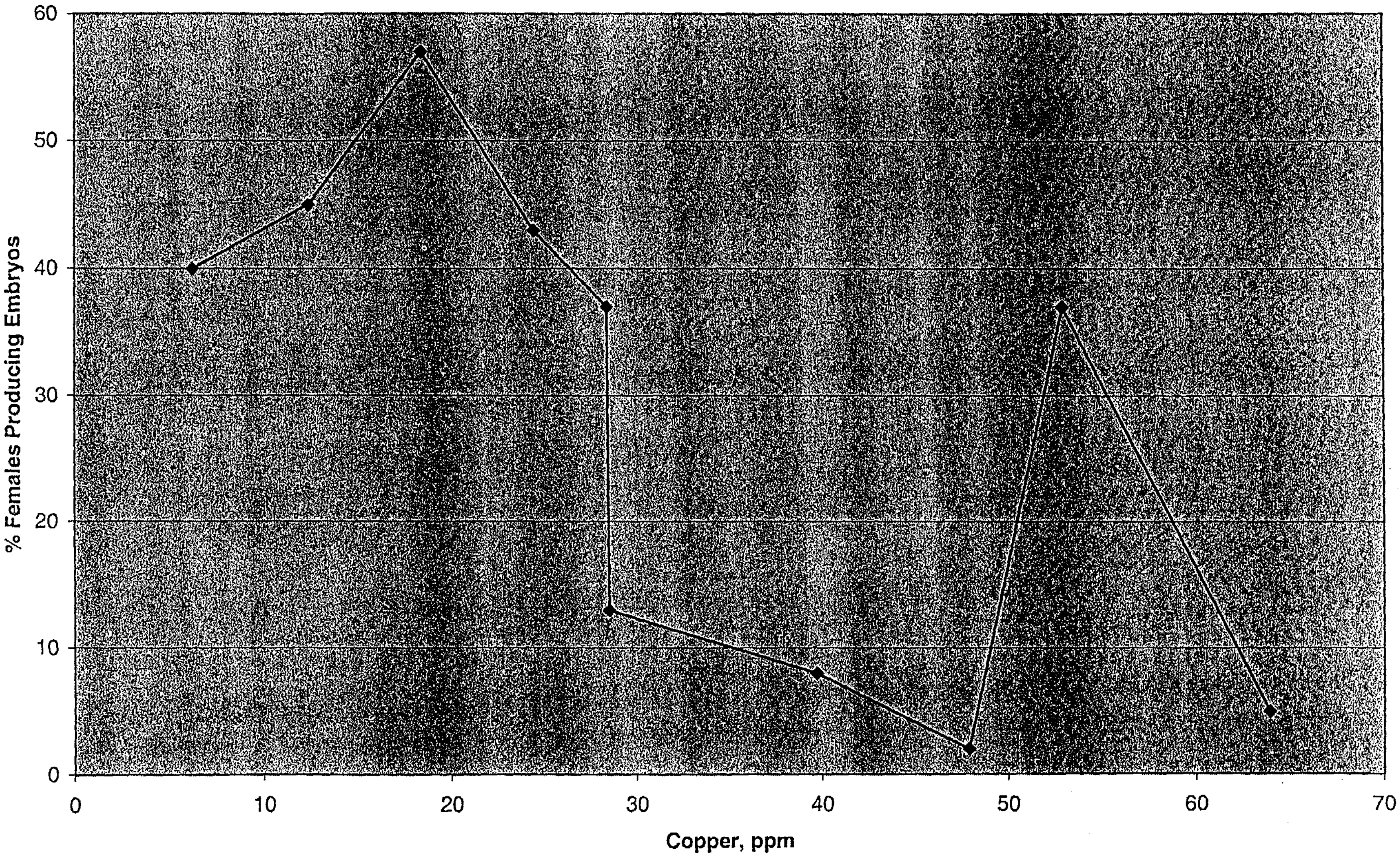


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Figure 14. Copper Concentrations vs. Percent Embryos Hatching

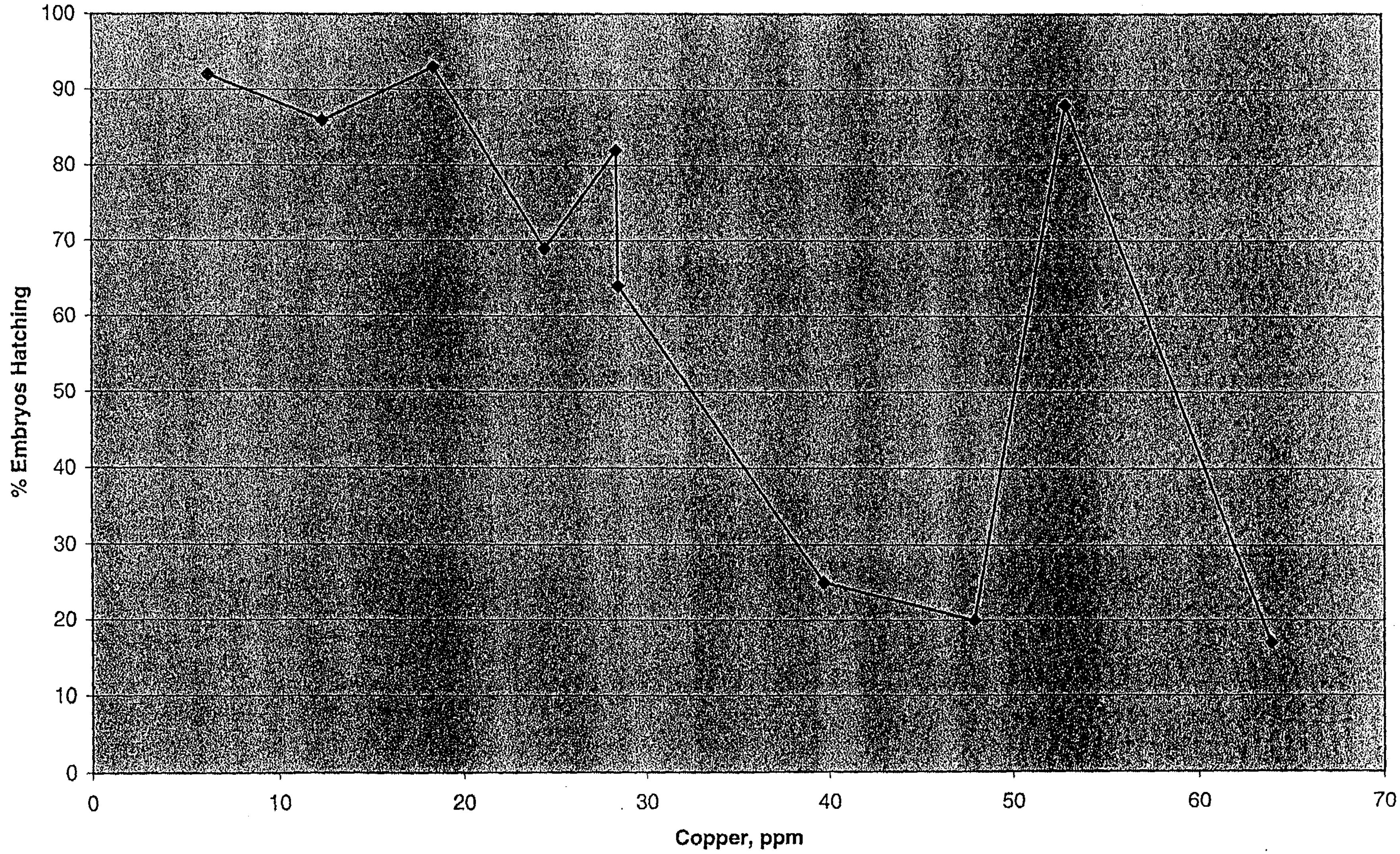

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Figure 15. Copper Concentrations vs. DNA Strand Damage in Embryos

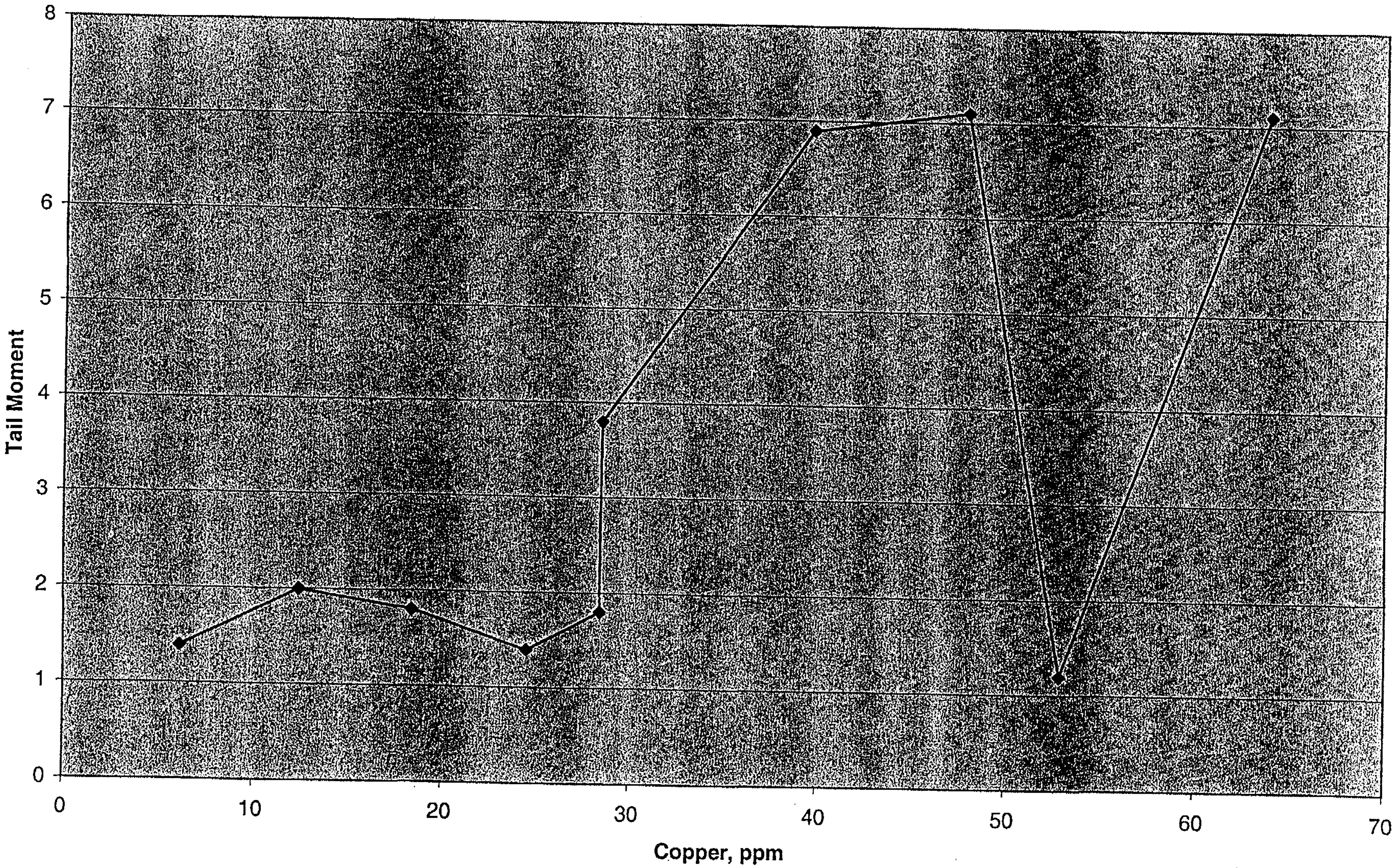

Table ,rrelation Coefficients between Lead Concentrations and Grass S. .p (*Palaemonetes pugio*) Toxicity Test Results

Station	Lead	Mortality		Females Developing Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
BL	6.4	12		72		37	*	82		1.8	
Foster Creek	7.6	12	*	80		40	*	92		1.4	
BU	11.8	12		77		45	*	86		2	
Rathall Creek	20.2	20		77		57		93		1.8	
CM	37.3	32	*	53		13	*	64	*	3.8	*
CU	56.3	23		63	*	37	*	88		1.2	
CL	77.5	15		77		43	*	69	*	1.4	
AL	147	23	*	23	*	8	*	25	*	6.9	*
AU	189	27	*	17	*	2	*	20	*	7.1	*
AM	310	23		18	*	5	*	17	*	7.1	*
Lab Control		8		83		72		93		1	
R Squared		0.446619		-0.878374789		-0.763964175		-0.905685397		0.85334732	
* Results significantly different from reference test location (Skidaway River)											

Figure 16. Lead Concentrations vs. Percent Mortality

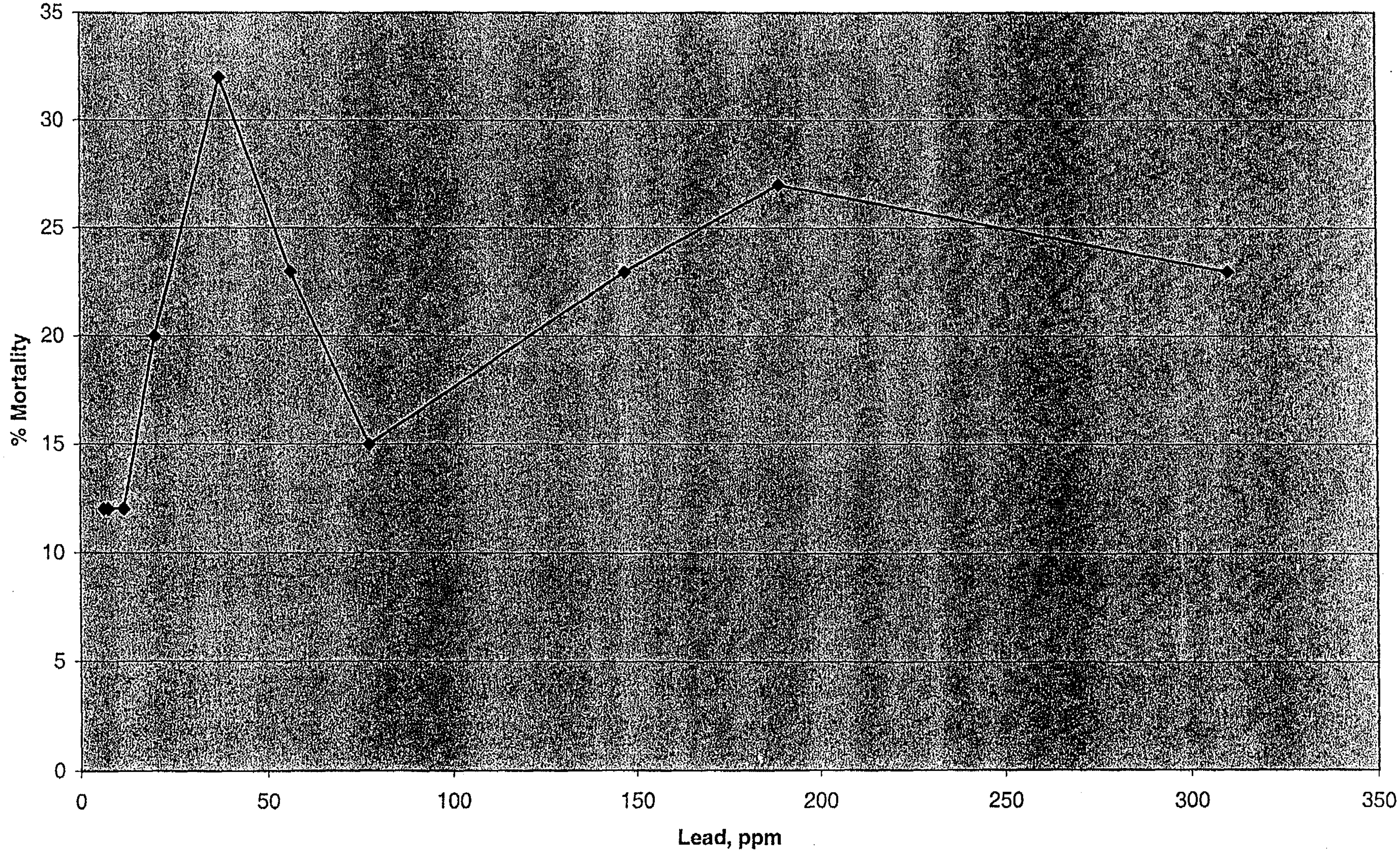

Figure 17. Lead Concentrations vs. Percent Females Developing Mature Ovaries

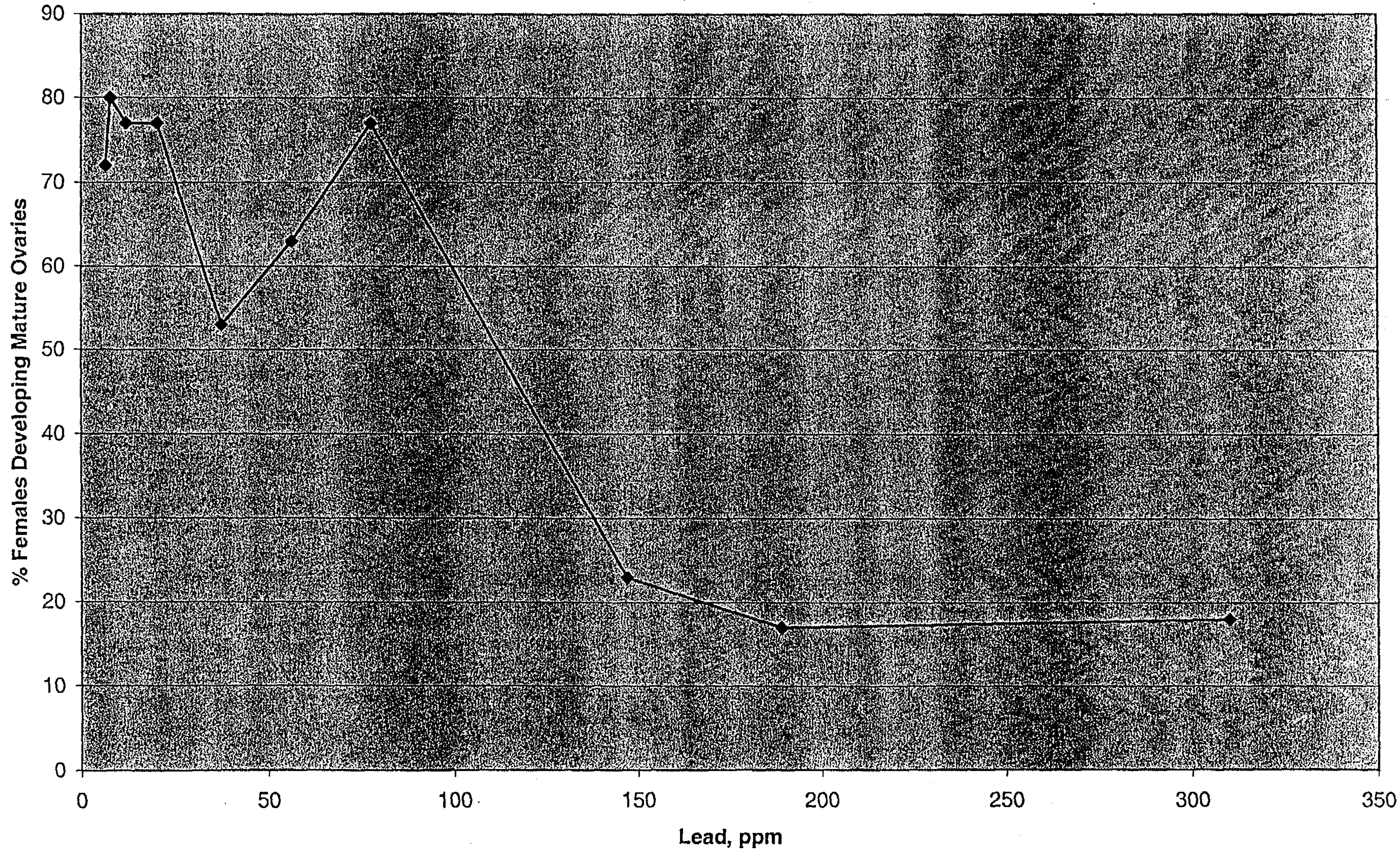

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Figure 18. Lead Concentrations vs. Percent Females Producing Embryos

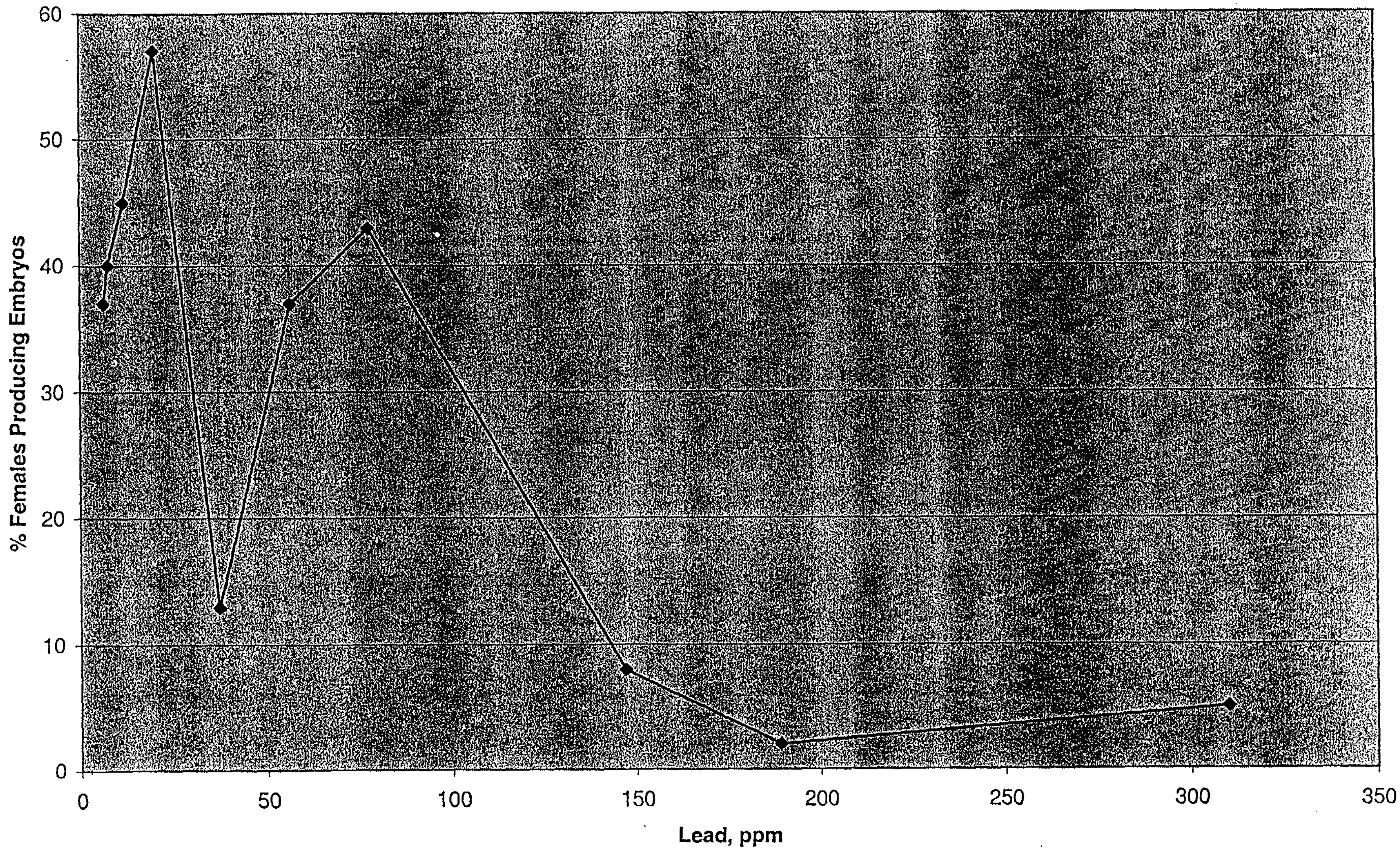

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Figure 19. Lead Concentrations vs. Percent Embryos Hatching

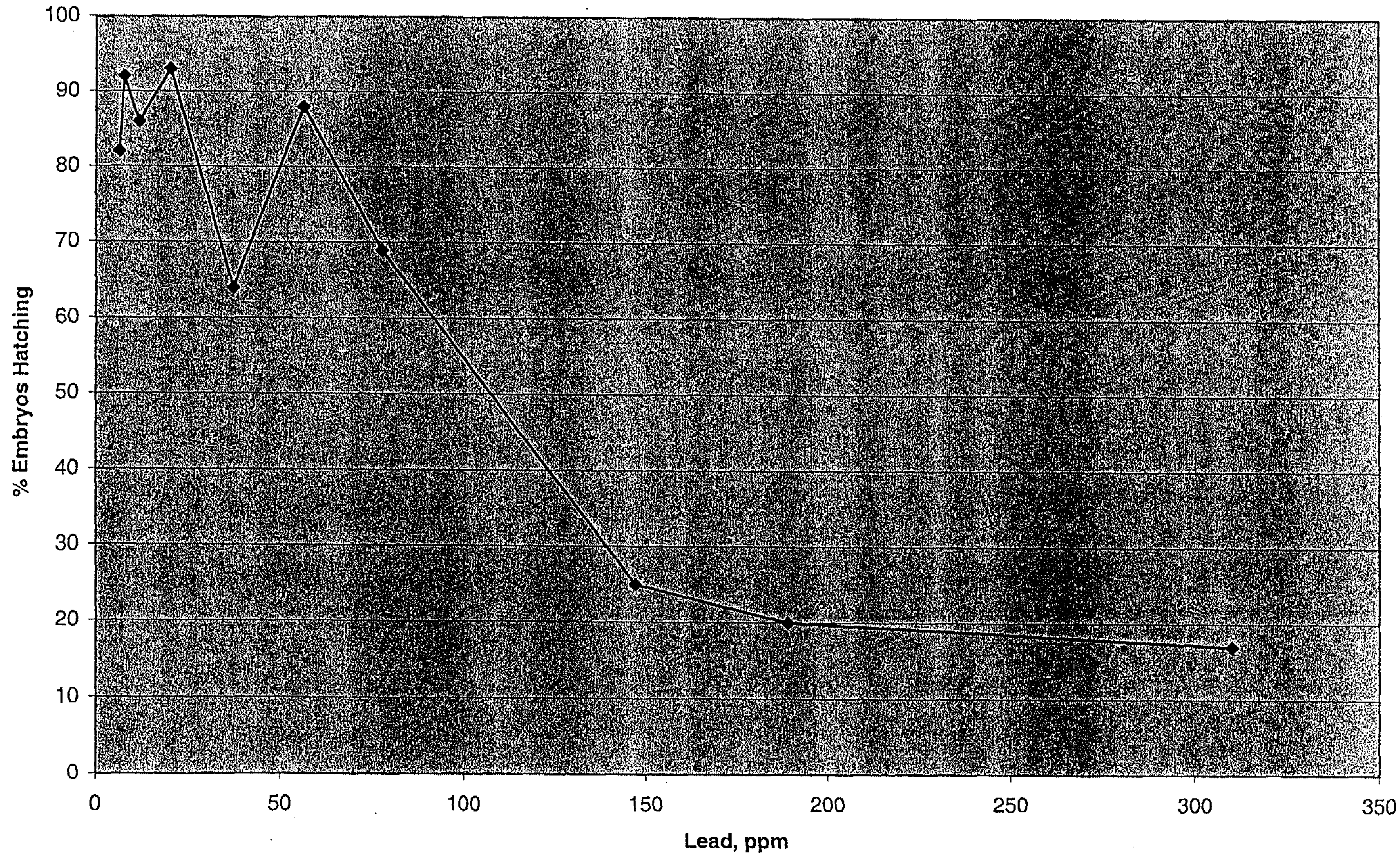

Figure 20. Lead Concentrations vs. DNA Strand Damage in Embryos

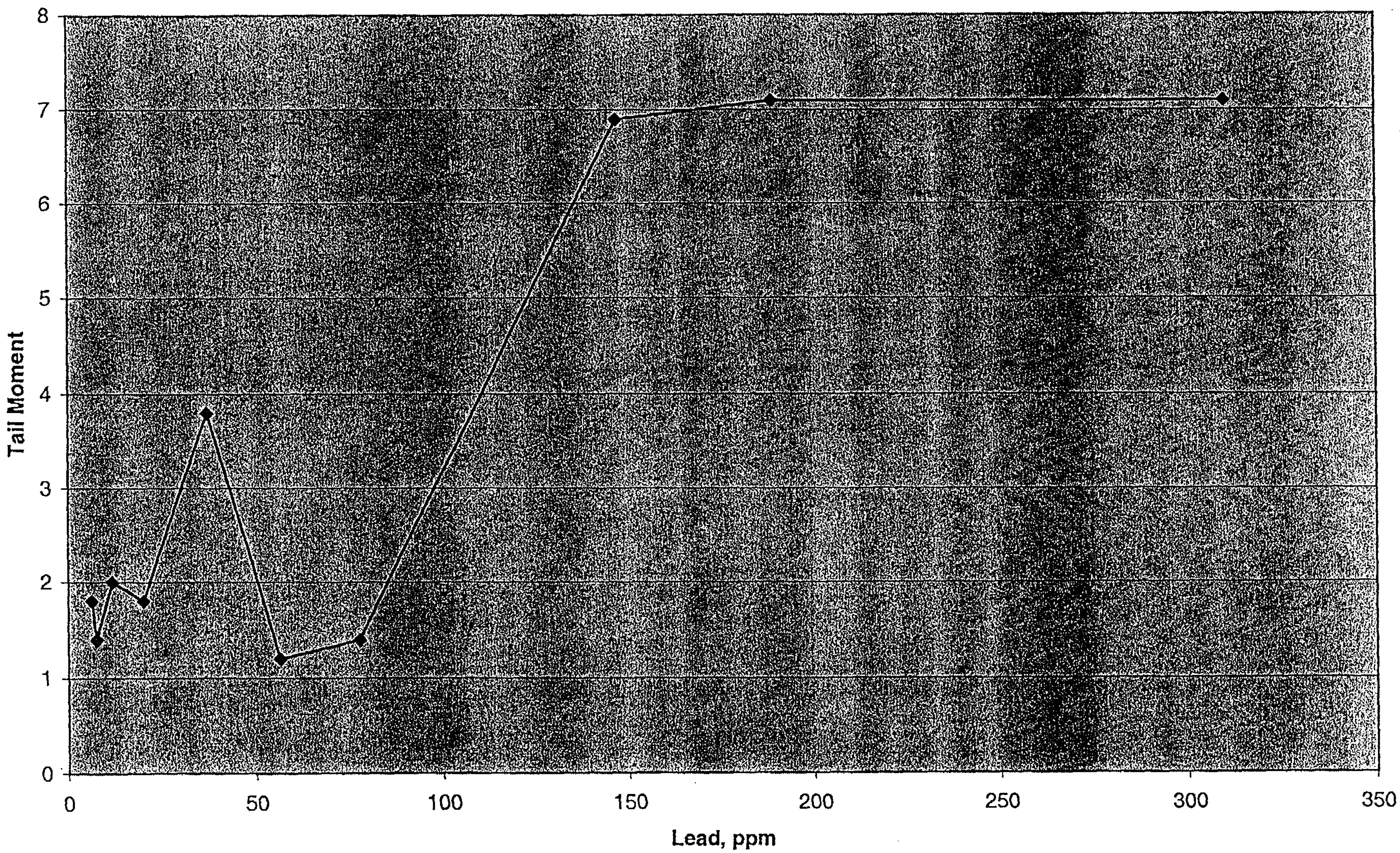

Table elation Coefficients between Manganese Concentrations and Grass Shrin . *alaemonetes pugio*) Toxicity Tests

Station	Manganese	Mortality		Females Developing Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Strand Damage in Embryos	
	ppm	%		%		%		%		Tail Moment	
Foster Creek	44.8	12		80		40	*	92		1.4	
BU	55.3	12		77		45	*	86		2	
BL	84.4	12		72		37	*	82		1.8	
CM	105	32	*	53		13	*	64	*	3.8	*
CL	116	15		77		43	*	69	*	1.4	
CU	161	23		63	*	37	*	88		1.2	
Rathall Creek	238	20	*	77		57		93		1.8	
AL	377	23	*	23	*	8	*	25	*	6.9	*
AU	682	27	*	17	*	2	*	20	*	7.1	*
AM	747	23		18	*	5	*	17	*	7.1	*
Lab		8		83		72		93		1	
R Squared		0.498663		-0.891630663		-0.731236053		-0.875937103		0.874971558	
* Results significantly different from reference test location (Skidaway River)											

Figure 21. Manganese Concentrations vs. Percent Mortality

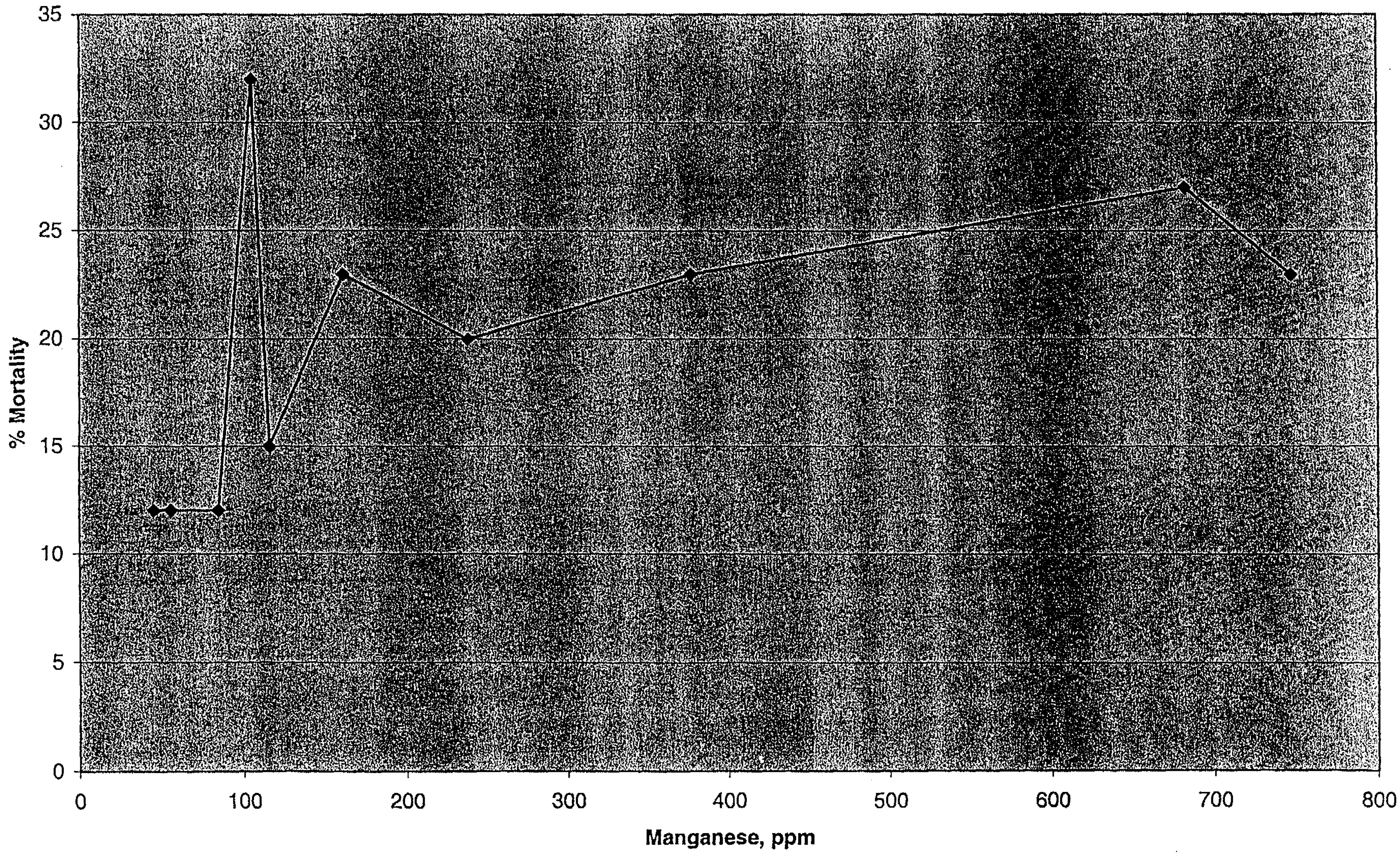

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Figure 22. Manganese Concentrations vs. Percent Females Developing Mature Ovaries

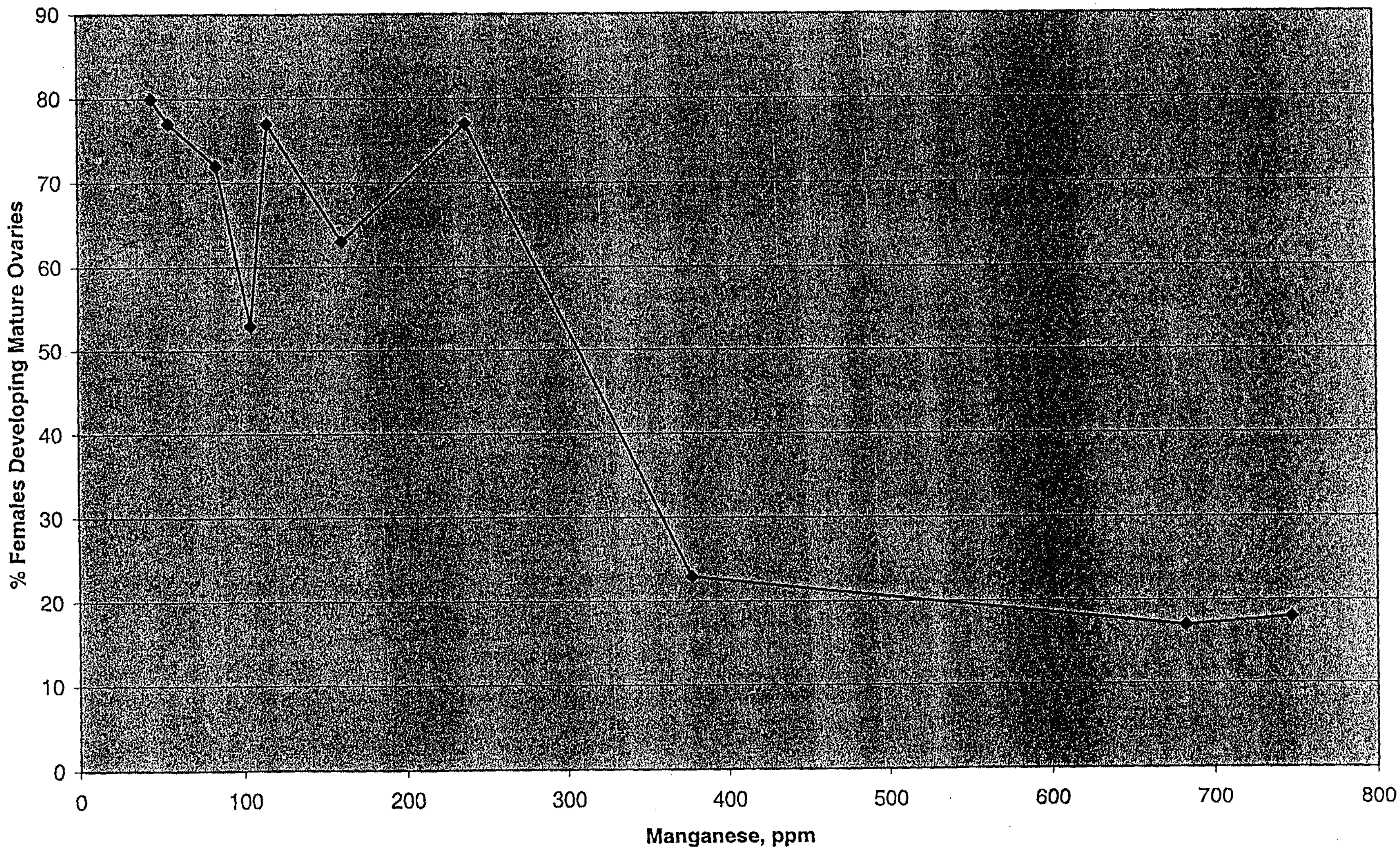


Figure 23. Manganese Concentrations vs. Percent Females Producing Embryos

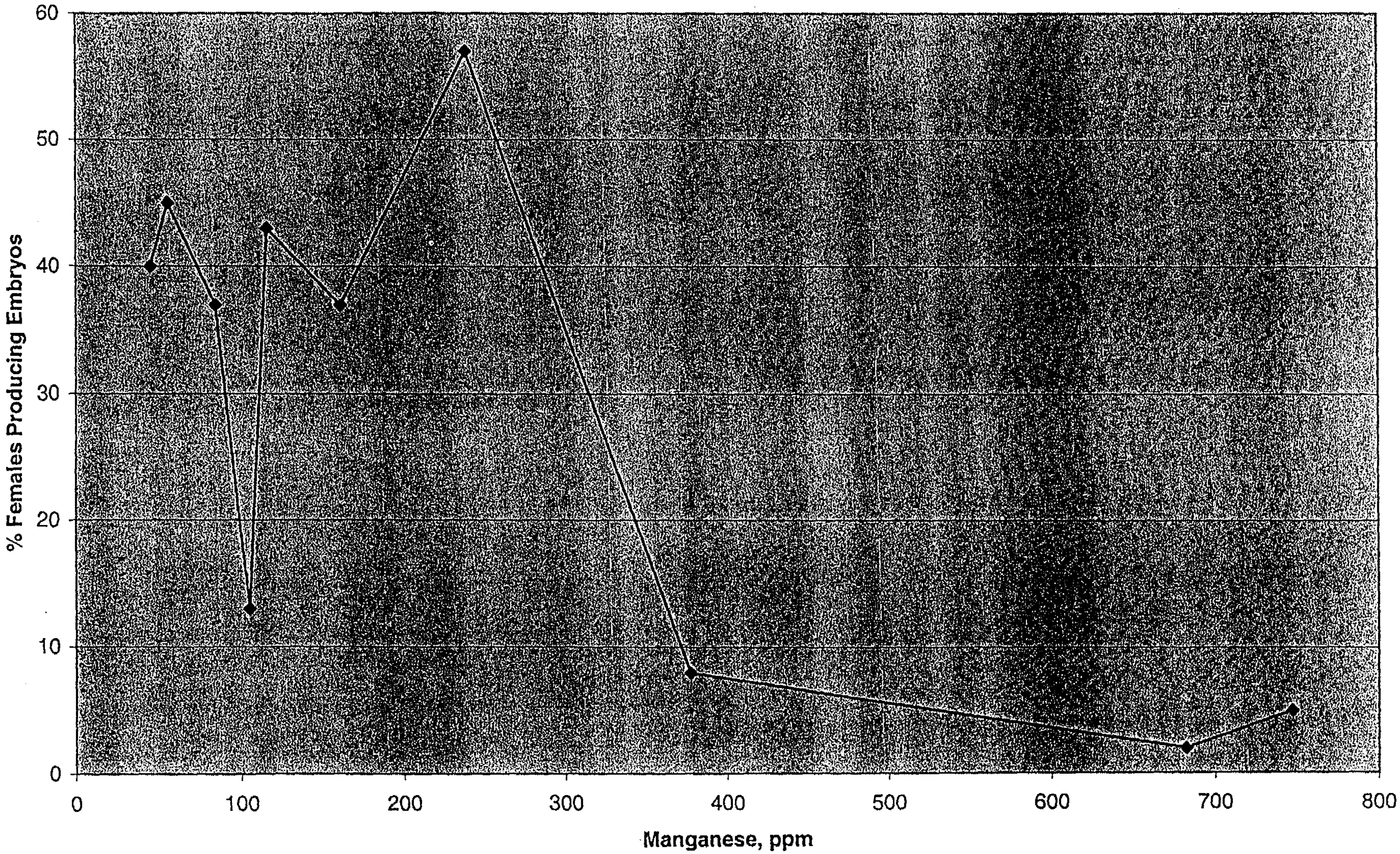


Figure 24. Manganese Concentrations vs. Percent Embryos Hatching

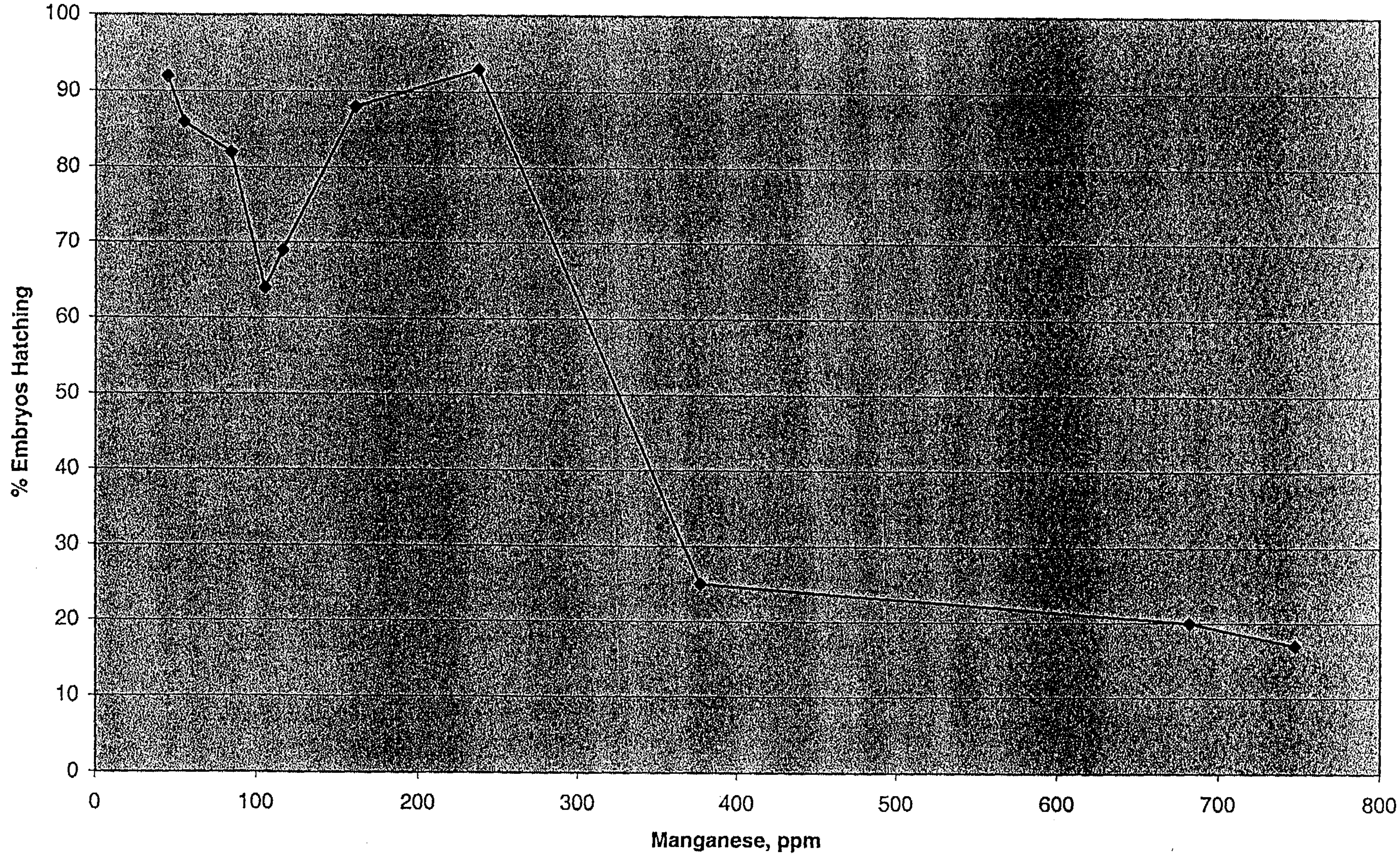
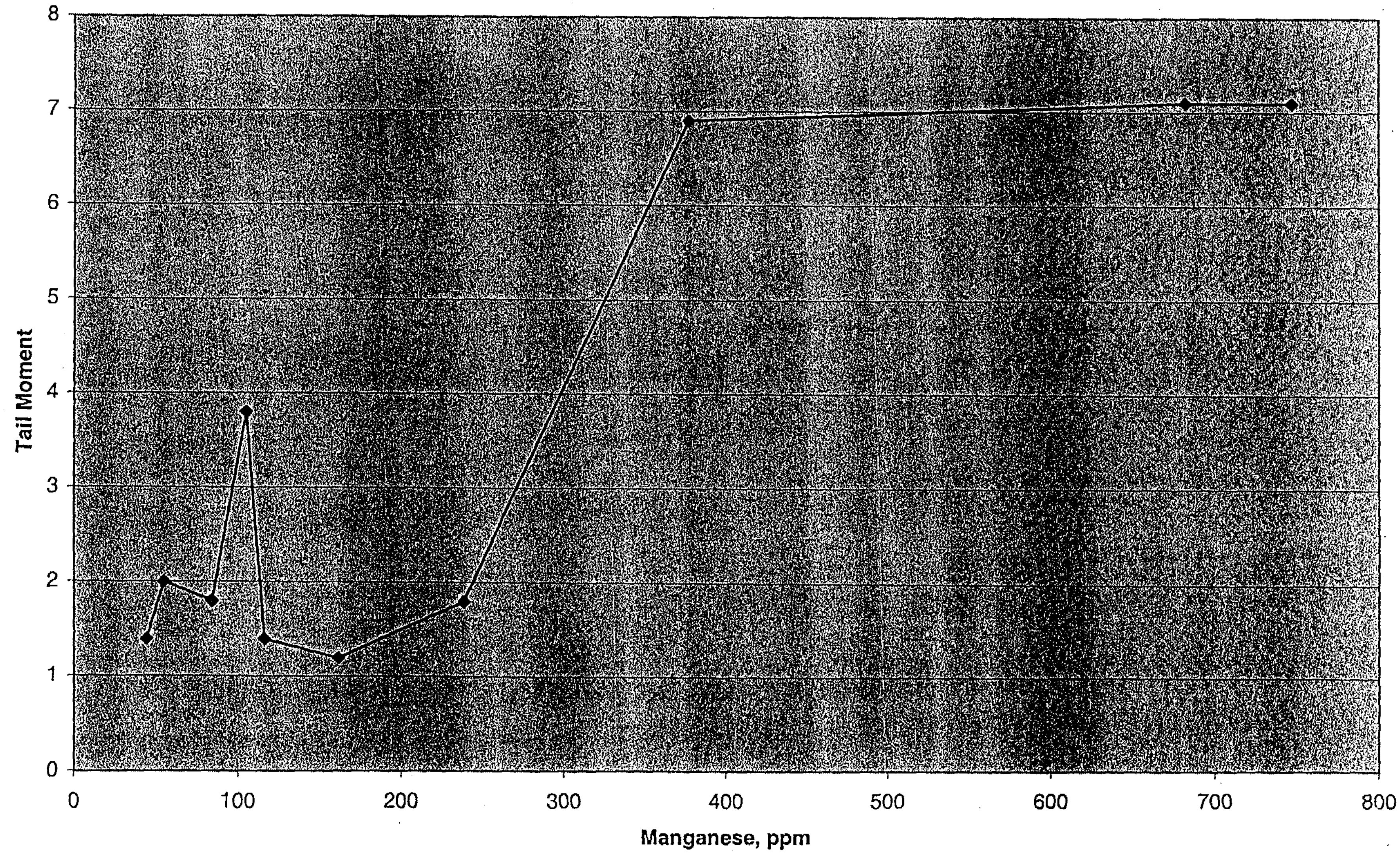


Figure 25. Manganese Concentrations vs. DNA Strand Damage in Embryos



Tabl orrelation Coefficients between Mercury Concentrations and Gra hrimp (*Palaemonetes pugio*) Toxicity Test Results

Station	Mercury	Mortality		Females Developing Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
Rathall Creek	0.016	20	*	77		57		93		1.8	
Foster Creek	0.062	12		80		40	*	92		1.4	
BL	0.062	12		72		37	*	82		1.8	
BU	0.087	12		77		45	*	86		2	
CL	0.12	15		77		43	*	69	*	1.4	
AL	0.12	23	*	23	*	8	*	25	*	6.9	*
AU	0.13	27	*	17	*	2	*	20	*	1.7	*
CM	0.17	32		53		13	*	64	*	3.8	*
AM	0.22	23		18	*	5	*	17	*	7.1	*
CU	0.3	23		63	*	37	*	88		1.2	
Lab		8		83		72		93		1	
R Squared		0.517187		-0.415680704		-0.442136784		-0.307666623		0.257903261	
* Results significantly different from reference test location (Skidaway River)											

Figure 26. Mercury Concentrations vs. Percent Mortality

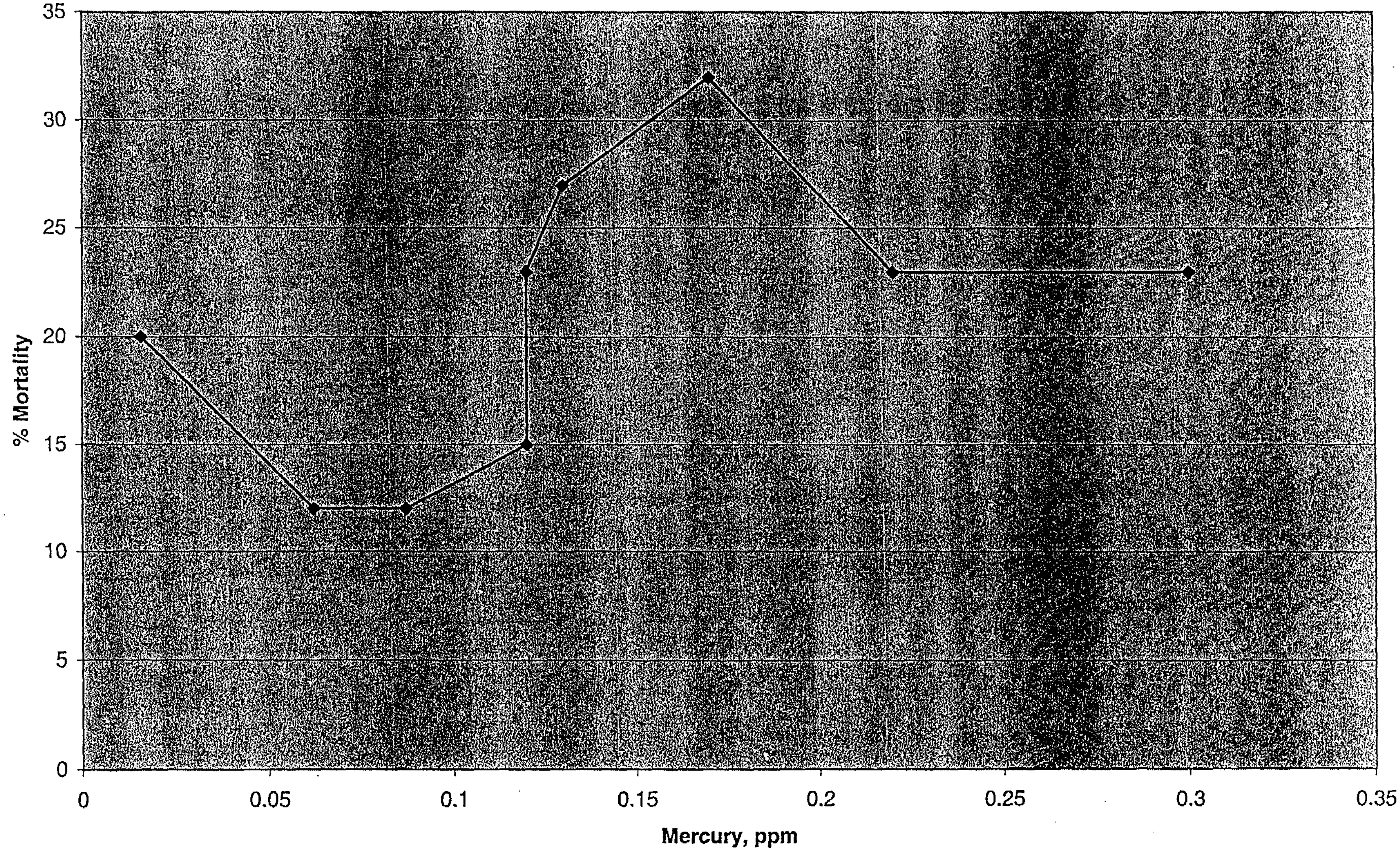


Figure 27. Percent Females Developing Mature Ovaries

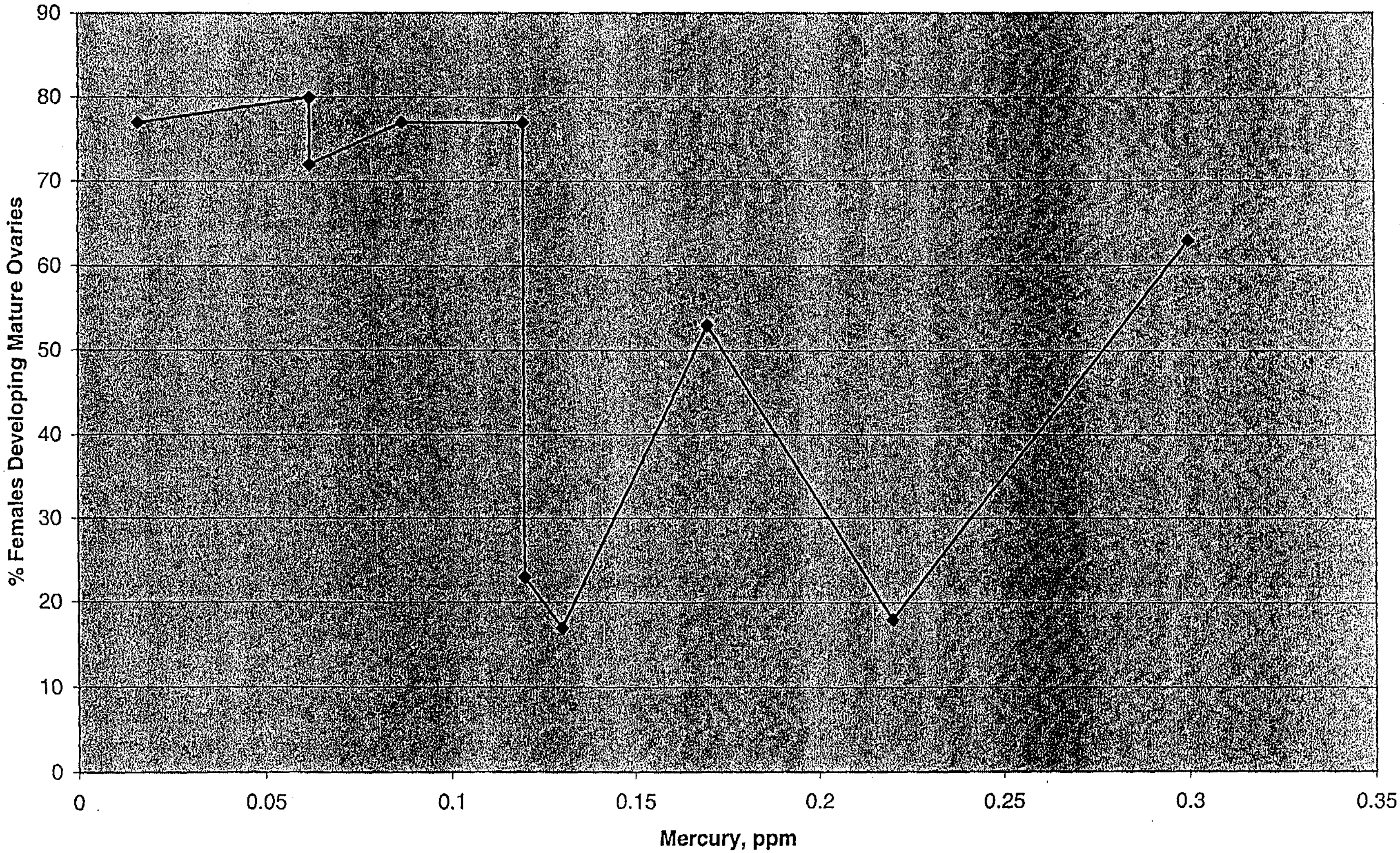


Figure 28. Percent Females Producing Embryos

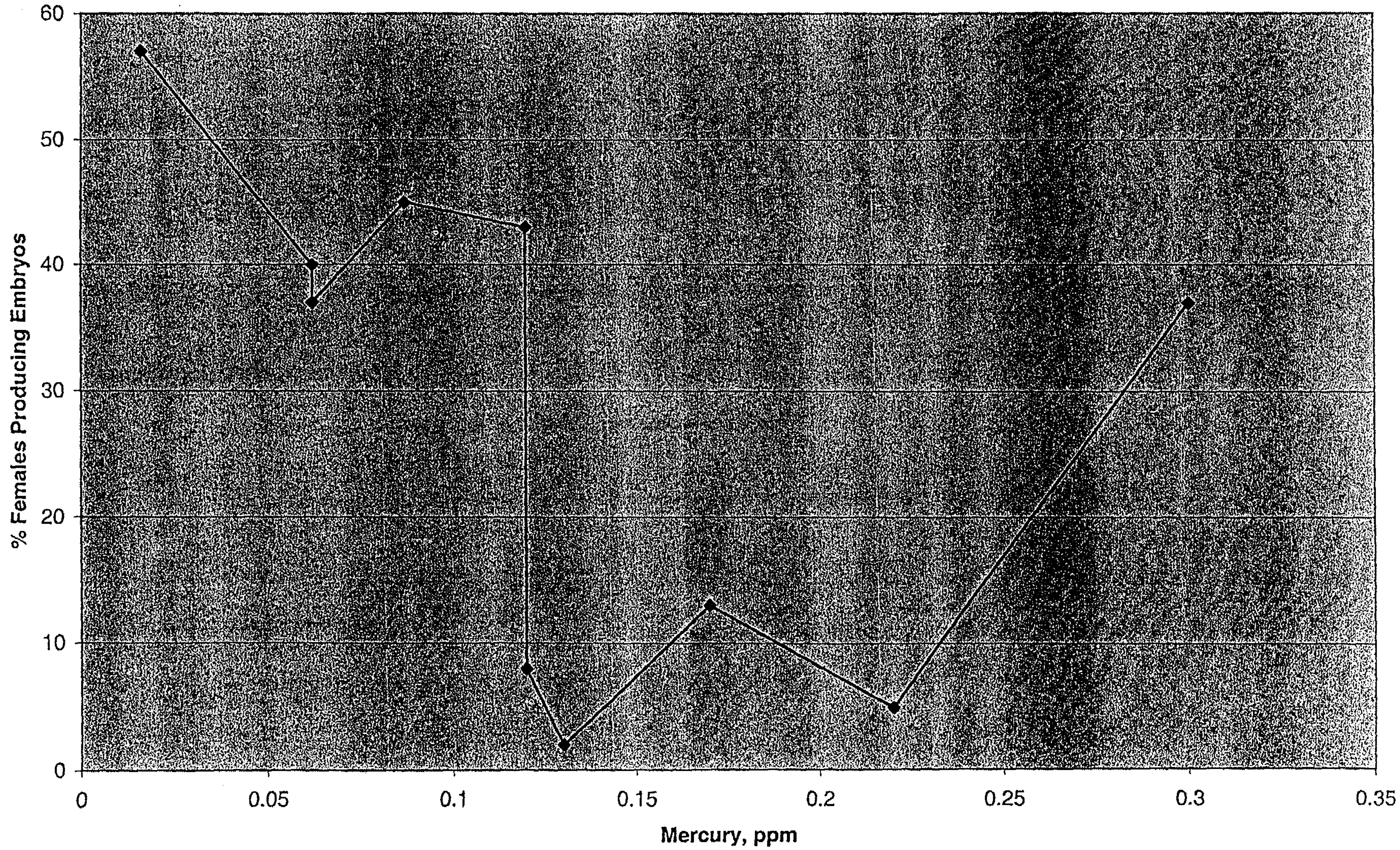


Figure 29. Percent Embryo Hatching

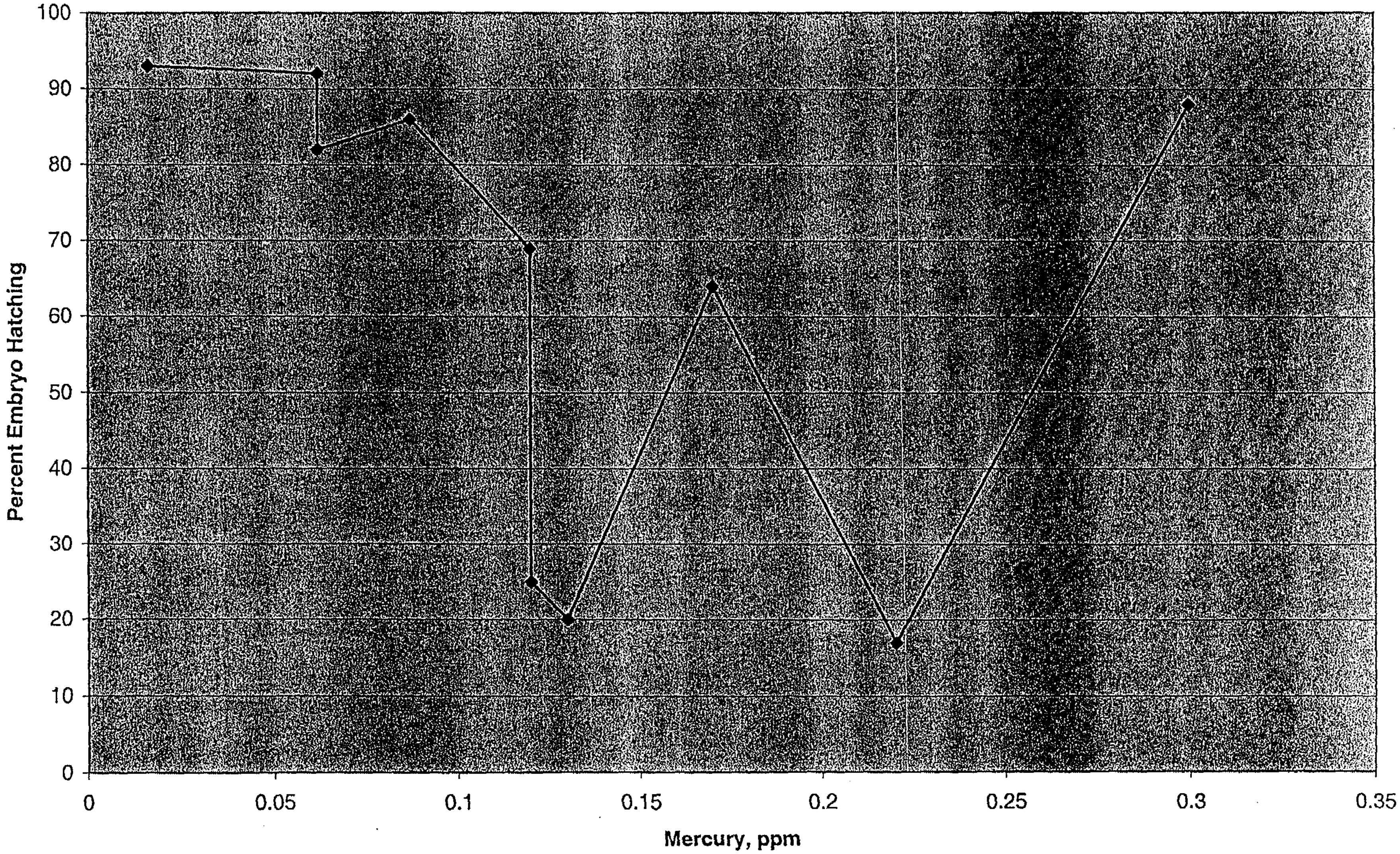


Figure 30. DNA Damage Tail Moment vs. Mercury Concentration

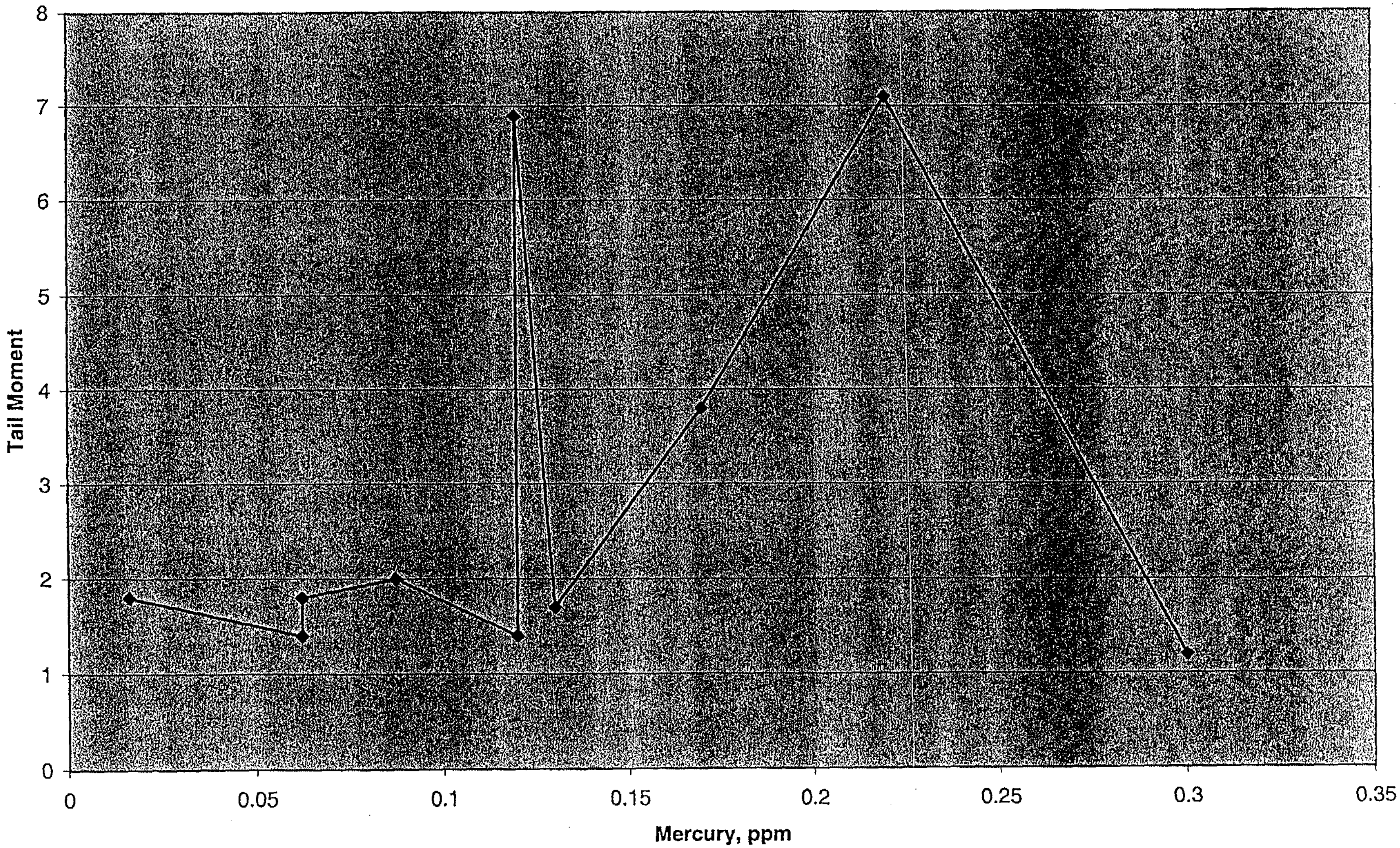


Table .rrelation Coefficients between Nickel Concentrations and Grass ..np (*Palaemonetes pugio*) Toxicity Test Results

Station	Nickel	Mortality		Females with Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
Foster Creek	3.4	12		80		40	*	92		1.4	
Rathall Creek	10.9	20	*	77		57		93		1.8	
BU	19.4	12		77		45	*	86		2	
BL	28.6	12		72		37	*	82		1.8	
CL	33	15		77		43	*	69	*	1.4	
CU	35.7	23		63	*	37	*	88		1.2	
CM	40.7	32	*	53		13	*	64	*	3.8	*
AL	373	23	*	23	*	8	*	25	*	6.9	*
AM	474	23		18	*	5	*	17	*	7.1	*
AU	606	27	*	17	*	2	*	20	*	7.1	*
Lab Control		8		83		72		93		1	
R Squared		0.484787		-0.946023556		-0.840405059		-0.943225997		0.940643319	
* Results significantly different from reference test location (Skidaway River)											

Table 31. Percent Mortality vs. Nickel Concentration

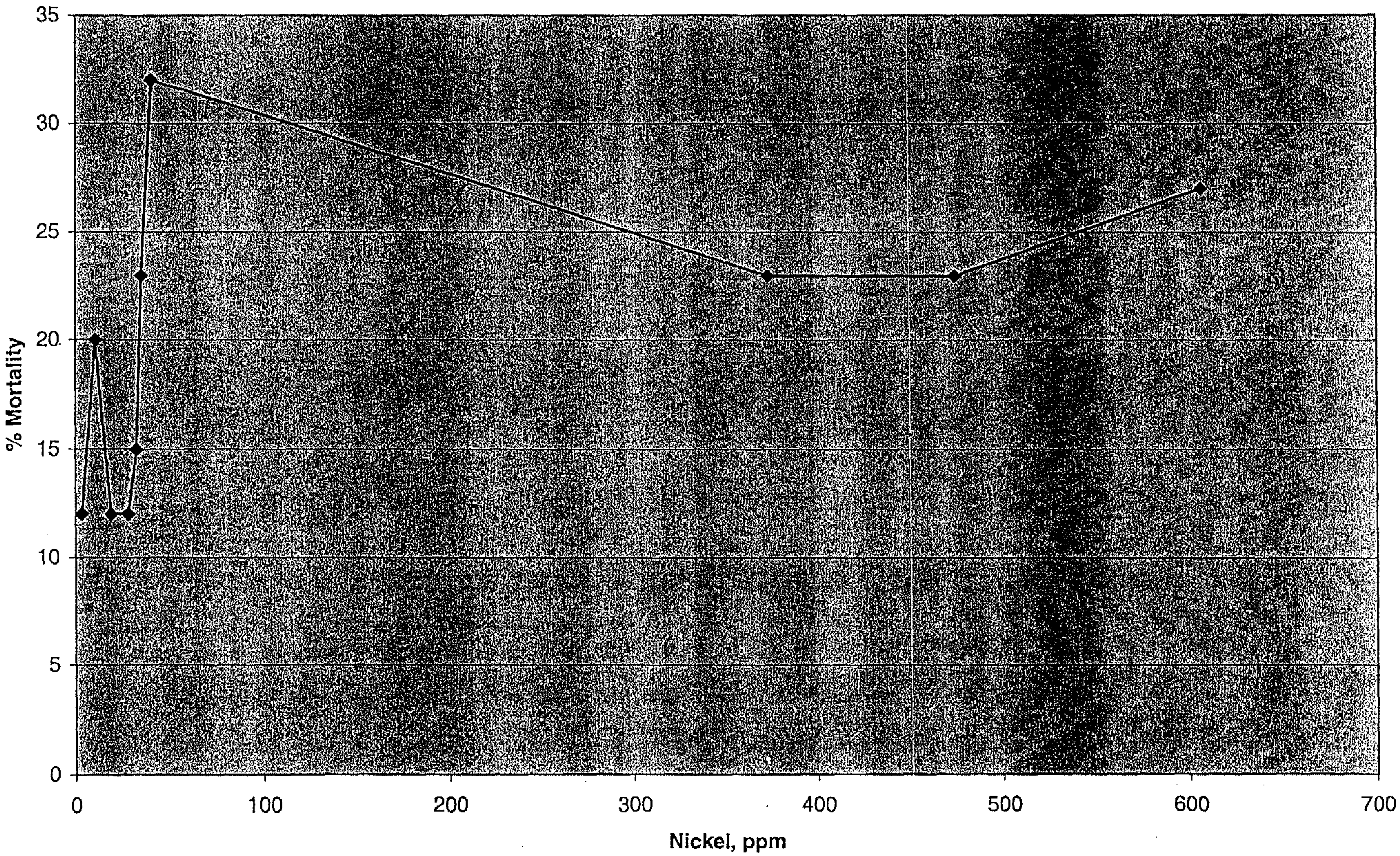


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Figure 32. Percent Females Developing Mature Ovaries

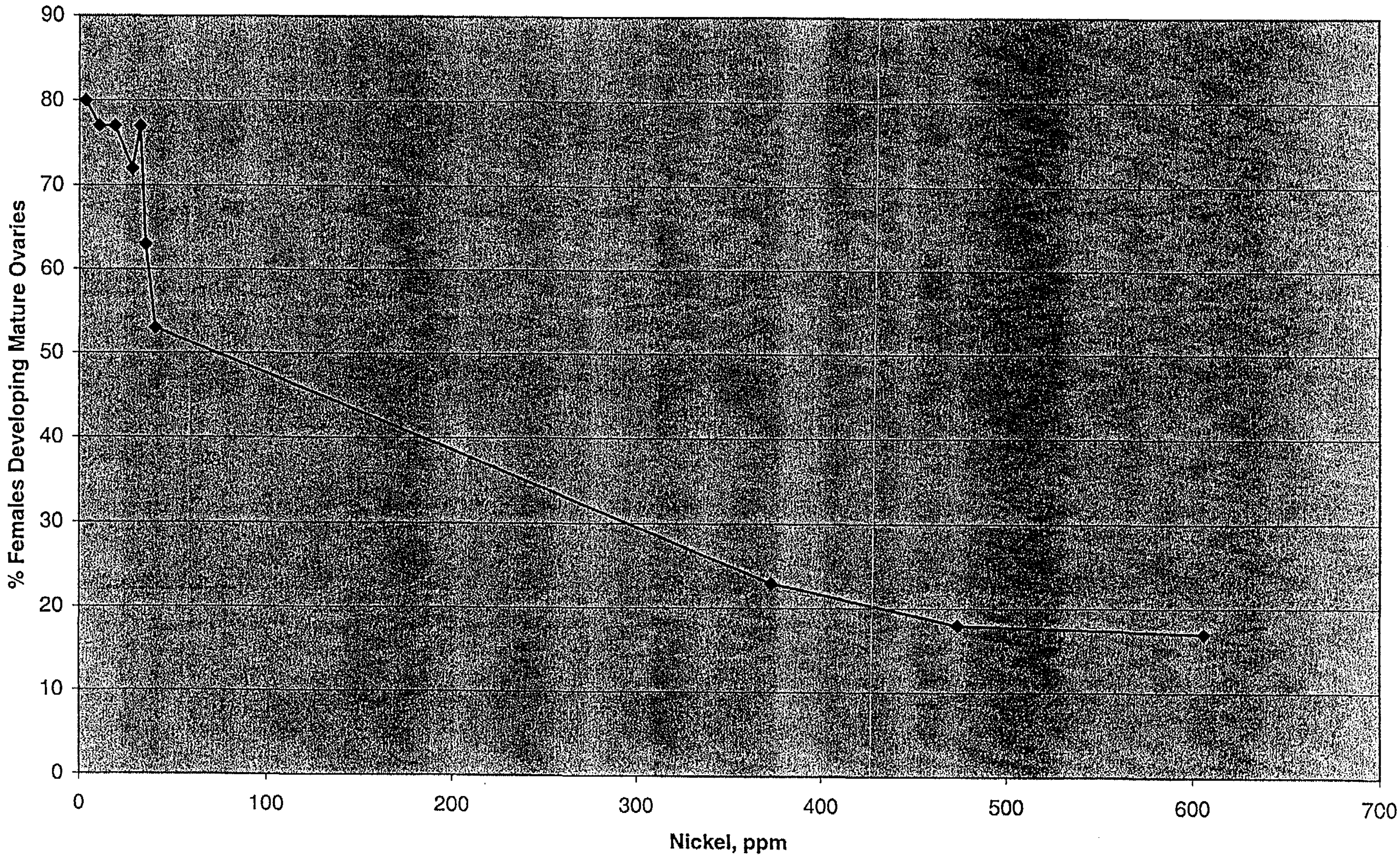

Figure 33. Percent Females Producing Embryos

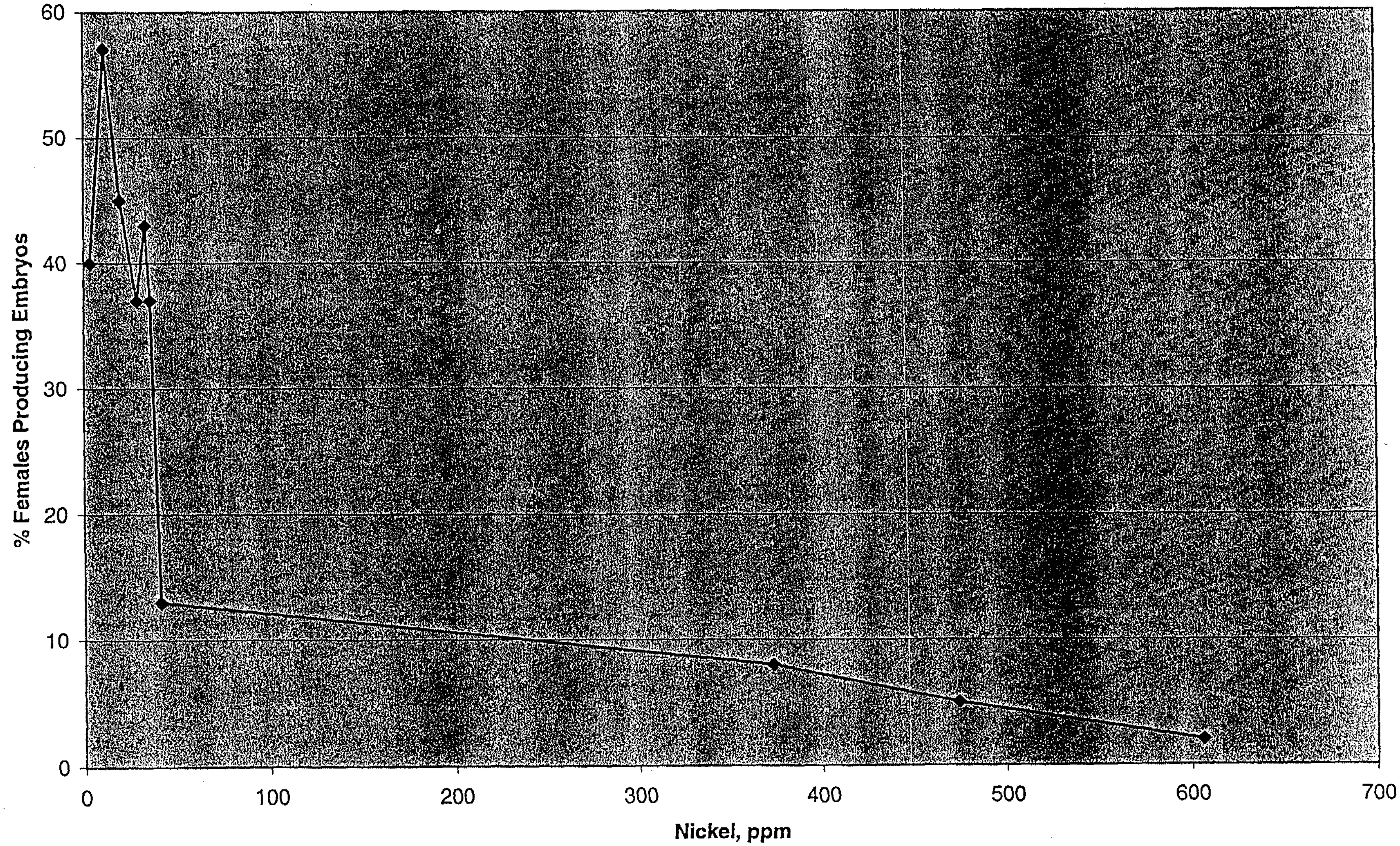

Figure 34. Percent Embryo Hatching vs. Nickel Concentrations

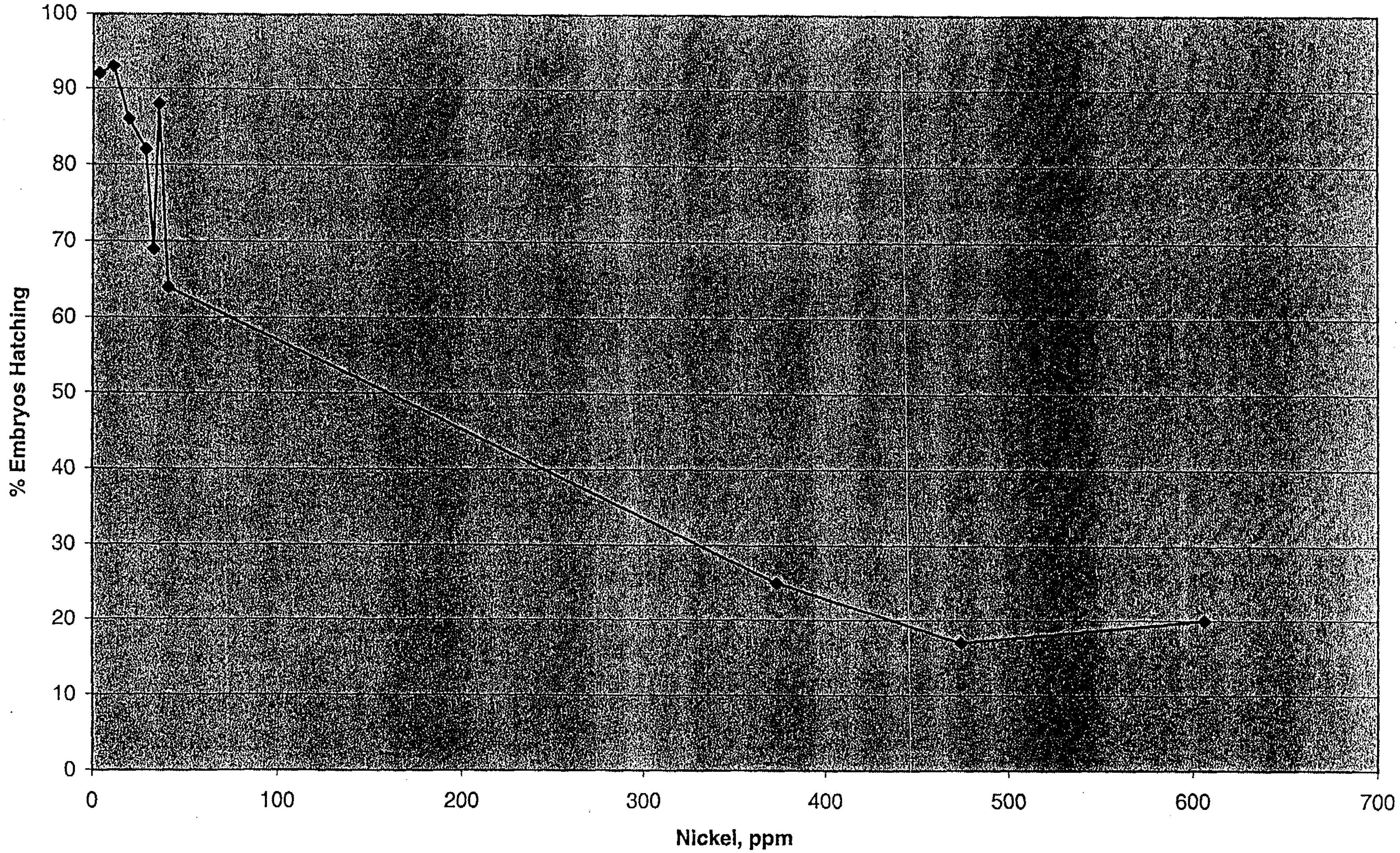

Figure 35. DNA Strand Damage in Embryos

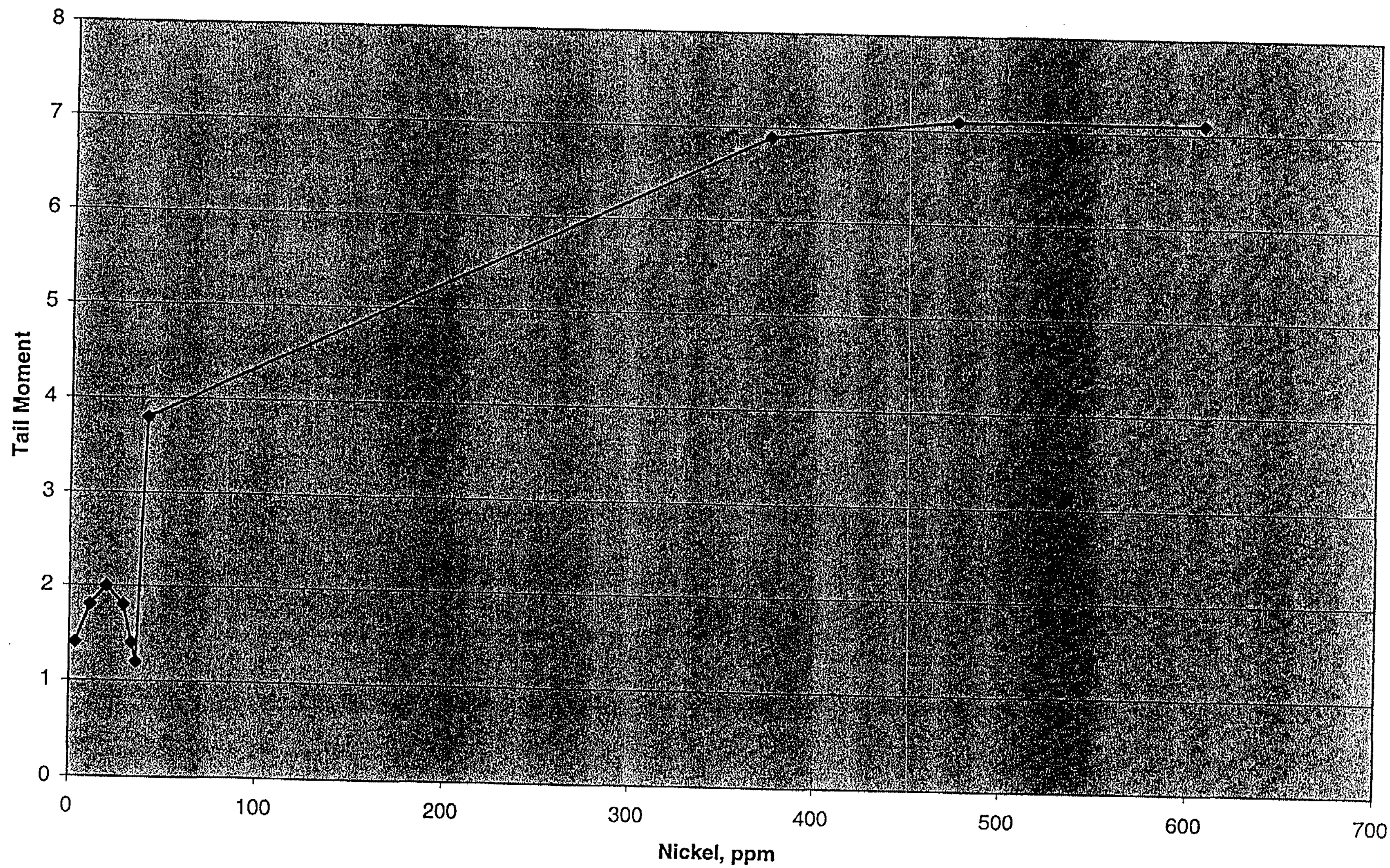

Table : orrelation Coefficients between Vanadium Concentrations and G. Shrimp (*Palaemonetes pugio*) Toxicity Test Results

Station	Vanadium	Mortality		Females with Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
Foster Creek	15.7	12		80		40	*	92		1.4	
BL	19.1	12		72		37	*	82		1.8	
BU	19.5	12		77		45	*	86		2	
CM	32.5	32	*	53		13	*	64	*	3.8	*
CL	34	15		77		43	*	69	*	1.4	
AL	38.8	23	*	23	*	8	*	25	*	6.9	*
AU	40.4	27	*	17	*	2	*	20	*	7.1	*
CU	49	23		63	*	37	*	88		1.2	
Rathall Creek	51.2	20	*	77		57		93		1.8	
AM	66.1	23		18	*	5	*	17	*	7.1	*
Lab Control		8		83		72		93		1	
		0.770265		-0.55953512		-0.338953612		-0.491943806		0.477616912	

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Figure 36. Vanadium Concentratoins vs. Percent Mortality

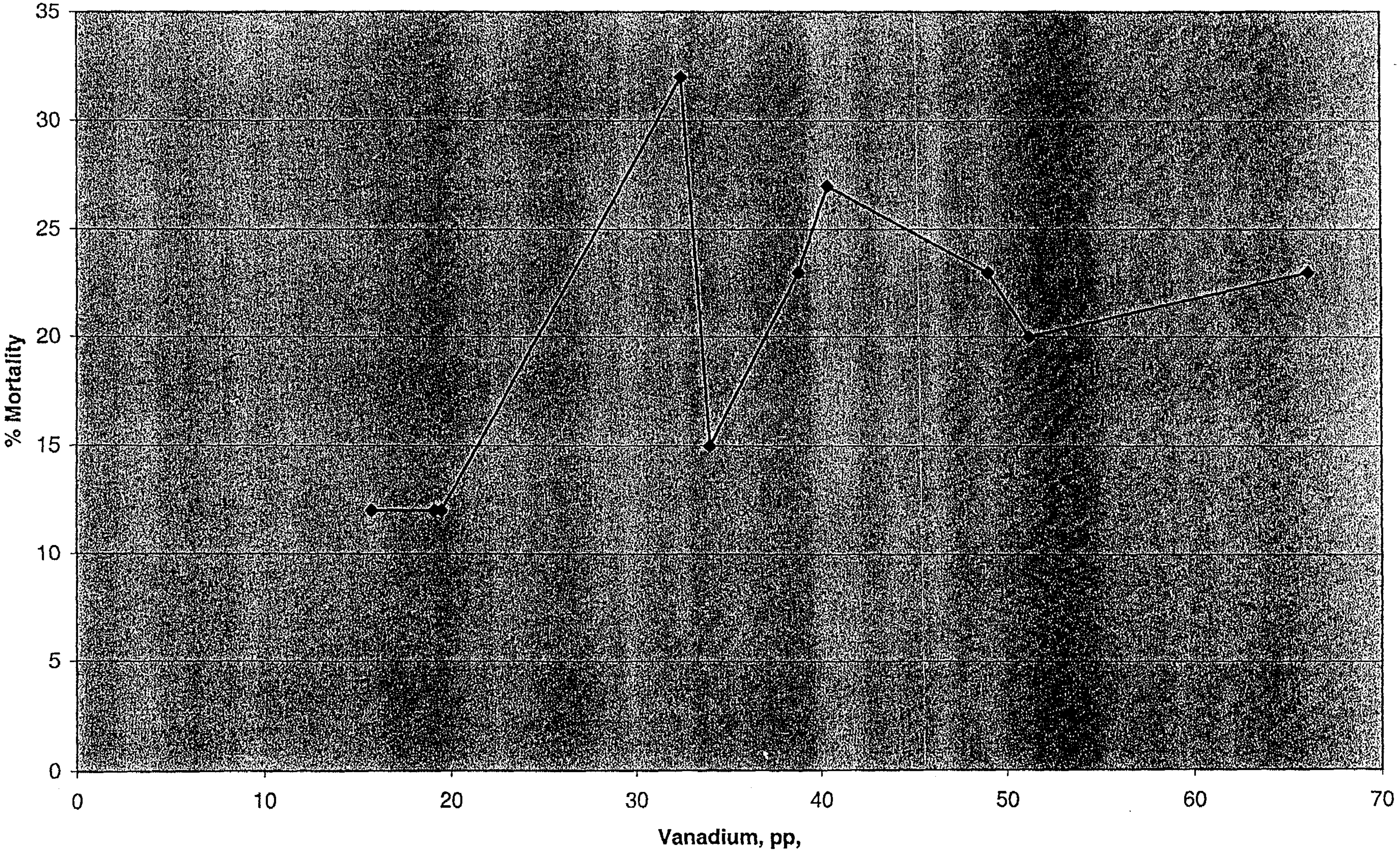

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Figure 37. Females with Mature Ovaries

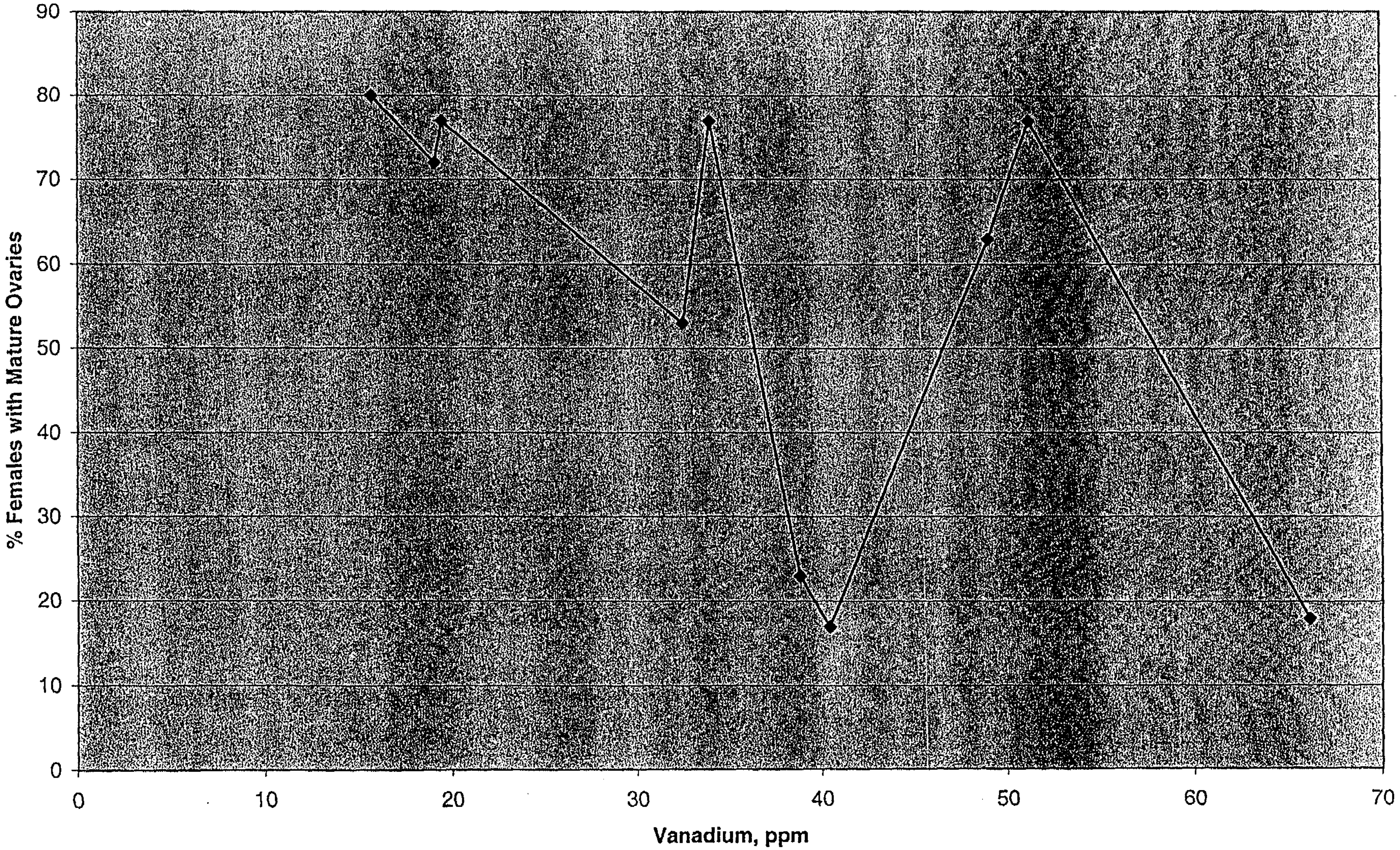

Figure 38. Females Producing Embryos

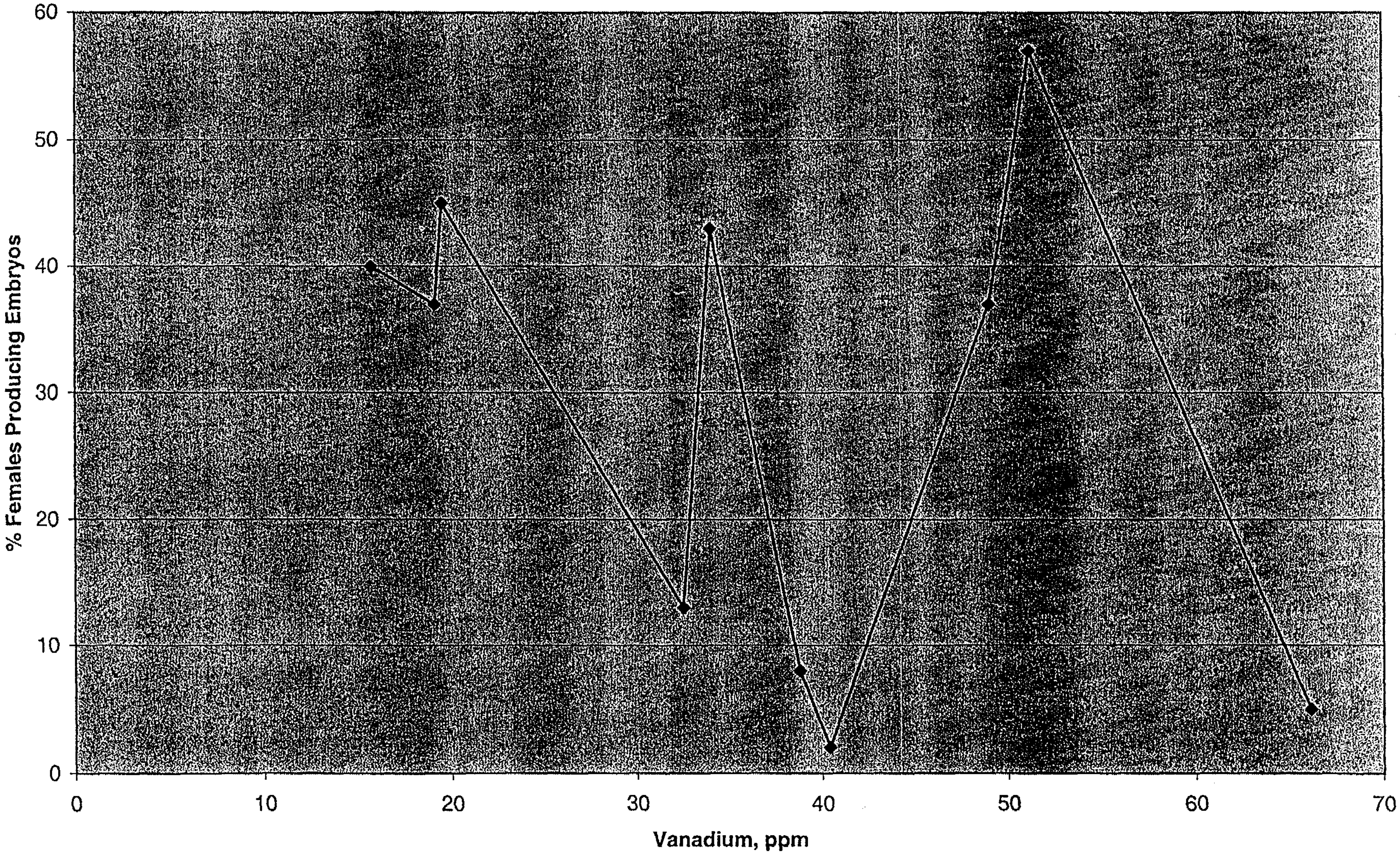

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Figure 39. Percent Embryos Hatching vs. Vanadium Concentrations

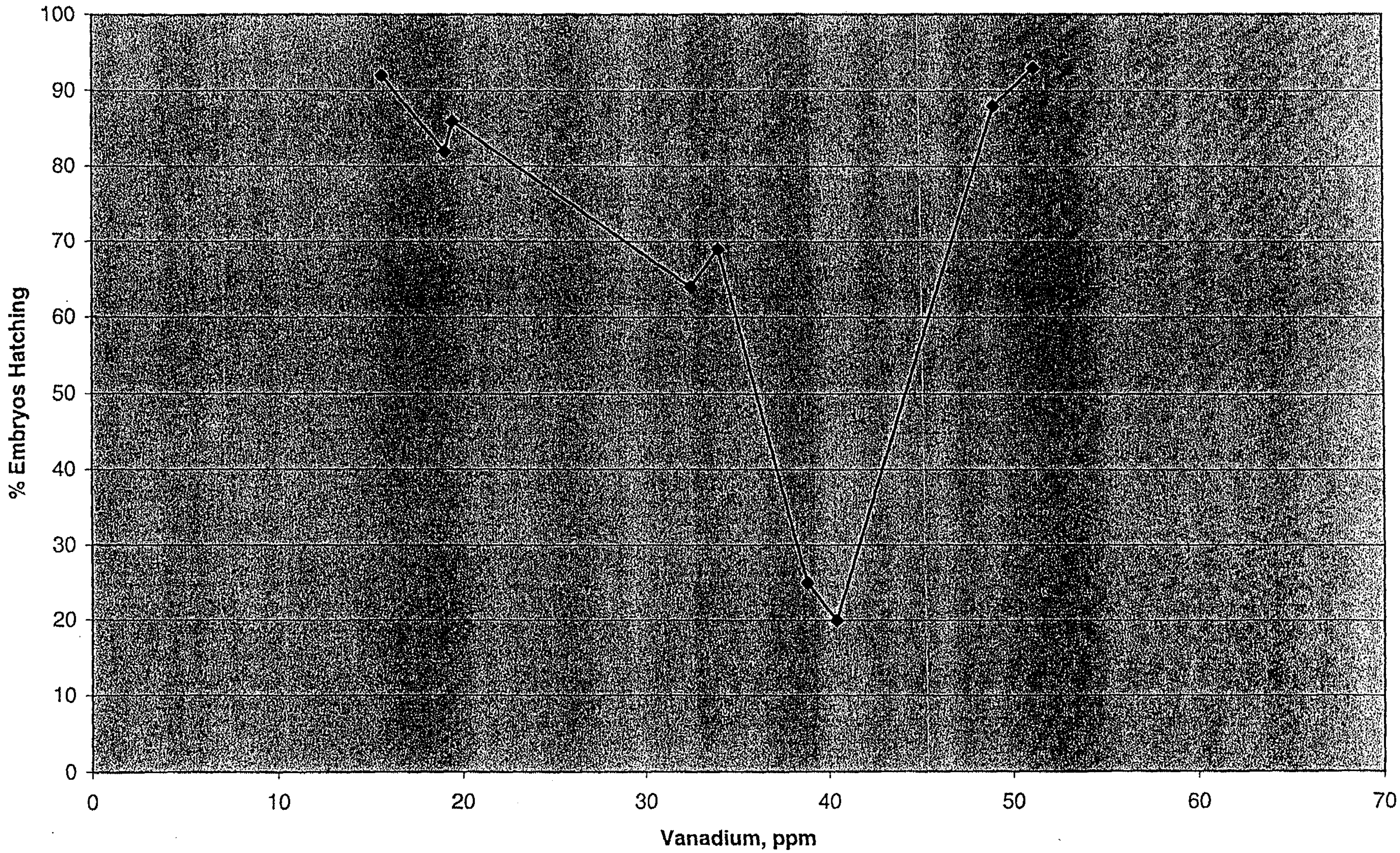

Figure 40. DNA Strand Damage vs. Vanadium Concentrations

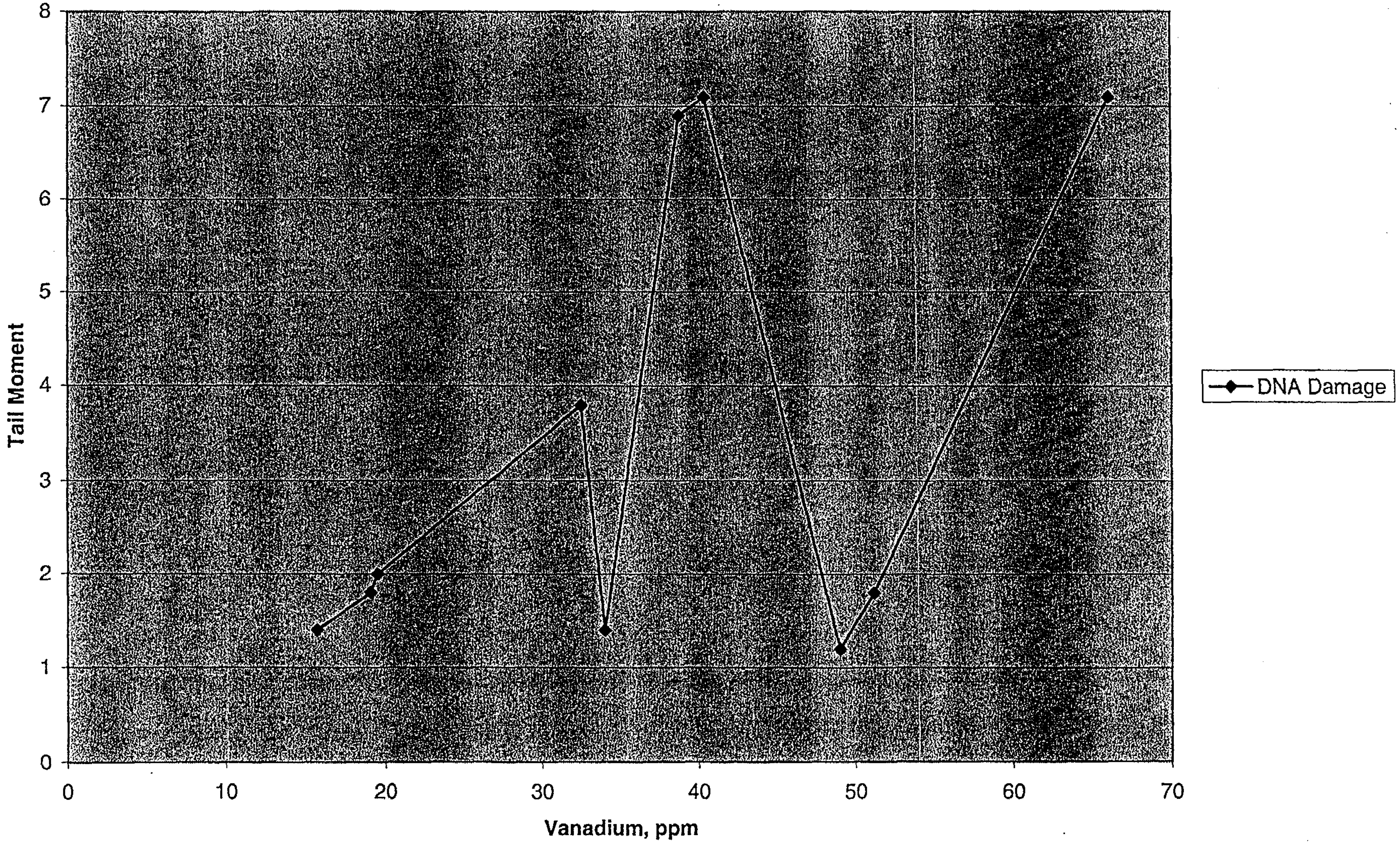

Table 1. …rrelation Coefficients between Zinc Concentrations and Grass Sh… (*Palaemonetes pugio*) Toxicity Test Results

Station	Zinc	Mortality		Females with Mature Ovaries		Females Producing Embryos		Embryos Hatching		DNA Damage	
	ppm	%		%		%		%		Tail Moment	
Foster Creek	22.7	12		80		40	*	92		1.4	
BU	55.9	12		77		45	*	86		2	
Rathall Creek	60.5	20	*	77		57		93		1.8	
BL	98.4	12		72		37	*	82		1.8	
CL	132	15		77		43	*	69	*	1.4	
CM	163	32	*	53		13	*	64	*	3.8	*
CU	227	23		63	*	37	*	88		1.2	
AL	847	23	*	23	*	8	*	25	*	6.9	*
AU	1330	27	*	17	*	2	*	20	*	7.1	*
AM	1640	23		18	*	5	*	17	*	7.1	*
Lab Control		8		83		72		93		1	
R Squared		0.476223		-0.935409305		-0.824512137		-0.931740535		0.916100235	

Table 1. COPC Protective Ranges

COPC	Mortality Test	Reproduction Test	Embryo Production Test	Embryo Hatching Test	DNA Damge Test	Final Protective Range
	ppm	ppm	ppm	ppm	ppm	ppm
Cadmium	No protective ranges derived for this contaminant					
Chromium	219 - 258	219 - 258	258 -317	258 - 317	219 - 258	219-258
Hexavalent Chromium	No protective ranges derived for this contaminant					ND
Copper	ND	28.4 - 28.5	ND	ND	ND	28.4 - 28.5
Lead	ND	77.5 - 147	77.5 - 147	77.5 - 147	77.5 - 147	77.5 - 147
Manganese	ND	238 - 377	ND	238 - 377	238 - 377	238 - 377
Mercury	No protective ranges derived for this contaminant					ND
Nickel	33 - 35.7	33 -35.7	35.7 - 40.7	35.7 - 40.7	35.7 - 40.7	35.7 - 40.7
Selanium	No protective ranges derived for this contaminant					ND
Vanadium	No protective ranges derived for this contaminant					ND
Zinc	132 - 163	132 - 163	227 - 847	227 - 847	227 - 847	132 - 163
	ND - Not Derived					

Figure 41. Percent Mortality vs. Zinc Mortality

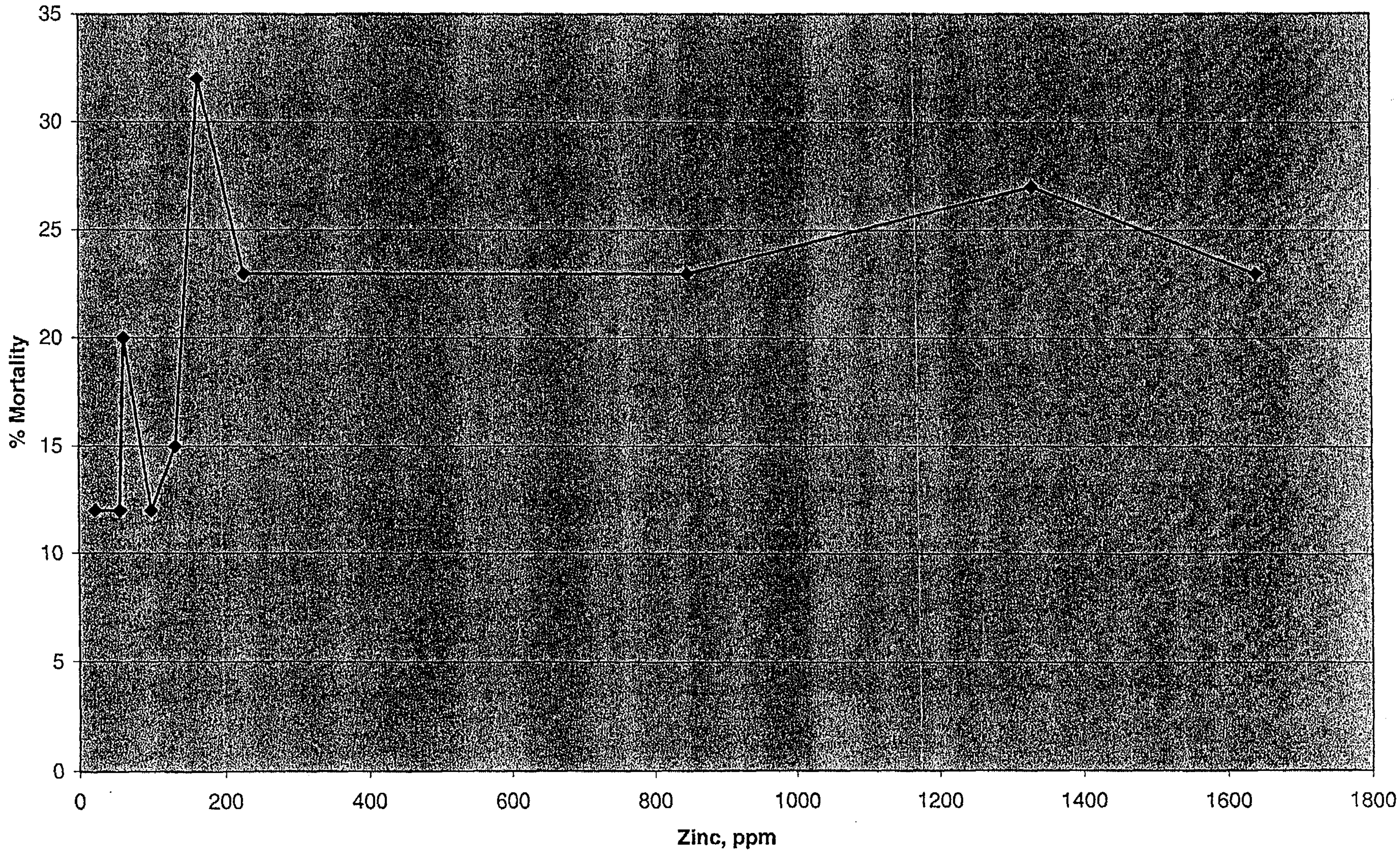

Figure 42. Percent Females Developing Mature Ovaries vs. Zinc Concentrations

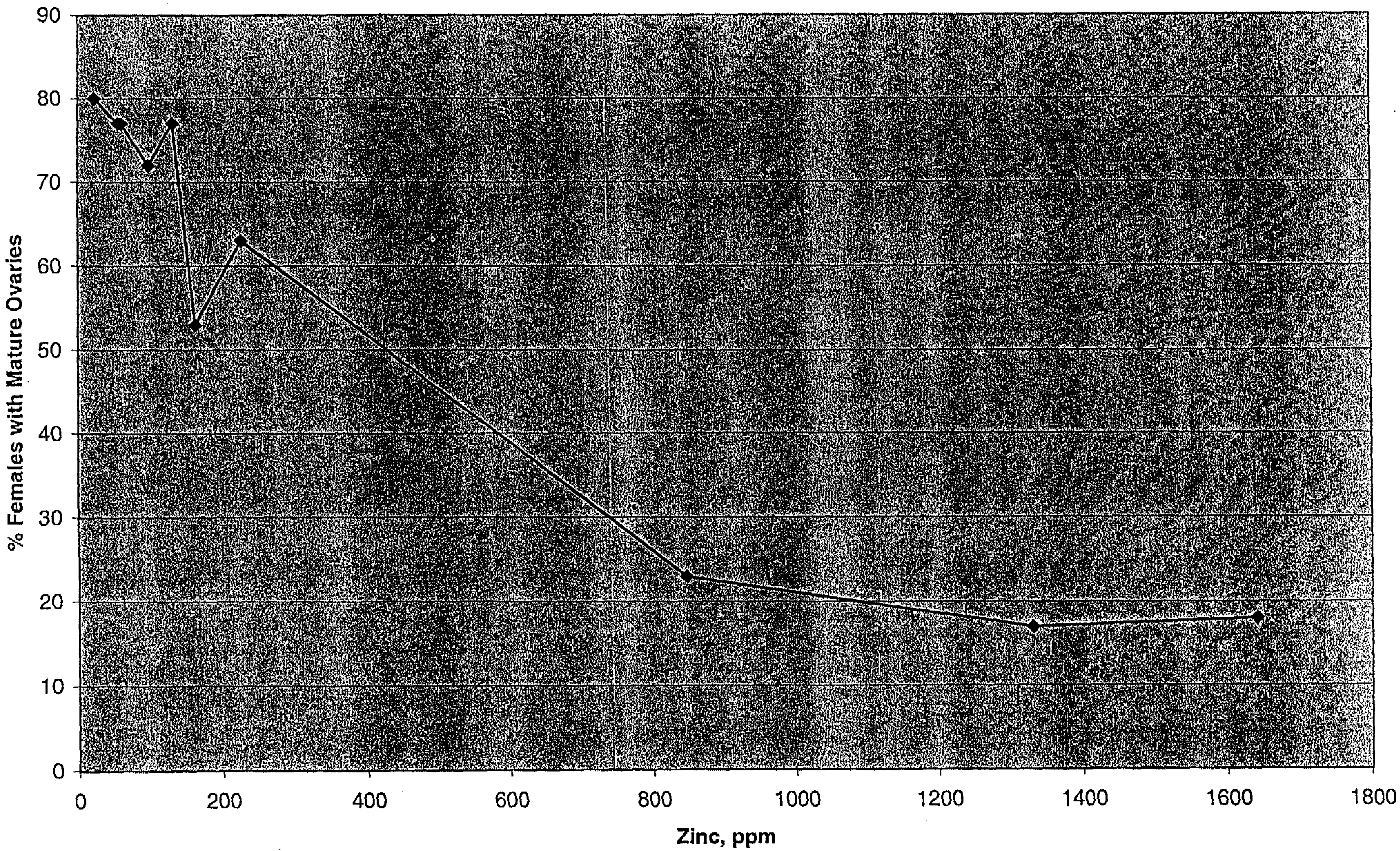

Figure 43. Percent Females Producing Embryos vs. Zinc Concentration

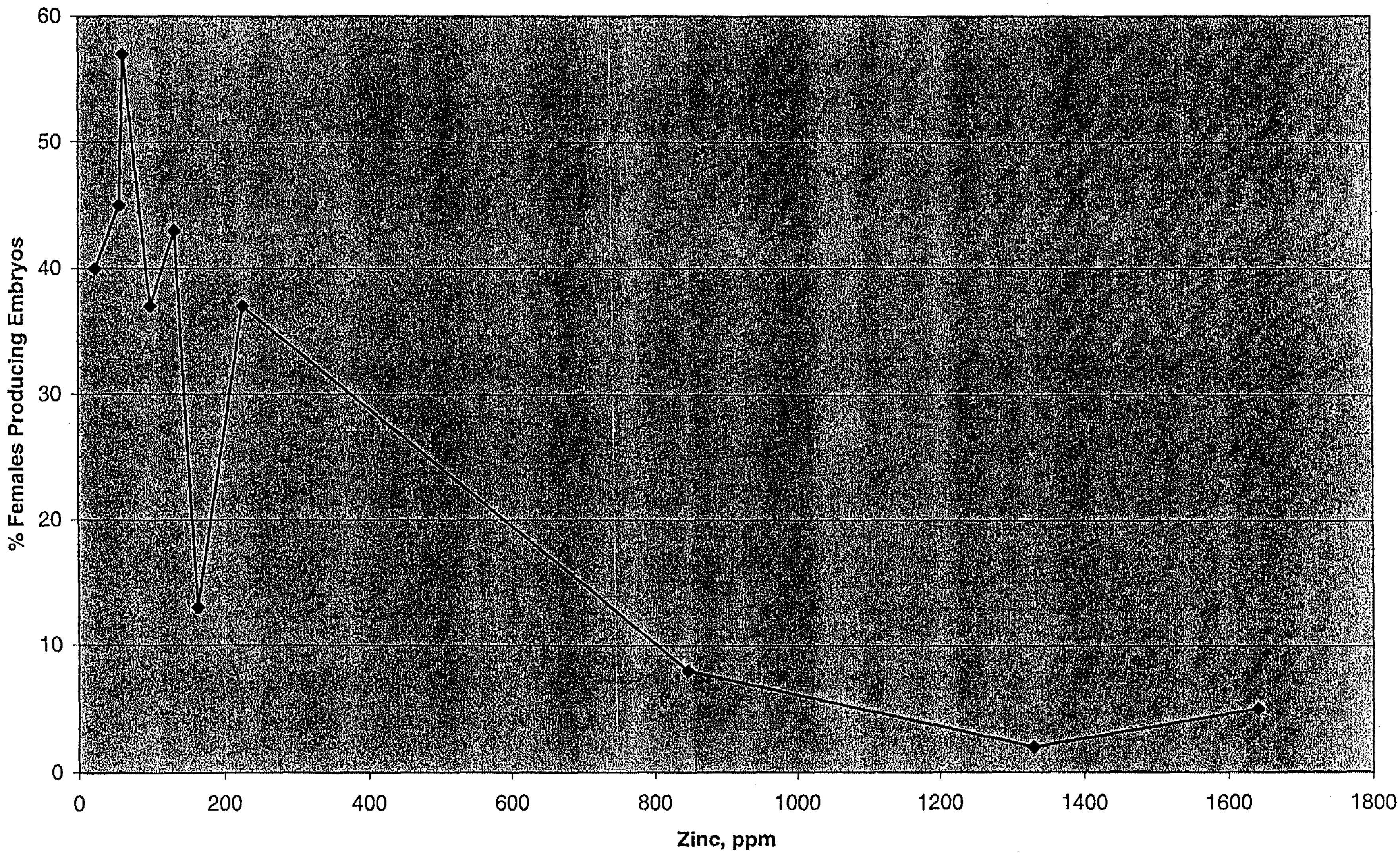

Figure 44. Percent Embryos Hatching vs. Zinc Concentration

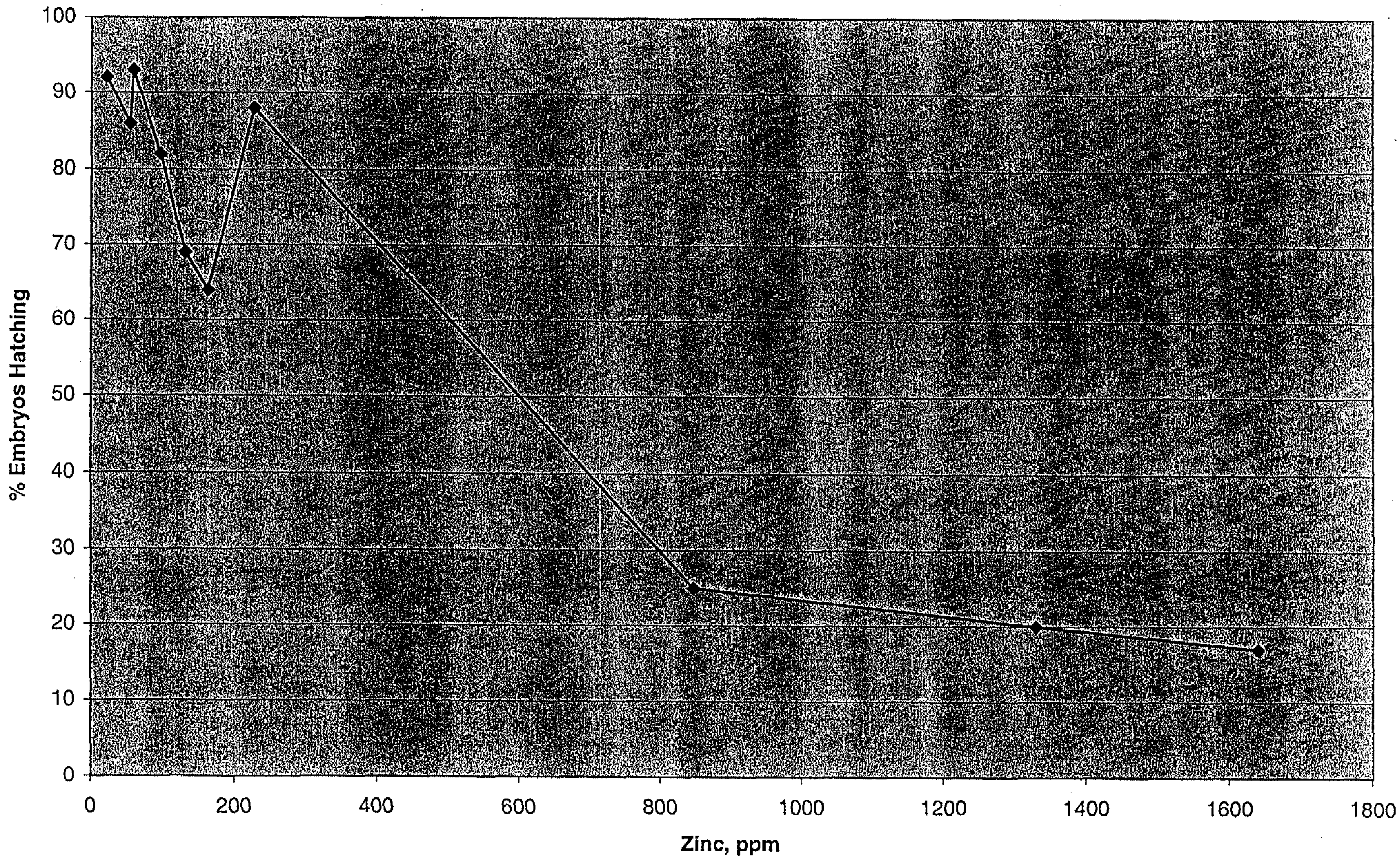

Figure 45. DNA Strand Damage in Embryos vs. Zinc Concnetration

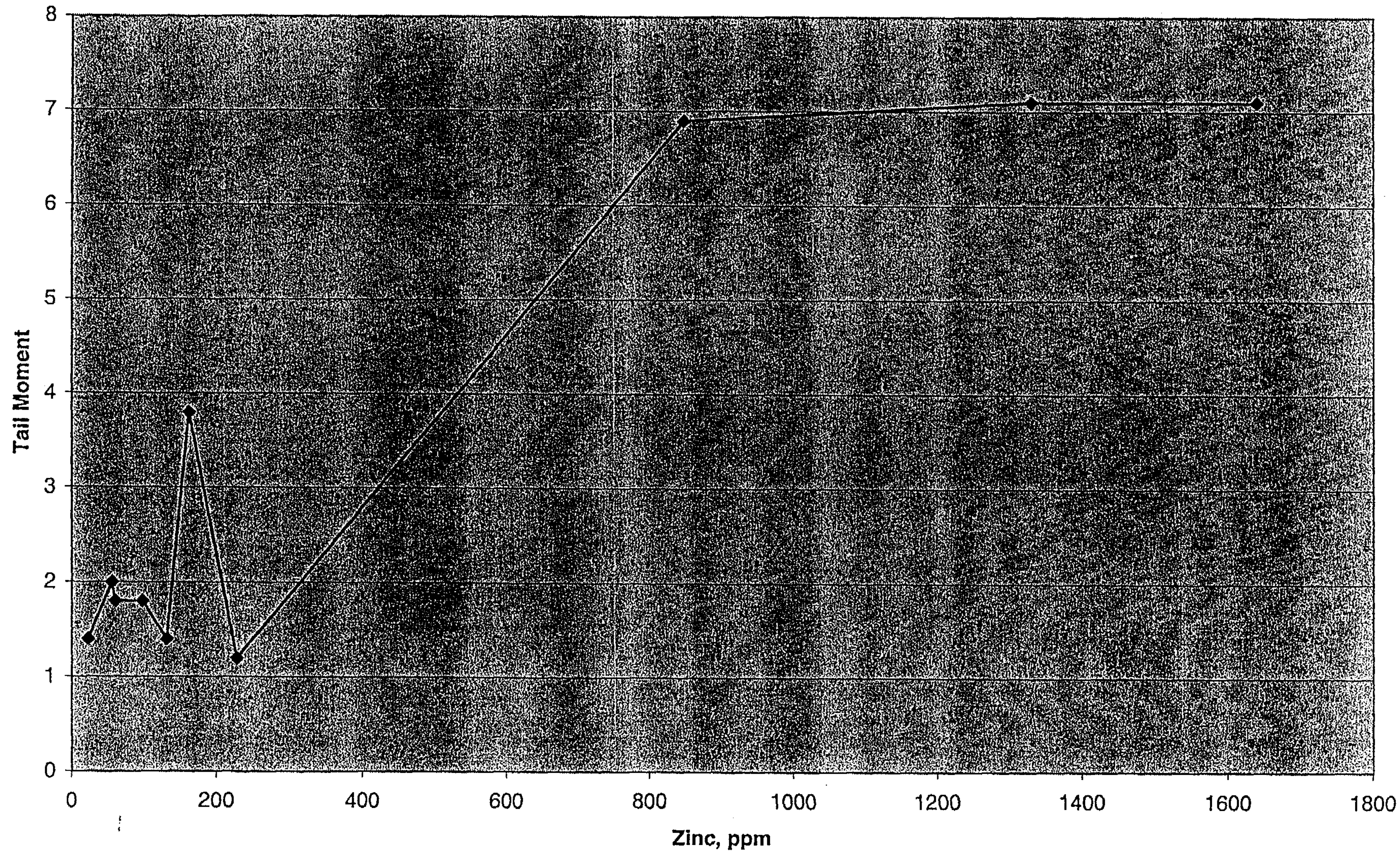

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Table 12. COPC Protective Ranges

COPC	Mortality Test	Reproduction Test	Embryo Production Test	Embryo Hatching Test	DNA Damge Test	Final Protective Range
	ppm	ppm	ppm	ppm	ppm	ppm
Cadmium	No protective ranges derived for this contaminant					
Chromium	219 - 258	219 - 258	258 -317	258 - 317	219 - 258	219-258
Hexavalent Chromium	No protective ranges derived for this contaminant					ND
Copper	ND	28.4 - 28.5	ND	ND	ND	28.4 - 28.5
Lead	ND	77.5 - 147	77.5 - 147	77.5 - 147	77.5 - 147	77.5 - 147
Manganese	ND	238 - 377	ND	238 - 377	238 - 377	238 - 377
Mercury	No protective ranges derived for this contaminant					ND
Nickel	33 - 35.7	33 -35.7	35.7 - 40.7	35.7 - 40.7	35.7 - 40.7	33 - 35.7
Selanium	No protective ranges derived for this contaminant					ND
Vanadium	No protective ranges derived for this contaminant					ND
Zinc	132 - 163	132 - 163	227 - 847	227 - 847	227 - 847	132 - 163
	ND - Not Derived					

Table 13. COPC Protective Ranges Compared to Reference Protective Levels and Reference Locations

COPC	Protective Range	TEL	ER-L	PEL	ER-M	Rathall Creek	Foster Creek
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
Chromium	219 - 258	52.3	81	160	370	40	13
Copper	28.4 - 28.5	18.7	34	108	270	18	6
Lead	77.5 - 147	30.2	47	112	218	20	8
Manganese	238 - 377	NA	NA	NA	NA	238	45
Nickel	33 - 35.7	15.9	21	42.8	52	11	3
Zinc	132 - 163	124	150	271	410	60	23

B

Appendix B

SCDHEC Concurrence Letter

D H E C

PROMOTE PROTECT PROSPER

2600 Bull Street
Columbia, SC 29201-1708

Waste

5 9 310

U.S. EPA REGION 4
OFFICE OF
REGIONAL ADMINISTRATOR

2002 SEP -9 A 11: 19

August 19, 2002

Jimmy Palmer
Regional Administrator
U.S. EPA, Region IV
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, Georgia 30303

Re : Macalloy Superfund Site
Charleston, South Carolina
Final Record of Decision

Dear Mr. Palmer :

The Department has reviewed and concurs with all parts of the Record of Decision (ROD) dated August 2002 for the Macalloy Superfund Site located in Charleston, South Carolina. In concurring with this ROD, the South Carolina Department of Health and Environmental Control (SCDHEC) does not waive any right or authority it may have under federal or state law. SCDHEC reserves any right or authority it may have to require corrective action in accordance with the South Carolina Pollution Control Act. These rights include, but are not limited to, the right to insure that all necessary permits are obtained, all clean-up goals and remedial criteria are met, and to take separate action in the event clean-up goals and remedial criteria are not met. Nothing in the concurrence shall preclude SCDHEC from exercising any additional administrative, legal and equitable remedies available to require additional response actions in the event that : (1)(a) previously unknown or undetected conditions arise at the site or (b) SCDHEC receives information not previously available concerning the premises upon which SCDHEC relied in concurring with the selected alternative; and (2) the implementation of the remedial alternative selected in the ROD is no longer protective human health or the environment.

The Department concurs with the selected alternative of *Onsite Chemical Reduction with Stabilization/Solidification* for soil remediation as described in the ROD. It is the Department's understanding that a series of pilot tests will be performed on site soils to determine the most effective method of delivering the reductive agent and stabilizing the soils. Furthermore, should the pilot testing not produce an acceptable method of treatment, *Excavation and Off-site Disposal* of the soils will be re-examined as a potential remedy.

The Department concurs with the selected alternative of *Enhanced In Situ Reduction* for groundwater as described in the ROD. According to the ROD, a chemical reductant will be utilized in the remediation. The final selection of the reductant as well as the method of delivery into the water table will be based on upcoming pilot testing.

The Department concurs with the selected remedy for storm water, *Comprehensive Storm Water and Sediment Management Plan*, with one exception. Per South Carolina Regulation 61-69, Shipyard Creek is classified as a Class SB (saltwater body) since it is a tributary to the Cooper River. Therefore, applying the standards of SC Regulation 61-68.G.13 would alter the proposed Cleanup Levels for Storm Water found in Table 12-1 of the ROD. Instead of establishing new limits at this time, the Department would prefer to see the current outfall limits found in NPDES Permit SC0004014 remain in effect until new limits can be calculated by the Department using stream dilution factors currently being developed by the USEPA. It is our understanding that the dilution factors and corresponding permit limits will be established prior to remedy construction beginning at the site.

Finally, the Department concurs with selected alternatives for radiological material, *Excavation and Off-site Disposal*; and sediments, *Removal and Upland Disposal*. It is the Department's understanding that details of these selections will be finalized during the Remedial Design, but are unlikely to change from the description in the ROD.

If you should have any questions regarding the Department's concurrence with the ROD, please contact Scott Wilson at (803) 896-4077.

Sincerely,

R. Lewis Shaw

R. Lewis Shaw
Deputy Commissioner
Environmental Quality Control

cc : Hartsill Truesdale, BLWM
Keith Lindler, BLWM
Richard Haynes, BLWM
Scott Wilson, BLWM
Kent Coleman, BLWM
Rick Richter, Trident EQC
52233; file

III. RESPONSIVENESS SUMMARY

RESPONSIVENESS SUMMARY

Part III of the Final Macalloy Record of Decision (ROD) is comprised of the Responsiveness Summary. This section presents a summary of comments received from the public, including potentially responsible parties (PRPs), during the public comment period as required by CERCLA Section 117 and NCP Sections 300.430(f)(3)(i)(F) and 300.430(f)(5)(iii)(B). The Responsiveness Summary allows EPA to reassess its initial determination that the Final selected remedy provides the best balance of trade-offs by factoring in any new information or points of view expressed by the community, local/state officials, and PRPs during the public comment period.

As discussed in Sections 3.0 and 14.0 of the Decision Summary (Part II) of this ROD, a 60-day public comment period on the Proposed Plan was held from April 11 to June 10, 2002. During this time period, EPA received written comments from five entities: South Carolina Department of Natural Resources (April 23, 2002); Honorable R. Keith Summey, Mayor of North Charleston (May 1, 2002); Macalloy Corporation (May 7, 2002); SCDHEC Office of Ocean and Coastal Resource Management (May 22, 2002); and CSX Transportation (June 6, 2002). The Proposed Plan public meeting was held on April 18, 2002 and was attended by approximately 20 people. No opposition to EPA's proposal was implied or otherwise stated during this meeting. The remaining content of the Responsiveness Summary consists of the following components:

- Written comments received, presented in chronological order, followed by EPA's written response;
- The April 2002 Proposed Plan;
- The verbatim legal transcript of the April 18, 2002 Proposed Plan Public Meeting; and
- Copies of slides used in the public meeting power point presentation.

South Carolina Department of
Natural Resources

Paul A. Sandifer, Ph.D.
Director
John V. Miglarese
Deputy Director for
Marine Resources

April 23, 2002

Mr. Craig Zeller
North Site Management Branch
Waste Management Division
USEPA Region 4
61 Forsyth Street
Atlanta, GA 30303-3104

RE: Proposed Plan
Macalloy Corporation Site;
Shipyard Creek; Charleston, S.C.

Dear Mr. Zeller:

The South Carolina Department of Natural Resources (SCDNR) has reviewed the Proposed Plan for the Macalloy Corporation Site, and offers the following comments.

Conceptually, the SCDNR supports the proposed remedies for contaminated soil, groundwater, stormwater, and sediments, with the following exceptions:

1) The SCDNR believes that the remedy for stormwater should be more protective of saltwater aquatic life, by incorporating the Criterion Continuous Concentration (CCC), rather than the Criterion Maximum Concentration (CMC) for arsenic, copper, and hexavalent chromium, as the Remedial Action Objectives (RAOs). Adopting the CCC as the RAO for each contaminant of concern would protect aquatic life in Shipyard Creek from chronic, as well as acute, effects of contaminated stormwater runoff from the site.

2) Similarly, the SCDNR believes that the remedy for groundwater discharging to the marsh should be more protective of saltwater aquatic life by incorporating the more stringent Criterion Continuous Concentration (CCC) for hexavalent chromium (50 µg/l) as the RAO for groundwater, rather than the Maximum Contaminant Level (MCL) allowable in drinking water for the protection of human health (100 µg/l).

3) The SCDNR recommends that the proposed plan clearly state the RAOs for contaminated sediments. The selected RAOs should ensure the removal or physical isolation of all sediments with concentrations of Contaminants of Concern (COCs) that exceed levels determined by EPA, in consultation with the Natural Resource Trustees, to be protective of benthic invertebrates and

higher–level trophic groups. The SCDNR further recommends that confirmatory sampling following excavation include the collection of 3-ft. sediment cores, analyzed for COCs in 1-ft increments, to verify the assumption that removing the top 18" of sediment will achieve the specified RAOs, with an adequate margin of safety for deeper-burrowing organisms and the animals that prey upon them.

4) In the absence of site-specific toxicity or bioaccumulation testing to evaluate the risk to terrestrial ecological receptors posed by exposure to COPCs in soils or sediments disposed onsite, the SCDNR recommends that all excavated sediments be managed along with contaminated soils as described under EPA's preferred remedial alternative for soils (Alternative S2b).

The SCDNR appreciates the opportunity to comment on the Proposed Plan. Please call Priscilla Wendt (843-762-5068), the SCDNR Project Manager for this site, if you have any questions regarding these comments.

Sincerely,

Robert E. Duncan
Environmental Program Director

Cc: NOAA
USFWS
SCDHEC

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

August 21, 2002

4WD-NSMB

Mrs. Priscilla Wendt
Environmental Management Section
Marine Resources Division
SC Department of Natural Resources
P.O. Box 12559
Charleston, SC 29422-2559

SUBJ: Superfund Proposed Plan for the Macalloy Corporation NPL Site; Charleston, South Carolina.

Dear Mrs. Wendt:

Thank you for your April 23, 2002 letter which transmitted South Carolina Department of Natural Resources (SCDNR) technical comments on EPA's Superfund Proposed Plan for the Macalloy NPL Site in Charleston, South Carolina. We have discussed SCDNR concerns regarding the Macalloy Proposed Plan verbally and via email correspondence many times since I received your initial comments. More recently, EPA has received and reviewed your correspondence dated July 31, 2002 which provided comments on EPA's Draft Record of Decision (ROD). EPA has attempted to modify the Final ROD to address expressed SCDNR concerns, and I believe we have reached a position of general agreement. This letter is written to formally document EPA responses to issues you raised on the Proposed Plan and ROD.

1. **With regard to the storm water remedy, SCDNR believes chronic (criterion continuous concentration) criteria are more appropriate than acute (criterion maximum concentration) criteria for protection of saltwater aquatic life.** EPA agrees that chronic water quality criteria are more conservative than acute standards. However, EPA believes acute (marine) water quality standards are more applicable given the intermittent nature of storm water discharges. Moreover, Macalloy has insisted that dilution and mixing zone evaluations be considered when establishing surface water remedial goals. Therefore, EPA believes the selected acute water quality criteria for lead, arsenic, copper, zinc and hexavalent chromium are adequately protective of human health and the environment and represent a fair compromise that will allow this project to proceed forward.

2. **Due to the confirmed groundwater to surface water pathway, SCDNR believes the more stringent criterion continuous concentration of 50 ug/L for hexavalent chromium should be the RAO for groundwater, rather than the 100 ug/L for hexavalent chromium**

which is the MCL (i.e. allowable concentration in drinking water for protection of human health). For EPA, this matter really becomes an issue of "enforce ability". Due to State of South Carolina groundwater classifications, MCLs (where available) are typically used as enforceable standards in groundwater remedy components. However, I believe the intent of SCDNR's comment will be addressed during groundwater remedy implementation as pilot treatability results for the groundwater remedy indicate hexavalent chromium will be reduced to "non-detect" concentrations.

3. **SCDNR recommends that sediment RAOs for constituents of concern be developed by EPA, in consultation with the Natural Resource Trustees (NRTs), to be protective of benthic invertebrates and higher trophic level receptors.** Lynn Wellman, EPA-Region 4 ETAG coordinator, developed protective risk ranges for the sediment constituents of concern in accordance with EPA Baseline Ecological Risk Assessment guidance. As requested, this evaluation was provided for the NRTs review as Appendix A to the Draft ROD which was forwarded to you in early July 2002. Appendix A was revised based on input from the NRTs, and is included in the Final August 2002 ROD. Protective risk ranges for chromium, nickel, and zinc in sediments of the 001 tidal creek have been retained as sediment remedial goals in the ROD.

4. **SCDNR recommends that confirmatory sampling following excavation include the collection of 3 feet sediment cores, analyzed for COCs in 1 foot increments, to verify the assumption that removing the top 18 inches will achieve the RAOs.** The 18 inch depth for sediment removal in the 001 tidal creek was a Feasibility Study assumption so a volume could be calculated for detailed remedy evaluation. Previous sediment sampling conducted by EPA during the removal assessment indicated most impacted sediments were in the 0 to 1 foot depth interval. Nonetheless, Section 12.2.4 of the Final August 2002 ROD does include upfront delineation sampling (before excavation) and confirmatory sampling (after excavation) to ensure the sediment remedy component effectively removes targeted material. The NRTs will have the opportunity to review draft work plans (and results) from both sampling events.

5. **SCDNR recommends that all excavated sediments be managed with contaminated upland soils.** Agreed.

6. **SCDNR recommends that a mitigation plan should be developed for any incidental injury to adjacent saltmarsh habitat as a result of sediment excavation in the 001 tidal creek.** Agreed. The following text was added to page 12-16 of the Final August 2002 ROD; "*Dredging in the tidal creek will be conducted in a manner that minimizes physical disturbance and impacts to the adjacent vegetated tidal marsh. Following dredging, impacts to the adjacent salt marsh will be assessed, and damaged areas will be revegetated.*'

I greatly appreciate your active participation in the ecological assessment of Macalloy which spanned the Preliminary Ecological Risk Evaluation effort as well as the Baseline Ecological Risk Assessment during the RI/FS. Your commitment as demonstrated by regular attendance at project meetings, and timely submission of constructive technical comments contributed to the final product and facilitated EPA completing the RI/FS process in 2.5 years. Your April 23, 2002 letter and EPA's response will be incorporated into the Responsiveness Summary (Part III) of the Final August 2002 ROD. Should you have any questions, or wish to discuss this matter in greater detail, please don't hesitate to contact me at 404.562.8827.

Sincerely,

Craig Zeller, P.E.
Remedial Project Manager

USE THIS SPACE TO WRITE YOUR COMMENTS

Your input on the Proposed Cleanup Plan for the Macalloy Corporation Site is important to EPA. The public's comments help EPA select a final cleanup remedy for the site.

You may use the space below to write your comments, then fold and mail. Comments must be postmarked by May 11, 2002. Please contact Craig Zeller at 404-562-8827 if you have any questions about the comment period.

If you have access to E-Mail, you may send comments to: *Zeller.Craig@epa.gov*.

The following comments are submitted by the City of North Charleston.

A. This property is important to the tax base of our City. This clean up project should be expedited to return this property to a viable use.

B. Concern has been expressed that once this property is cleaned up pilling cannot be used during construction. We need clarification on this subject. A heavy industrial use would definitely require the use of pilling.

R. Keith Summey
Mayor
05/01/02

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

August 21, 2002

4WD-NSMB

Honorable R. Keith Summey, Mayor
City of North Charleston
4900 LaCross Road
P.O. Box 190016
North Charleston, SC 29419-9016

SUBJ: Superfund Proposed Plan for the Macalloy Corporation NPL Site; North Charleston, South Carolina.

Dear Mayor Summey:

Thank you for your May 1, 2002 letter which transmitted City of North Charleston comments on EPA's Superfund Proposed Plan for the Macalloy NPL Site in North Charleston, South Carolina.

The Macalloy Record of Decision was finalized on the above date, and the final remedial alternatives selected by EPA were identical to the components proposed in the subject document. At this time, EPA has started the Remedial Design effort that will produce engineering drawings and construction specifications needed for actual remedy implementation. EPA has also initiated discussions with responsible parties to determine what entity will assume the lead role during the Remedial Action. Cleanup of the Macalloy property is anticipated to begin in Spring 2003.

EPA has met with you and your staff several times during the investigation phase and most recently on June 26, 2002 to discuss potential redevelopment opportunities for the 125 acre Macalloy property. EPA fully understands the intrinsic value that this property brings to the City of North Charleston, and is committed to expediting the cleanup so that remediation can be integrated with redevelopment and site re-use. I will keep you informed of our progress in reaching this goal as we move forward.

Thank you for your genuine interest in EPA's activities at the Macalloy Site. Your May 1, 2002 letter and EPA's response will be incorporated into the Responsiveness Summary (Part III) of the Final August 2002 ROD. Should you have any questions, or wish to discuss issues pertaining to Macalloy, please don't hesitate to contact me at 404.562.8827.

Sincerely,

Craig Zeller, P.E.
Remedial Project Manager

MACALLOY CORPORATION
P.O. BOX ... • CHARLESTON, S.C. 29402 • (803) 722-8355

May7, 2002

Mr. Craig, Zeller, P.E.
Remedial Project Manager
USEPA Region 4
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303

RE: Macalloy Corporation Superfund Site
North Charleston, South Carolina

Dear Mr. Zeller:

We are writing to provide public comment on the Proposed Remediation Plan (Proposed Plan) for the above referenced Superfund Site (Site). Continued cooperation between Macalloy and EPA contributed greatly to the completion of the Remedial Investigation and Feasibility Study (RI/FS) and subsequent Proposed Plan in a timely fashion. Without that cooperation, and in large part due to your efforts, we would not have arrived at this point in the relative short period of time and moved that much closer to completion of site remediation. Consultants and scientists contracted to provide technical advice throughout this project have provided evidence demonstrating that certain measures proposed in EPA's plan are unnecessary and risk loss of the limited resources. Accordingly, Macalloy requests EPA's Proposed Plan be revised to eliminate the requirement to monitor and remove sediments from Shipyard Creek and to revise the stormwater effluent limits in accordance with the recommendation provided by the South Carolina Department of Health and Environmental Control (DHEC).

First, Macalloy requests dredging in Zone A and monitoring sediments in Zone C, Shipyard Creek, be deleted from the Proposed Plan. We disagree with EPA's decision to incorporate a sediment toxicity study on grass shrimp into the RI that was performed by the Skidaway Institute. The methods used by the Skidaway Institute are not approved by EPA and have not stood the test of peer review to determine their validity, credibility, and repeatability. The lack of credibility is further evidenced by the quality of the Final Toxicity Report, which contains critical omissions. Yet, the results of this Sediment Toxicity Study (Study) impacts the proposed remediation action for Shipyard Creek. The

Study indicates sediments in Shipyard Creek are toxic to grass shrimp. This data was relied on despite the fact that a grass shrimp collection and population study performed by Breedlove, Dennis, Young & Associates (BDY) as part of the RI suggests otherwise, and population studies conducted by Macalloy Corporation indicate the grass shrimp population in Shipyard Creek is abundant. Accordingly, we feel monitoring of Zone A of Shipyard Creek may be a prudent activity, but dredging and continued monitoring of Zone C is not necessary and is not supported by the existing data.

Second, as part of the RI/FS, Macalloy was required to select appropriate surface water remedial goals for storm water run-off; the remedial goals adopted by EPA directly contravene the established scientific data and the applicable or relevant and appropriate requirements (ARAR) proposed by DHEC. To aid both DHEC and CERCLA in selecting the appropriate ARAR, Macalloy retained ENSAFE to prepare a technical memorandum that established discharge limits based on mixing zone modeling and dissolved-to-total metals translation. ENSAFE's findings were submitted to EPA and DHEC in a Technical Memorandum entitled Development of Surface Water Remedial Goals for Macalloy Using Mixing Zone Modeling and Dissolved-to-Total Metals Translation. This study demonstrated that even if required to comply with discharge stormwater limits, these limits should take into account dilution, a conservatively sized mixing zone, and credit for the translation of dissolved metals to total recoverable metals. EPA proposed numerical limits for Macalloy Corporation's stormwater discharge for copper set at the water quality standard, without any consideration of dilution or a mixing zone referenced in the ENSAFE document. No explanation or regulatory basis was provided for this decision.

Furthermore, EPA's Proposed Plan contradicts the position regarding dilution taken by DHEC, the Agency with delegated authority to enforce and develop water quality standards and surface water ARARs for CERCLA sites in South Carolina. Although DHEC did not agree with Macalloy's recommended surface water ARARs, it did recommend an alternative that allows for dilution:

> *Shipyard Creek is not on the State's impaired waters list for any of the parameters being discharged. Further, use of such stringent limitations may result in unnecessary costly treatment.* Therefore, our recommendation is that the permit limitations for Outfall 004 in the current NPDES permit be used with a "reopener" clause in the CERCLA plan that will allow it to be reopened to impose different limitations when we are able to obtain stream flow information needed to determine limitations based on the recently revised water quality standards.

DHEC letter to Zeller, March 14, 2002, p. 2.

As a general rule, the state and federal permitting authorities are required to provide a basis for concluding that a discharge has the reasonable potential to cause an excursion above applicable water quality criteria before mandating a water quality-based effluent limit or ARAR. 54 *Fed. Reg.* 23868 (applicable to ARARs through enforcement of discharge limits). The evaluation process requires that the permitting authority "must use reliable and consistent procedures." *Id.* Dilution is a factor that must be considered as part of these procedures. The EPA Preamble to the water quality standards states:

> Although the procedures can vary considerably from one state to another, ***most such procedures account for any dilution of the effluent in the receiving water,*** after considering mixing zones if applicable, any contributions of the pollutant from upstream point and nonpoint sources, the variability of the pollutant in the effluent, and, when evaluating whole effluent toxicity, the sensitivity of the test species in a toxicity test.

54 *Fed. Reg.* 23868 (emphasis added). Therefore, Macalloy respectfully requests EPA do one of the following: (1) adopt the surface water limits proposed by Macalloy, (2) develop other such limits based on dilution, mixing zones and credit for dissolved metals, or (3) adopt the proposal by DHEC of March 14, 2002.

For the foregoing reasons, we respectfully request that EPA examine the ENSAFE Technical Memorandum and reconsider its proposals for remediation of the site with regard to removal of sediments and monitoring in Shipyard Creek, and revising the stormwater limits to levels proposed by Macalloy or DHEC.

Sincerely,

T.M. Nelson
Vice President of Engineering

Cc: Ethan Ware, McNair Law Firm
Dan Cowan, EnSafe

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

August 21, 2002

4WD-NSMB

Mr. T.M. Nelson
Vice President of Engineering
Macalloy Corporation
P.O. Box 130
Charleston, SC 29402

SUBJ: Superfund Proposed Plan for the Macalloy Corporation NPL Site; Charleston, South Carolina.

Dear Mr. Nelson:

Thank you for your May 7, 2002 letter which transmitted Macalloy Corporation technical comments on EPA's Superfund Proposed Plan for the Macalloy NPL Site in Charleston, South Carolina. Your letter raised two issues on EPA's proposed cleanup plan for the Site which involved: 1) EPA's decision to remove sediments of the 001 tidal creek based on results of the grass shrimp toxicity test conducted by the Skidaway Institute; and 2) The methodology EPA utilized to develop protective surface water cleanup goals for the storm water remedy component. EPA's responses to these two issues are presented separately below.

Grass Shrimp Toxicity Test/001 Tidal Creek Sediments

Macalloy's major criticism of the grass shrimp (*palaemonetes pugio*) toxicity test performed by Richard Lee with the Skidaway Institute of Oceanography related to the lack of technical peer review of test methods employed to ensure repeatability and validity of test results. In addition, Macalloy stated that the final grass shrimp report lacked proper elaboration of test methods and contained critical omissions requested by Macalloy's ecological consultant. A technical review of the grass shrimp toxicity test performed by Skidaway was performed by EPA's Gulf Breeze Laboratory in Pensacola, FL. These reviewers also noted that the "[...*testing methods require further elaboration.....and it is suggested that any test be thoroughly evaluated in a round robin exercise that addresses uncertainties associated with laboratory to laboratory variation.*" Therefore, Macalloy's objection regarding this specific issue is acknowledged.

However, use of the grass shrimp to test sediment quality is highly recommended for the Gulf of Mexico and Southeastern coasts because of their ubiquitous presence and their functional role in these coastal estuarine ecosystems. Grass shrimp represent 65% of the biomass is some tidal creeks and are detritus feeders that are preyed upon by several species of fish. In practice, the grass shrimp toxicity test has provided consistent results, and has proven to be one of the more dose-responsive assays available. For example, during the removal assessment phase and Preliminary Ecological Risk Evaluation (PERE) effort at Macalloy, the grass shrimp bioassay predicted poor performance on chronic endpoints (DNA damage/embryo hatching success) for stations SPY04 and SPY03 that were located in the 001 tidal creek. Subsequently, the comprehensive Baseline Ecological Risk Assessment (BERA) conducted during the RI/FS process indicated similar results for chronic endpoints in all three reaches of the 001 tidal creek (Zone A). With a few exceptions, the grass shrimp toxicity test indicated adequately protective sediment quality at established reference stations and other sampling locations with much less site related impact.

EPA's decision to excavate sediments from the 001 tidal creek was not solely based on the results of the grass shrimp toxicity test. Rather, multiple lines of evidence factored into EPA's decision to select Alternative M4 (sediment removal with upland disposal) for the 001 tidal creek, and to retain Zone C for monitoring during the 5 year review. The key factors include:

- Mean chromium concentrations in sediments of the 001 tidal creek (Zone A) were 2,610 mg/kg; compared with 265 mg/kg chromium for Zone C (median contaminant gradient), 85 mg/kg chromium for Zone B (low contaminant gradient), and ranged from 13 to 40 mg/kg on average from the reference stations.

- Mean ERM quotients for the upper, middle, and lower reaches of the 001 tidal creek were 3.1, 2.9, and 1.9 respectively. These values represent Category 4 sediments (mean ERM quotient > 1.5) and represent sediments with the highest potential for toxicity. All other ERM quotients from Zone B, Zone C and reference locations were Category 2 (mean ERM quotient 0.11 to 0.51) and below.

- Historically, the 001 tidal creek received the bulk of process water discharges from plant operations. The above discussion appears to validate our conceptual site model for contaminant transport to Shipyard Creek.

- Zone C was retained for monitoring during the 5 year review process based on grass shrimp toxicity results, and contaminant concentrations that approximate established protective risk ranges for chromium, nickel and zinc. Furthermore, this item was requested by the Natural Resource Trustees, and EPA feels that the estimated $20,000 expenditure is justified to maintain positive working relationships that may lead to a formal resource damage settlement, if warranted.

- Finally, Alternative M4 (estimated present worth cost = $492,000) was the most cost effective, ARAR compliant alternative evaluated in detail during the FS. Alternative M2 (Enhanced Monitored Natural Recovery) was estimated at $626,000, and Alternative M3 (Capping) was estimated at $559,000. From cost and permanence considerations, M4 provided significant advantages to the other alternatives evaluated.

Methodology Utilized to Develop Protective Surface Water Goals for Storm Water

Macalloy has advocated the use of dilution and mixing zones when calculating adequately protective surface water remedial goals as delineated in detail in the Technical Memorandum titled, "*Development of Surface Water Remedial Goals for Macalloy Using Mixing Zone Modeling and Dissolved-To-Totals Metals Translation*" (EnSafe, February 22, 2002). Since active production at the facility ceased in July 1998, the EPA CERCLA Program goal has been to develop protective surface/storm water criteria that meet the substantive requirements of the Clean Water Act so that NPDES methodology can be discontinued. As you know, this Technical Memorandum was forwarded to respective Water Programs within EPA and SCDHEC for their review and comment. EPA and SCDHEC review comments on the EnSafe Technical Memorandum were provided to you in correspondence dated March 14, 2002 (Melinda Vickers, SCDHEC - Industrial Wastewater Permitting Section), and March 1, 2002 (Tom McGill, EPA NPDES and Biosolids Section).

Based upon the EPA/SCDHEC review of the EnSafe Technical Memorandum, and many subsequent discussions with Macalloy, the following conclusions and path forward were developed:

- The CORMIX model utilized by EnSafe in the Technical Memorandum has been widely applied to evaluate near field mixing problems and to establish mixing zones for regulatory purposes. Furthermore, the dissolved to total metals translation analysis conducted by EnSafe is applicable to this situation.

- The SCDHEC Water Program is currently working on a dissolved oxygen TMDL model for the Cooper River that will determine the stream dilution available in Shipyard Creek. Results of the TMDL model are not expected until early 2003. Alternate limits based on dilution will be evaluated by EPA once the dissolved oxygen TMDL model results are available. EPA believes this commitment is clear in Section 12.2.5 (Storm Water Management) of the Final August 2002 ROD.

- Defensible and adequately protective surface water remedial goals for lead, arsenic, copper, zinc, and hexavalent chromium were needed in the short term so the Proposed Plan and ROD could be finalized. SCDHEC suggested the use of NPDES permit limitations for Outfall 004 until alternate numbers could be calculated. EPA believes that the assumptions used to calculate numerical limits for Outfall 004 no longer apply due to the extensive amount of site reconfiguration (i.e. surface water removal action) and that process water discharges have ceased (i.e. no longer reflects contaminants of concern in the end of pipe effluent).

- EPA believes that acute ambient water quality criteria are the most appropriate given the intermittent nature of storm water discharges. Use of acute (marine) water quality criteria in the short term is considered conservative, but will ensure existing water quality is not further degraded. As stated in Section 12.2.5, end-of-pipe discharges will be monitored for one year after remedial construction is completed. This will provide the opportunity to evaluate the expected positive effects that soil and groundwater remediation will have on resultant storm water quality. Changes in the monitoring program and the adoption of alternate, less conservative end-of-pipe limits will be evaluated at the end of the one year monitoring program described in the ROD.

EPA appreciates Macalloy's cooperation throughout the 2.5 year RI/FS process. Considering the amount of complex technical decisions required to reach the Proposed Plan/ROD phase, the fact that EPA and Macalloy differ slightly on only two issues should be considered a success story. Your May 7, 2002 letter and EPA's response will be incorporated into the Responsiveness Summary (Part III) of the Final August 2002 ROD. Should you have any questions, or wish to discuss this matter in greater detail, please don't hesitate to contact me at 404.562.8827.

Sincerely,

Craig Zeller, P.E.
Remedial Project Manager

S.C. Department of Health and Environmental Control
D H E C
PROMOTE PROTECT PROSPER

Office of Ocean and Coastal Resource Management

1362 McMillan Avenue, Suite 400
Charleston, SC 29405

(843) 747-4323 FAX (843) 744-5847

Christopher L. Brooks, Deputy Commissioner

May 22, 2002

Mr. Craig Zeller
North Site Management Branch
Waste Management Division
USEPA Region 4
61 Forsyth Street
Atlanta, GA 30303-3104

RE: Macalloy Corporation Site

Dear Mr. Zeller:

OCRM is in receipt of a document you submitted describing the proposed plan to remove and or contain contaminated soils at the Macalloy Corporation Site, Charleston, SC. Upon review of the alternatives, OCRM agrees, in concept, with the proposed methods and plans. However, more specific information will be necessary prior to OCRM's approval of the proposal. Such information should include the area of impact and the ultimate spoil location.

It is not clear from the document whether this activity will be pursued by an agency of the federal government or by a private company such as the Macalloy Corporation. Further, in a phone conversation with you several weeks ago, you mentioned the possibility that either may be the ultimate 'applicant'. Administratively, OCRM treats these two options differently in the public notice process. If the federal government is the applicant then OCRM issues a Federal Consistency, if a private company is the applicant OCRM requires a direct permit.

When you determine who the applicant is to be, please resubmit the proposal so that OCRM may pursue the appropriate administrative action. If you have any questions on this matter please do not hesitate to contact me.

Sincerely,

Mark A. Caldwell
Senior Regulatory Biologist

may02let.doc
xc: Richard Chinnis, Director of Regulatory Programs
Rob Mikell, Federal Certification Manager

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

August 21, 2002

4WD-NSMB

Mr. Mark Caldwell, Senior Regulatory Biologist
SC Department of Health & Environmental Control
Office of Ocean & Coastal Resource Management
1362 McMillan Avenue, Suite 400
Charleston, SC 29405

SUBJ: Superfund Proposed Plan for the Macalloy Corporation NPL Site; Charleston, South Carolina.

Dear Mr. Caldwell:

Thank you for your May 22, 2002 letter which transmitted OCRM comments on EPA's Superfund Proposed Plan for the Macalloy NPL Site in Charleston, South Carolina.

The Macalloy Record of Decision has been finalized, and the final remedial alternatives selected by EPA were identical to the components proposed in the subject document. At this time, EPA has started the Remedial Design effort and has initiated discussions with responsible parties to determine what entity will assume the lead role during actual remedy implementation and construction. Details of sediment removal and restoration in the 001 tidal creek will be delineated in the design documents which will be provided to your office for review likely in Spring 2003. At that time, the "applicant" will be determined and EPA-Region 4 will coordinate with OCRM regarding the appropriate administrative process to pursue regarding critical area and storm water permits.

EPA appreciates all the assistance and timely reviews OCRM has provided on this project and other CERCLA cleanups in the Charleston area. Your May 22, 2002 letter and EPA's response will be incorporated into the Responsiveness Summary (Part III) of the Final August 2002 ROD. Should you have any questions, or wish to discuss this matter in greater detail, please don't hesitate to contact me at 404.562.8827.

Sincerely,

Craig Zeller, P.E.
Remedial Project Manager

McGuireWoods LLP
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Jacksonville, FL 32202-3661
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May 8, 2002

By Federal Express

Craig Zeller, P.E., Remedial Project Manager
USEPA Region IV
Atlanta Federal Center
61 Forsyth Street, S.W.
Atlanta, GA 30303

Superfund Proposed Plan
Macalloy Corporation Site, Charleston, Charleston County, South Carolina

Dear Mr. Zeller:

We have been asked to represent CSX Transportation, Inc. ("CSXT") in this matter. CSXT hereby requests an extension of the public comment period for 30 days as provided for in the National Contingency Plan, 40 C.F.R. § 300.430(f)(3) and at page 16 of the April 2002 Proposed Plan. CSXT intends to submit comments during the comment period as extended.

Please call if you have any questions about this.

Sincerely yours,

Donald D. Anderson

DDA:bam

cc: W. Patrick Harrison
Ron Holley

\\REA\116161.1

CSX
TRANSPORTATION

W. Patrick Harrison
Director Environmental Remediation

1590 Marietta Boulevard, NW
Atlanta, GA 30318
(404) 350-5355
Fax (904) 245-2233

File: Charleston, SC
Macalloy NPL Site
EPS 0034103

June 6, 2002

Mr. Craig Zeller. P.E.
Remedial Project Manager
EPA Region 4
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303

Comments of CSX Transportation, Inc. on Superfund Proposed Plan
Macalloy Corporation Site
Charleston, Charleston County, South Carolina
April 2002

Dear Mr. Zeller:

CSX Transportation, Inc. (CSXT) has reviewed the referenced plan, as well as supporting documentation transmitted by your memorandum dated April 15, 2002, to Ron Holley, Holley Consultants. These are CSXT's comments on the proposed plan.

CSXT owns property immediately north of and adjacent to the Macalloy Site, as shown on Figure 7-3 of the Macalloy FS Report. The property is an inactive rail yard.

The Proposed Plan includes a component for Storm Water Management. This would be a component of whatever remedial alternative is selected by EPA. The Proposed Plan states, in pertinent part:

> Currently, offsite storm water runoff commingles with storm water from disturbed onsite areas, increasing the quantity of water that must be managed.
>
> This increase jeopardizes the effectiveness of the detention basins at removing solids.
>
> To address this concern, the proposed storm water management plan will include an upgradient offsite collection ditch to intercept offsite storm water before it commingles with onsite runoff.

Proposed Plan, at 12. Figures 7-3 and 7-4 show the construction of the offsite collection ditch on CSXT property. Those figures show the ditch as "Work by Others." The projected construction cost for the storm water management plan ($1,010,000) does not include the offsite ditch on CSXT property. Nor does the estimated annual operations and maintenance cost ($246,000) include the cost of maintaining the offsite ditch.[1]

Thus, the Proposed Plan explicitly states that a diversion ditch would be constructed on CSXT property and implicitly suggests that CSXT or others would do the offsite work. CSXT objects for the following reasons:

1. The storm water flow from CSXT property consists in part of storm water that falls on the CSXT property. There is no legal basis to compel CSXT to take action on its own property to prevent the natural flow off of its property. In any event, there is no evidentiary basis in the record to justify such a requirement.

2. Storm water from the areas north of the CSXT property also flows through a culvert on the CSXT property and then to the Macalloy Site. Assuming there is a legal basis to prevent this storm water flow, the government's attention must be directed to those responsible for that storm water – the City of North Charleston and South Carolina Department of Transportation, not CSXT.

3. The proposed diversion reportedly would benefit Macalloy and the public by facilitating compliance with water quality standards. No such benefit accrues to CSXT because it is not in violation of water quality standards, and would not be in violation if the diversion were not made. The cost should therefore be borne by others.

4. The proposed diversion would adversely impact the value and utility of CSXT property, particularly if a ditch were constructed. Preliminary design information discussed at a site meeting on December 5, 2001, indicated that a six foot deep ditch with 3H:1V side slopes may be needed. The width of this ditch would be about 36 to 40 feet, which would take a significant area of the property out of service and block access to portions of the property. Needless to say, any purported requirement for such a construction on CSXT property without just compensation would constitute a taking in violation of the United States Constitution.

5. Maintenance of a diversion ditch or other conveyance could involve a major continuing cost due to minimal slopes from the property to Shipyard Creek, uncontrolled runoff from areas not owned by CSXT, soil characteristics, the probability of frequent standing water, and other factors.

Additional concerns would have to be addressed prior to plan finalization. These include, but may not be limited to, the following:

1. It is unclear whether the storm drainage pipe crossing CSXT property from Union Heights was authorized by CSXT and/or its predecessors. Clarification is needed to determine whether this pipe should be taken out of service and storm water diverted. The invert elevation of the pipe discharge appears to govern the elevation of the proposed diversion, and would require a significantly deeper conveyance.

---

[1] These costs were taken from Table 7-2 of the Macalloy FS Report.

2. Two other pipes crossing CSXT property from Union Heights have been rumored. These and any other storm drains, sanitary sewers, or other potential interferences should be located and addressed prior to making a determination that a ditch or other conveyance is feasible.

3. If additional pipes are present, it is likely that the drainage area from Union Heights indicated in supporting documentation to the plan is underestimated, and flow contributions should be revised.

4. A diversion ditch as proposed would also transport runoff from areas not owned by CSXT across the CSXT property. CSXT would not have control over the quantity and quality of this runoff. This situation could adversely affect CSXT interests in terms of environmental impacts on its property or liability in the event of water quality impacts by others.

In addition, CSXT believes a more detailed investigation is needed to determine whether a diversion conveyance is technically feasible.

Thank you for the opportunity to comment on the proposed plan. Please direct any response or inquiry to the undersigned.

Sincerely,

Wm P. Harrison

W. Patrick Harrison, REM
Director Environmental Remediation

cc: Donald D. Anderson, Esq.
Ronald E. Holley, PE

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

August 21, 2002

4WD-NSMB

Mr. W. Patrick Harrison, Director
Environmental Remediation
CSX Transportation
1590 Marietta Boulevard, NW
Atlanta, GA 30318

SUBJ: Superfund Proposed Plan for the Macalloy Corporation NPL Site; Charleston, South Carolina.

Dear Mr. Harrison:

The Region 4 Office of the United States Environmental Protection Agency (EPA) has received and reviewed your letter dated June 6, 2002 which transmitted CSX Transportation (CSXT) technical comments on EPA's Superfund Proposed Plan for the Macalloy Corporation NPL Site in Charleston, South Carolina.

CSXT's interest in the proposed cleanup plan for Macalloy primarily involves the comprehensive storm water management plan developed by EPA to achieve applicable acute ambient water quality criteria and whole effluent toxicity testing requirements of intermittent storm water discharges from the Macalloy property to tidally influenced Shipyard Creek. Pursuant to requirements of the Federal Clean Water Act and comparable State of South Carolina requirements, numerical limits for storm water have been established for lead, arsenic, copper, zinc and hexavalent chromium. As discussed at our December 5, 2001 project meeting in Charleston, EPA has identified 3 general strategies to meet the above requirements. These are summarized below:

<u>Option 1 - Plug Breaches in Power Line Berm:</u>

An elevated berm which consists of a power line right-a-way runs in a north/south direction on CSXT property, parallel to the Macalloy property boundary and the 002 settling canal. During the 12/05/01 site walk over, 3 breaches to this berm were noted, thus conveying storm water which originates off-site to the Macalloy 002 settling canal. One breach is illustrated on Figures 7-3/7-4 from the Feasibility Study, which you reference in your letter. This breach actually consists of a storm sewer outfall maintained by the City of North Charleston and the South Carolina Department of Transportation (SCDOT) to convey storm water from Spurill Avenue and Union Heights. The other two breaches are south of the storm sewer outfall and consist of ditches dug through the power line berm. These ditches were apparently constructed by CSXT to properly drain the southern portion of the active railyard. However, it appears that these ditches were installed without an approved storm water management permit from SCDHEC's Office of Ocean and Coastal Resource Management, and without prior approval by Macalloy. Under this option, EPA would simply plug the 3 breaches and allow CSXT, the City of North Charleston, and SCDOT to responsibly manage storm water which originates on their property. EPA does not view option 1 to be a viable alternative given the potential flooding problems created along Spurill Avenue, Union Heights and CSXT's railyard.

Option 2 - Plug Breaches/Diversion of Off-Site Surface Water:

This option was the storm water management plan developed by EPA and described in the Final Feasibility Study Report (EnSafe, March 29, 2002) and the April 2002 Proposed Plan. This alternative includes plugging the 3 breaches in the power line berm as discussed in Option 1 above, but also includes diverting this water around the Macalloy property with ultimate discharge to upper Shipyard Creek. Under this option, the elevated power line berm would serve as the earthen diversion structure and a small conveyance would be excavated on the western side of the berm to direct water around the Macalloy property. EPA acknowledges that the conceptual plan has several technical issues which need to be resolved in the Remedial Design effort. These include such as issues as the 3H:1V side slopes of the proposed diversion ditch, the necessary grades/diversion ditch slopes to convey storm water to upper Shipyard Creek, who pays for diversion ditch construction costs, and diversion ditch maintenance issues as described in your June 6, 2002 letter. EPA believes these issues can be resolved to the mutual satisfaction of all stakeholders during the Remedial Design phase. As a result, EPA has selected this option as the surface water management plan in the August 2002 Final Record of Decision (ROD). Further details regarding the established Performance Standards and cleanup levels for the storm water remedy component can be found in Section 12.2.5 of the Final ROD.

Option 3 - Breaches Remain/Modify On-Site Surface Water Management Plan:

Under this option, the 3 breaches of the power line berm would remain and off-site water would continue to discharge to Macalloy's 002 settling canal. During the Remedial Design phase, EPA would set up storm water gauges at the 3 discharge points to monitor storm water quality and quantity which enters the 002 settling canal. Once this data was evaluated and its impact determined on the performance of the on-site storm water management system constructed on the Macalloy NPL Site, EPA would contact the responsible parties for appropriate participation in the construction and performance monitoring of the surface water management system remedy.

Thank you for your input into EPA's proposed cleanup plan for the Macalloy property. EPA remains receptive to other feasible storm water management alternatives identified by CSXT and its consultants; and is committed to continuing a constructive dialogue with CSXT, the City of North Charleston and SCDOT to resolve this issue amicably. Your June 6, 2002 letter and EPA's response will be incorporated into the Responsiveness Summary (Part III) of the Final

August 2002 ROD. Should you have any questions, or wish to discuss this matter in greater detail, please don't hesitate to contact me at 404.562.8827.

Sincerely,

Craig Zeller, P.E.
Remedial Project Manager

SUPERFUND PROPOSED PLAN

Macalloy Corporation Site
Charleston, Charleston County, South Carolina

U.S. EPA Region 4
Atlanta, GA

April 2002

EPA ANNOUNCES PROPOSED PLAN

The Region 4 Office of the United States Environmental Protection Agency (EPA) has developed this **Proposed Plan** to inform citizens and local officials of the Preferred Alternative for cleaning up contaminated soil, groundwater, storm water, and sediment at the Macalloy Corporation Site in Charleston, South Carolina, and the rationale for its preference.

This plan also explains how the public can be involved in the remedy selection process. The EPA, the lead agency for site activities, in consultation with the South Carolina Department of Health and Environmental Control (SCDHEC), the support agency, will not issue a final decision on cleanup until comments from the public are considered.

The EPA is issuing this Proposed Plan as part of its public participation responsibilities under Section 117(A) of the **Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA)** and Section 300.430(f)(2) of the **National Contingency Plan (NCP)**. This Proposed Plan summarizes information that can be found in greater detail in the **Remedial Investigation/Feasibility Study (RI/FS)** reports and other technical documents in the **Administrative Record** file for this site. This plan summarizes key information from the Administrative Record, but is not a substitute for the documents in it.

Refer to the **information repositories** listed on page 16 for further details.

To Help You Understand this Proposed Plan. Acronyms are defined in the box below, listed in the order in which they appear. Terms that appear in **bold** throughout the text are defined in the glossary at the end of this publication.

EPA	U.S. Environmental Protection Agency
SCDHEC	South Carolina Department of Health and Environmental Control
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
NCP	National Contingency Plan
RI/FS	Remedial Investigation/Feasibility Study
RCRA	Resource Conservation and Recovery Act
NPDES	National Pollutant Discharge Elimination System
RAO	Remedial Action Objective
mg/kg	milligrams per kilogram
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
PRB	Permeable Reactive Barrier
O&M	Operation and Maintenance
S/S	Stabilization/Solidification
DPT	Direct Push Technology
ARARs	Applicable or Relevant and Appropriate Requirements

EPA's Proposed Cleanup Plan
Public Comment Period:
April 11 - May 11, 2002

Public Meeting —April 18, 2002
Commissioner of
Public Works Building
103 St. Philip Street
7:00 p.m.

SITE BACKGROUND

The former Macalloy plant is located at 1800 Pittsburgh Avenue on approximately 147 acres fronting Shipyard Creek in an industrial and commercial section of the Charleston Peninsula (see Figures 1 and 2 at the end of this publication). The plant produced ferrochromium alloy by smelting chromium ore in submerged electric arc furnaces. It was owned/operated by Pittsburgh Metallurgical Company from 1941 to 1966, Airco (British Oxygen Corporation) from 1966 to 1979, and Macalloy from 1979 to July 1998, when alloy production ceased. At various times from 1942 to the present, the Department of Defense has owned, operated, or otherwise used portions of the site to produce and store ferrochromium alloy, chrome ore, and slag (waste).

Raw materials and finished product were transported from the plant via rail, highways, and the adjacent Shipyard Creek. Alloy manufacturing activities have resulted in the generation of slag, fine particulate matter, ashes and dust, gas conditioning tower sludge and associated wastewater, and air pollution control equipment dust.

During its final years of operation, the plant was regulated by several federal environmental statutes, primarily the **Clean Water Act**, the **Clean Air Act**, and the **Resource Conservation and Recovery Act (RCRA)**. Macalloy began the RCRA corrective action process in 1996. In January 1997, pursuant to the terms of a consent order with the SCDHEC, Macalloy initiated offsite disposal of treated dust from an unlined surface impoundment. Macalloy also initiated a removal action in June 1998 under a consent order with EPA to implement a surface water management system to mitigate transport of contaminants to Shipyard Creek while a final site remedy was developed.

After production at the plant ceased in July 1998, Macalloy, the EPA, and the SCDHEC decided that **CERCLA** would be a more appropriate mechanism for this site. Subsequently, it was proposed for inclusion on the **National Priorities List** on October 22, 1999, and was listed as "final" the following February. On March 29, 2000, Macalloy entered into an agreement with the EPA to perform a CERCLA RI/FS. The RI/FS work plan was approved as final by EPA on June 1, 2000.

In December 2000, the first phase of the RI was completed by Macalloy with oversight by EPA and SCDHEC. The primary focus of Phase I was to assess the nature and extent of soil and groundwater contamination on the Macalloy property and to evaluate the risk to human health and the environment from site media. The *Final Phase I RI Report* was approved by EPA on May 17, 2001. Several data gaps were identified in the Phase I RI that needed to be filled before an FS could begin. Therefore, a second phase of the RI was conducted in June 2001. The primary focus was to assess risk to human and ecological receptors from potential contamination in Shipyard Creek. The *Final Phase II RI Report* was approved by EPA on March 21, 2002.

SITE CHARACTERISTICS

The Phase I and Phase II RIs indicated that:

- Approximately 60,000 cubic yards of site soil are contaminated with **hexavalent chromium** that can **leach** to groundwater and surface water at concentrations hazardous to human health and the environment. Contamination is primarily concentrated in and around a former marsh that was filled with material from plant operations, including raw materials, slag, sludge, and treated and untreated dust from air pollution control equipment. The contamination extends from the surface to a depth of approximately 6 feet. A small quantity of contaminated soil (1,500 cubic yards) was found in other isolated areas of the plant. An additional 55,000 cubic yards of onsite material used as **berm** material for surface impoundments also contain elevated concentrations of hexavalent chromium. Figure 3 delineates the areas of soil contamination.

- A **plume** of groundwater contaminated with hexavalent chromium extends from this former marsh area to Shipyard Creek. A second plume of hexavalent chromium is in the plant's former concentrator area (see Figure 4). The plumes are confined to the shallow aquifer and have not penetrated a clay confining layer that occurs approximately 20 feet below ground surface.

- Approximately 110 cubic yards of soil and debris with gamma radiation levels greater than **background levels** were identified near the former concentrator area (see Figure 2). This material is believed to have been brought to the site in railcars carrying feedstock for alloy production. The average depth of the material is 18 inches. The **radionuclides** detected were radium-226, thorium-232, potassium-40, and uranium -235.

Continued on page 3

SITE CHARACTERISTICS

Continued from page 2

- Surface water samples collected pursuant to the **National Pollutant Discharge Elimination System (NPDES)** permit indicated the hexavalent chromium limit was exceeded in three surface water sampling locations associated with the storm water management system. Other metals including **arsenic, copper, lead,** and **zinc** were identified as being a concern due to offsite discharge to Shipyard Creek.

- Sediment in a tidal creek (Zone A, Figure 3), formerly an outfall for onsite surface water discharging to Shipyard Creek, contained elevated levels of **total chromium, nickel,** and zinc. The volume of contaminated sediment was estimated to be 1,000 cubic yards to a depth of 18 inches.

The contaminated unsaturated and saturated soil in the dust impoundment and former marsh area are source materials that continue to impact groundwater and surface water quality. Therefore, this material is considered a **principal threat waste.**

SCOPE AND ROLE OF THE ACTION

The EPA's proposed cleanup plan described in this document is intended to be the final action for remediating the site. This site-wide proposed plan will address the following:

Medium	Contamination
surface/subsurface soil	hexavalent chromium
shallow groundwater	hexavalent chromium
debris	gamma radiation
sediment	total chromium, nickel, and zinc
storm water	arsenic, copper, hexavalent chromium, lead, and zinc

SUMMARY OF SITE RISKS

As part of the RI/FS, a **Baseline Risk Assessment** was conducted to evaluate current and potential effects of contaminants on human health and the environment. Human health exposure pathways evaluated in this assessment included ingestion, inhalation, and dermal contact with surface soils and groundwater and ingestion of shellfish from Shipyard Creek. The EPA based its cleanup levels on an expected future industrial land use exposure scenario for an on-site worker.

Groundwater ingestion is not a likely exposure pathway since shallow groundwater at Macalloy is not currently used for consumption, and won't likely be in the future. Available data indicate that the shallow aquifer quality does not meet primary and secondary drinking water standards promulgated under the **Safe Drinking Water Act.** Nonetheless, shallow groundwater beneath the site was conservatively assumed to be a source of drinking water because South Carolina classifies all groundwater as a potential underground source of drinking water.

Ecological exposure pathways included direct exposure of terrestrial and aquatic communities to site soil and Shipyard Creek sediment and surface water as well as indirect (food-chain) exposure to species that use both habitats.

Actual or threatened releases of hazardous substances from this site, if not addressed by the Preferred Alternative or one of the other active measures considered, may present a current or potential threat to public health, welfare, or the environment.

Human Health Risks

Risk levels for potential cancer-causing chemicals are based on the concentration of the chemical and its strength as a cancer-causing agent. A risk range of 10^{-4} to 10^{-6} for the protection of human health is generally considered acceptable. This range would mean an increased chance of no more than one additional case of cancer in 10,000 (10^{-4}) to one million (10^{-6}) people.

Chemicals producing harmful effects other than cancer are compared with reference doses (highest levels not causing harmful effects) to calculate a hazard quotient. A hazard quotient above 1 indicates that constituents are present at concentrations that may produce harmful effects other than cancer.

No chemicals of concern were identified for surface soil under the future site worker (industrial) scenario. However, hexavalent chromium was identified as a contaminant in soil that could **leach** to shallow groundwater at concentrations hazardous to human health.

Risk and hazard calculations were overwhelmingly driven by the conservative assumption that groundwater will be used as drinking water.

Continued on page 4

Human Health Risks *Continued from page 3*

Hexavalent chromium in shallow groundwater accounted for 91% of the hazard associated with ingestion (hazard quotient=31). Calculated carcinogenic risk (5E-05) was within the EPA's acceptable risk range. No chemicals of concern were identified for groundwater below the clay confining unit under the future site worker scenario.

No chemicals of concern for shellfish ingestion were identified in the human health risk assessment under the assumption that recreational receptors would consume equal quantities of crab, oyster, and shrimp from Shipyard Creek. Using the conservative assumption that receptors consume only shrimp harvested downgradient of Macalloy, arsenic in shrimp was the only chemical that exceeded **reasonable maximum exposure** hazard quotient and cancer risk values.

However, the calculated risk levels are within the range calculated for ingesting shellfish containing arsenic at background levels. No chemicals of concern were identified for the **central tendency exposure** evaluations.

A general area gamma radiation survey was performed by the EPA to evaluate the nature and extent of potential radiological contamination across the Macalloy site and the potential risk posed to the public. The survey indicated a small area near the former concentrator building had elevated radiation levels (twice background or higher).

Ecological Risks

Following a preliminary evaluation of contaminant concentrations in site soil and in Shipyard Creek surface water and sediment, additional data were collected to evaluate risk to ecological receptors across expected contaminant gradients in three zones of Shipyard Creek (A, B, and C) (see Figure 2). Sediment chemistry, **acute** and **chronic** sediment **toxicity** testing, grass shrimp abundance, tissue chemistry, and food-chain modeling were used to assess potential risk to ecological receptors based on a multiple lines-of-evidence approach.

Results from the selected measurement endpoints demonstrated that no unacceptable risk exists in Zone B. One measurement endpoint in Zone C indicated unacceptable risks. However, based on the strength and magnitude of observed adverse effects and the expectation of diminishing risks following remediation, a risk management decision was made to monitor only in Zone C. Zone A comprises a small tidal creek that historically received process water discharges from plant operations. Sediments within this channel contained elevated concentrations of total chromium, nickel, and zinc above protective ecological criteria and exhibited chronic effects on grass shrimp in laboratory toxicity tests. For these reasons, EPA concluded there is an unacceptable risk to the **benthic** community, and Zone A was retained for further evaluation in the FS.

Fate and Transport Summary

Soil-to-groundwater, groundwater-to-surface water, and onsite soil- and surface water-to-offsite surface water pathways and receptors were evaluated for each constituent detected at Macalloy. Hexavalent chromium, antimony, arsenic, trivalent chromium, and copper were identified as contaminants having potentially significant migration pathways in the RI.

Hexavalent chromium exceeded its site-specific screening level in soil samples that were generally associated with a groundwater plume. Hexavalent chromium groundwater concentrations also exceeded its surface water screening value within the plume. A significant portion of the hexavalent chromium groundwater plume lies adjacent to the marsh and Shipyard Creek and could potentially migrate to that surface water body. However, no marsh well samples had hexavalent chromium. Additionally, hexavalent chromium is thought to be discharging to onsite surface water due to site hydrogeology. Because of the migration pathways for hexavalent chromium from soil and groundwater, it was retained for further evaluation in the FS.

Antimony and arsenic exceeded site-specific screening levels and/or background concentrations in soil. Arsenic also exceeded its MCL and surface water screening criteria in isolated groundwater wells. However for both of these metals, there is no discernable groundwater plume and their human health risk assessment in groundwater produced hazard quotients less than 1. Therefore, antimony and arsenic were not retained for further evaluation in the FS.

Trivalent chromium exceeded its surface water screening criteria in several groundwater samples. However, trivalent chromium's solubility (and thus its mobility in groundwater) is very low and its

Continued on page 5

Fate and Transport Summary

Continued from page 4

presence in the samples may be associated with solid particles remaining in the well after drilling. These solids are not mobile in groundwater. None of the filtered groundwater samples from the marsh wells had trivalent chromium exceeding the surface water criteria. Therefore, trivalent chromium was not retained for further evaluation in the FS.

Copper in groundwater exceeded its surface water criteria in six isolated wells. But since there was no discernable groundwater plume, and none of the filtered samples from the marsh wells exceeded copper surface water criteria, it was not retained for further evaluation in the FS.

REMEDIAL ACTION OBJECTIVES

Based on the RI and Baseline Risk Assessment results, the following Remedial Action Objectives (RAOs) were developed for the Macalloy site:

- Prevent future site worker exposure to unacceptable hazard levels in groundwater.
- Remediate shallow groundwater zones exhibiting the highest concentrations of hexavalent chromium and limit its migration to Shipyard Creek to minimize long-term threats.
- Remediate soil that leaches hexavalent chromium to groundwater and surface water at concentrations hazardous to human health and the environment.
- Mitigate offsite hexavalent chromium discharges in storm water to Shipyard Creek through a combination of the aforementioned remediation measures and a comprehensive site-wide storm water management plan.
- Manage storm water discharges of toxic inorganic compounds in accordance with the comprehensive storm water management plan to protect ambient saltwater quality in Shipyard Creek.
- Remediate soil and debris that produce elevated levels of gamma radiation to mitigate current exposure pathways.
- Mitigate the exposure of benthic organisms to contaminated sediments in the tidal creek.

The actions proposed in this plan will address these RAOs by:

- Reducing hexavalent chromium concentrations in soil to 23 **milligrams per kilogram (mg/kg).** This remedial goal is a site-specific concentration calculated to prevent leaching of hexavalent chromium from soil to groundwater at concentrations above the groundwater **maximum contaminant level (MCL).**
- Reducing radiation levels in soil and debris to 12 micro-Roentgens per hour, which is twice the background radiation level at the Macalloy site.
- Reducing hexavalent chromium concentrations in groundwater to less than 100 micrograms per liter (μg/L). MCL compliance will be monitored on a site-wide basis to ensure groundwater quality remains protective of human health and the environment.
- Reducing concentrations of lead, arsenic, hexavalent chromium, copper, and zinc in storm water to the remedial goals listed below. These goals were developed to meet the substantive requirements of the Clean Water Act.

Parameter	Limit
Flow	Report
Total suspended solids (μg/L)	110,000
Total lead (μg/L)	220
Total arsenic (μg/L)	69
Total copper (μg/L)	5.8
Total zinc (μg/L)	9.5
Hexavalent chromium (μg/L)	1,100
Acute Whole Effluent Toxicity	report

- Reducing exposure of benthic organisms to unacceptable concentrations of chromium, nickel, and zinc in tidal creek sediment.

SUMMARY OF REMEDIAL ALTERNATIVES

Remedial alternatives for the Macalloy site are summarized in the table on the next page. The alternatives are numbered to correspond with the numbers in the FS report.

SOIL ALTERNATIVES

For all soil alternatives, a deed restriction that prohibits residential reuse of the property would need to be implemented.

Alternative S1: No Action
Estimated Capital Cost: $0
Estimated Annual Operation and Maintenance (O&M) Cost: $10,000 every 5 years
Estimated Present Worth Cost: $22,000
Estimated Construction Time Frame: None
Estimated Time to Achieve RAOS: Not applicable

The no-action alternative is considered a baseline against which other alternatives are compared. In the no-action alternative, no remedial actions are taken to contain, remove, or treat contaminated soil or to prevent contaminant leaching from soil to groundwater. Under this alternative, no changes would be made to existing site conditions or exposure scenarios. NCP-required five-year monitoring costs are associated with this alternative. **Present worth analysis** costs are based on review once every five years for 30 years.

Alternative S2a: Onsite Chemical Reduction and Stabilization/Solidification: In Situ Injection and Ex Situ Treatment of Berm and Shallow Isolated Areas
Estimated Capital Cost: $6,773,000
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $6,773,000
Estimated Construction Time Frame: 6 months
Estimated Time to Achieve RAOs: 6 months

Reduction and stabilization/solidification (s/s) systems reduce the solubility or chemical reactivity of a waste by changing its chemical state or by physical entrapment. The actual mechanisms of reduction and s/s depend on the chemical agents used and the soil's characteristics. Reduction and s/s occur either **in situ** or **ex situ**.

Chemical reduction can be promoted by injecting, infiltrating, or mixing a reductant into the soil, resulting in the conversion of hexavalent chromium to trivalent chromium, a less toxic and less mobile form of the metal. Ferrous sulfate has been demonstrated to be an effective reductant for soil contaminated with hexavalent chromium.

S/s, if needed, generally requires mixing the soil with an s/s reagent, such as Portland cement, to immobilize contaminants and strengthen the soil.

Approximately 55,000 cubic yards of berm material and 1,500 cubic yards of shallow, isolated soil areas would be treated ex situ with a mixing device such as a pugmill and placed as compacted fill onsite, consistent with site redevelopment. The remaining 60,000 cubic yards of soil would be treated by in situ injection techniques.

EPA has recently conducted bench-scale and pilot-scale studies to evaluate various reductants and injection methods for treating hexavalent chromium-contaminated soil at Macalloy.

Direct-push technology (DPT) was applied during the pilot study at strategic locations. DPT provides a mechanism for rapid, economical injection of reductants (s/s agents are not used with this delivery option).

This system uses hydraulic pressure and/or a percussion hammer to push metal rods into subsurface soil. The reductant can be injected into the soil as the rods are slowly removed from the subsurface. The EPA pilot study results indicated that this method has limited effectiveness in Macalloy soil.

Confirmation sampling would be required to verify that the remedial goals have been met following treatment. Long-term effectiveness of this alternative would be evaluated with the groundwater monitoring program developed for the groundwater remedial alternatives discussed later in this Proposed Plan.

Alternative S2b: Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with Mechanical Mixing
Estimated Capital Cost: $7,883,000
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $7,883,000
Estimated Construction Time Frame: 7 months
Estimated Time to Achieve RAOs: 7 months

This alternative is similar to S2a, except that all 115,000 cubic yards of contaminated berm material and soil would be excavated and treated ex situ by mechanical mixing methods. Excavated soil would be placed in thin layers in its original location or in other onsite locations, consistent with site redevelopment. Soil would be mixed with reductants and s/s agents using common construction equipment such as tillers and scarifiers, augers, backhoes, track mixers, or high speed rotary mixers.

Continued on page 7 after the table.

SUMMARY OF REMEDIAL ALTERNATIVES
MACALLOY CORPORATION SITE

Medium	FS Designation	Description
Soil	S1	No action
	S2a	Onsite chemical reduction and stabilization/solidification: in situ injection and ex situ treatment of berm and shallow isolated areas
	S2b	Onsite chemical reduction and stabilization/solidification: ex situ treatment with mechanical mixing
	S2c	Onsite chemical reduction and stabilization/solidification: ex situ treatment with a pugmill
	S3	Excavation with offsite disposal
	S4	Hot mix asphalt cap
Groundwater	G1	No action
	G2a	Enhanced in situ reduction: Hydrogen Release Compound™
	G2b	Enhanced in situ reduction: chemical reductant
	G2c	Enhanced in situ reduction: carbohydrate reductant
	G3	Zero-valent iron permeable reactive barrier with enhanced in situ reduction
	G4	Groundwater containment
Radiological Material	R1	No action
	R2	Excavation and offsite disposal
	R3	Soil cover
Sediment	M1	No action
	M2	Enhanced monitored natural recovery
	M3	Cap
	M4	Excavation and upland disposal
Storm Water	—	Comprehensive storm water management plan

Alternative S2b: Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with Mechanical Mixing *Continued from page 6*

Confirmation sampling would verify that the remedial goals have been met following treatment. As with Alternative S2a, long-term effectiveness of the alternative would be evaluated with the groundwater remedy.

Ex situ treatment methods involve significantly more material handling than in situ methods; however, ex situ methods offer the ability to carefully control mixing and blending ratios and may require less reagent than in situ techniques. Mechanical mixing techniques can also be used to treat contaminated soil in place below the water table.

Alternative S2c: Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with a Pugmill

Estimated Capital Cost: $10,372,000
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $10,372,000
Estimated Construction Time Frame: 7 months
Estimated Time to Achieve RAOs: 7 months

This alternative is similar to S2b, except that the 115,000 cubic yards of excavated soil and berm material would be mixed in a pugmill. This technology includes:

1. Staging excavated soil.
2. Screening soil to remove materials too large in diameter to be effectively treated by pugmill.
3. Blending the reducing and stabilizing agents and water in a continuous feed or batch operation.

Continued on page 8

Alternative S2c: Onsite Chemical Reduction and Stabilization/Solidification: Ex Situ Treatment with a Pugmill *Continued from page 7*

4. Placing the treated material back into the excavation or in other areas needing fill.
5. Conducting confirmation sampling.

The long-term effectiveness of the alternative would be evaluated with the groundwater remedy.

Although a pugmill is an effective and proven mixing technology, it does not offer the ability to treat contaminated soil in place below the water table, and it is sensitive to the size, hardness, and abrasiveness of the material being treated.

Alternative S3: Excavation with Offsite Disposal
Estimated Capital Cost: $8,872,000
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $8,872,000
Estimated Construction Time Frame: 6 months
Estimated Time to Achieve RAOs: 6 months

Approximately 115,000 cubic yards of contaminated soil and berm material would be excavated and transported to a RCRA-permitted offsite treatment and/or disposal facility. Prior to disposal, some pre-treatment may be required to meet **land disposal restrictions**. The open excavation would then be backfilled with clean soil. Confirmation samples would be collected from the excavation to confirm removal of soil with contaminant concentrations exceeding the remedial goal.

No long-term maintenance or monitoring would be required after excavating and disposing of the contaminated soil.

Alternative S4: Hot Mix Asphalt Cap
Estimated Capital Cost: $6,259,000
Estimated Annual O&M Cost: $11,000 each year and $732,000 at year 15
Estimated Present Worth Cost: $6,681,000
Estimated Construction Time Frame: 5 months
Estimated Time to Achieve RAOs: 5 months

An asphalt cap is a source containment alternative used to control the vertical migration of contaminants by reducing or eliminating surface water infiltration through soil that results in the production of **leachate**. **Institutional controls** and regular maintenance are required to ensure the cap's performance over time. The cap would be designed to reduce the leaching of hexavalent chromium to minimize groundwater and surface water contamination, as well as to support industrial traffic loads.

Initially, approximately 55,000 cubic yards of berm material and contaminated soil from isolated areas would be excavated and treated ex situ using the chemical reduction and s/s techniques discussed in Alternative S2c, and consolidated within the proposed 12-acre cap area or used as fill material elsewhere onsite. These consolidated materials would be compacted to form a dense, strong base to support a hot mix asphalt cap for the remaining 60,000 cubic yard of contaminated soil.

Because of the cap's susceptibility to weathering, cracking, and subsidence, the long-term effectiveness of this alternative would be a function of proper and regular maintenance. The system would require five-year reviews and ongoing repairs. During the life of the cap, the pavement would be inspected and repaired as needed to maintain its protective capacity. Resurfacing the capped area with asphalt after 15 years was included in the cost estimate. A deed restriction would ensure that any necessary excavation or disturbance of the cap would be properly repaired.

GROUNDWATER ALTERNATIVES

Alternative G1: No Action
Estimated Capital Cost: $40,000
Estimated Annual O&M Cost: $18,000 every 5 years
Estimated Present Worth Cost: $79,000
Estimated Construction Time Frame: None
Estimated Time to Achieve RAOs: Not applicable

The NCP requires that a no-action alternative be considered as a baseline against which all other alternatives will be evaluated. In the no-action alternative, no remedial action would be taken, future site use would be uncontrolled, and groundwater could be used for residential purposes. Groundwater would remain in place to attenuate according to natural processes. No engineering or institutional controls would be implemented. NCP-required five-year monitoring costs are associated with this alternative. Costs are based on groundwater sampling and data review once every five years for 30 years.

Continued on page 9

GROUNDWATER ALTERNATIVES
continued from page 8

Alternative G2a: Enhanced In Situ Reduction: Hydrogen Release Compound™
Estimated Capital Cost: $1,462,000
Estimated Annual O&M Cost: $84,000
Estimated Present Worth Cost: $1,672,000
Estimated Construction Time Frame: 2 months
Estimated Time to Achieve RAOs: 2 years

An enhanced in situ reductive treatment system intercepts migrating contaminants in groundwater and permanently immobilizes or degrades them into harmless end products. The results of the RI groundwater investigation indicated that hexavalent chromium reduction is favorable in the shallow aquifer. The reductants can be delivered passively, actively, or as a combination of the two and can address source areas, as well as provide downgradient containment.

In this alternative, a grid-based application of the reductant would be delivered to the groundwater plume by DPT in one or two applications. The reductant in this alternative is Hydrogen Release Compound™, a proprietary compound manufactured as a viscous gel, which promotes biological reduction of hexavalent chromium to trivalent chromium, which is less toxic and less mobile. An advantage of the Hydrogen Release Compound™ is that it is a time-release compound that can take advantage of groundwater movement for contaminant reduction. Groundwater monitoring for five years after implementation of this alternative is required to evaluate system effectiveness.

Alternative G2b: Enhanced In Situ Reduction: Chemical Reductant
Estimated Capital Cost: $1,843,000
Estimated Annual O&M Cost: $84,000
Estimated Present Worth Cost: $2,053,000
Estimated Construction Time Frame: 2 months
Estimated Time to Achieve RAOs: 2 years

This alternative is similar to Alternative G2a, except that a chemical reductant is used rather than the Hydrogen Release Compound™. The EPA has recently completed a pilot study indicating that a mixture of ferrous sulfate and sodium dithionite quickly and effectively reduced hexavalent chromium to trivalent chromium in shallow groundwater at the Macalloy site. Other chemicals may also be considered during remedial design.

The delivery methods pilot-tested by the EPA consisted of grids of DPT points and temporary groundwater wells. Other potential delivery options include a gallery of pipes or surface impoundments to infiltrate the reductant. Groundwater monitoring for five years after implementation of this alternative is required to evaluate system effectiveness.

Alternative G2c: Enhanced In Situ Reduction: Carbohydrate Reductant
Estimated Capital Cost: $471,000
Estimated Annual O&M Cost: $192,000
Estimated Present Worth Cost: $1,012,000
Estimated Construction Time Frame: 1 month
Estimated Time to Achieve RAOs: 3 years

This alternative is similar to Alternatives G2a and G2b, except that a common carbohydrate is used as the reductant. The carbohydrate reductant would be delivered via groundwater wells, an infiltration gallery, or trenches. The carbohydrate would be injected or infiltrated routinely (weekly or monthly) during the treatment period, which would vary based on the application layout. Because the carbohydrate would have to be routinely injected over a period of time, it may not achieve remedial goals as quickly as the Hydrogen Release Compound™ or a chemical reductant. Groundwater monitoring for five years after implementation of this alternative is required to evaluate system effectiveness.

Alternative G3: Zero-Valent Iron Permeable Reactive Barrier (PRB) with Enhanced In Situ Reduction
Estimated Capital Cost: $1,958,000
Estimated Annual O&M Cost: $51,000
Estimated Present Worth Cost: $2,591,000
Estimated Construction Time Frame: 1 month
Estimated Time to Achieve RAOs: 30 years

A PRB would be installed downgradient of the hexavalent chromium plume along Shipyard Creek, perpendicular to groundwater flow, to treat hexavalent chromium in groundwater before it migrates offsite.

Groundwater would flow through a reactive medium (iron filings) and be passively treated to meet remedial goals.

Enhanced in situ reduction as discussed in Alternative G2b would be used to target the hexavalent chromium contamination near the concentrator area. *Continued on page 10*

Alternative G3: Zero-Valent Iron Permeable Reactive Barrier (PRB) with Enhanced In Situ Reduction *Continued from page 9*

The PRB provides containment only and does not remove or destroy the source of contamination. Long-term operation and maintenance of the PRB would be required along with groundwater monitoring. For the FS, an operating period of 30 years was assumed.

Alternative G4: Groundwater Containment
Estimated Capital Cost: $655,000
Estimated Annual O&M Cost: $99,000
Estimated Present Worth Cost: $1,883,000
Estimated Construction Time Frame: 1 month
Estimated Time to Achieve RAOs: 30 years

Pump-and-treat is a containment remedy for hexavalent chromium-contaminated groundwater. It includes long-term groundwater extraction, treatment, and disposal of the extracted groundwater. Macalloy operated a pump-and-treat system for hexavalent chromium-contaminated groundwater at its plant from 1996 to June 2000. Operation was suspended prior to the RI so that the groundwater investigation would not be artificially influenced by the extraction system.

When operating, groundwater was pumped from 21 extraction wells to a treatment system that used ferrous sulfate to convert hexavalent chromium to trivalent chromium.

The treated water was discharged to Shipyard Creek via a permitted outfall. The effectiveness of the groundwater remediation system was evaluated during the RI. Results indicated that the extraction wells cannot be pumped at a sustainable rate that would maintain a significant and effective contaminant capture zone.

Alternative G4 proposes to modify the existing system to improve its effectiveness. The modified groundwater collection and treatment system would include abandonment of the current extraction wells, installation of collection trenches, upgrade of the current ex situ treatment system, and system monitoring. The goal of the new system would be to minimize downgradient migration of hexavalent chromium.

Treated groundwater would be discharged to the sanitary sewer, discharged directly to waters of the state via an NPDES permit, or reinjected into the same aquifer. The pump-and-treat system would require long-term operation and maintenance and a long-term groundwater monitoring program to verify its effectiveness.

RADIOLOGICAL MATERIAL ALTERNATIVES

Alternative R1: No Action
Estimated Capital Cost: $0
Estimated Annual O&M Cost: $5,000 every 5 years
Estimated Present Worth Cost: $11,000
Estimated Construction Time Frame: None
Estimated Time to Achieve RAOs: Not applicable

The no-action alternative is considered a baseline against which other alternatives are compared. In this alternative, no remedial actions would be taken to contain, remove, or treat radioactive materials, and no changes would be made to existing site conditions or exposure scenarios. NCP-required five-year monitoring costs are associated with this alternative.

Alternative R2: Excavation with Offsite Disposal
Estimated Capital Cost: $15,000
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $15,000
Estimated Construction Time Frame: 1 week
Estimated Time to Achieve RAOs: 1 week

In this alternative, approximately 110 cubic yards of soil and debris that produce gamma radiation exceeding the remedial goal would be excavated and disposed of in a Subtitle D landfill in South Carolina. Confirmation sampling (screening) would be conducted to verify that materials producing gamma radiation above the remedial goal were removed.

The area would be backfilled using onsite borrow materials. No long-term operation, maintenance, or monitoring is associated with this alternative.

Alternative R3: Soil Cover
Estimated Capital Cost: $24,000
Estimated Annual O&M Cost: $14,000
Estimated Present Worth Cost: $41,000
Estimated Construction Time Frame: 1 week
Estimated Time to Achieve RAOs: 30 years

Onsite soil would be used to cover the radioactive soil and debris to mitigate current exposure pathways. The approximately 8,000 ft^2

Continued on page 11

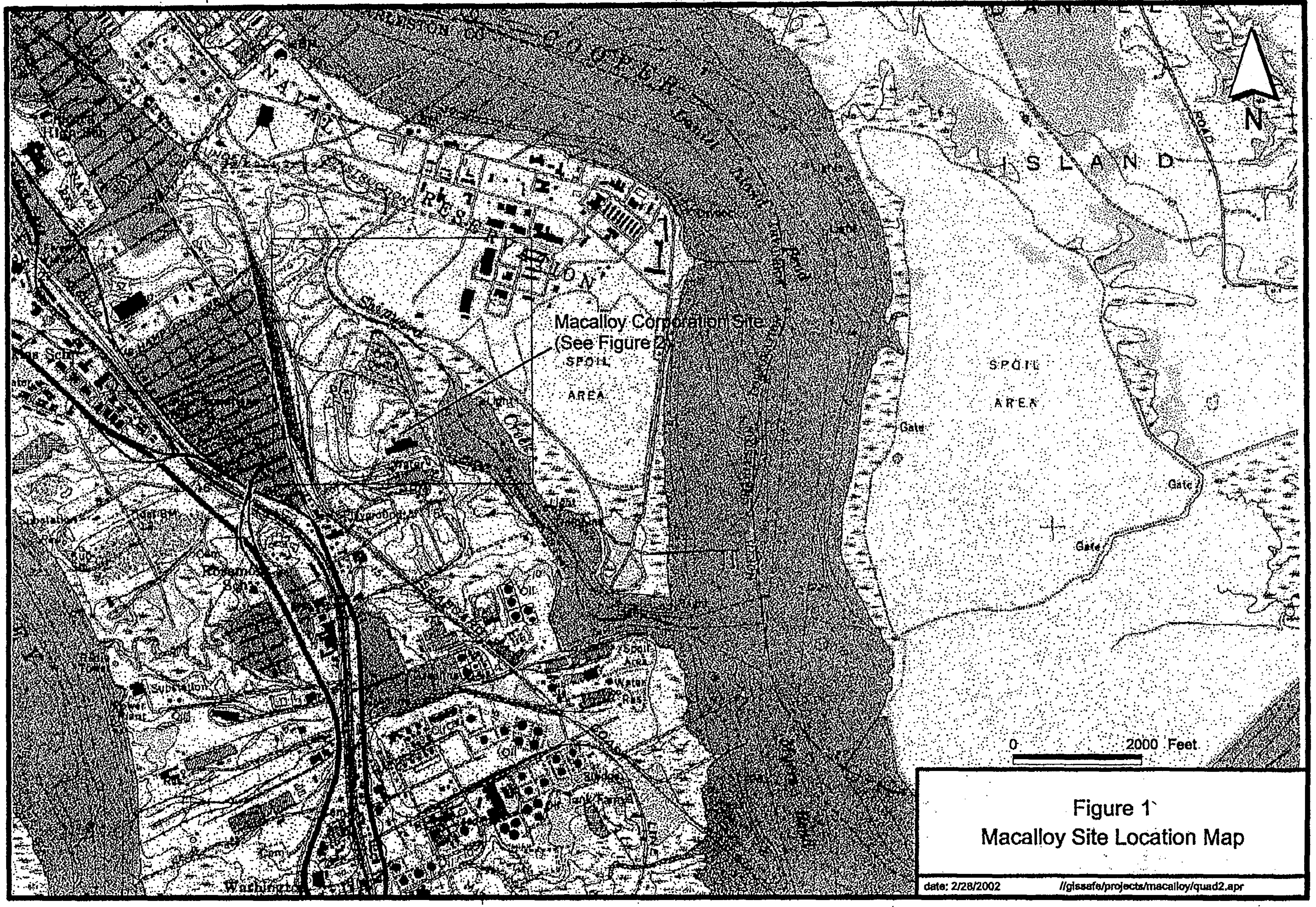


Figure 1`
Macalloy Site Location Map

59 347

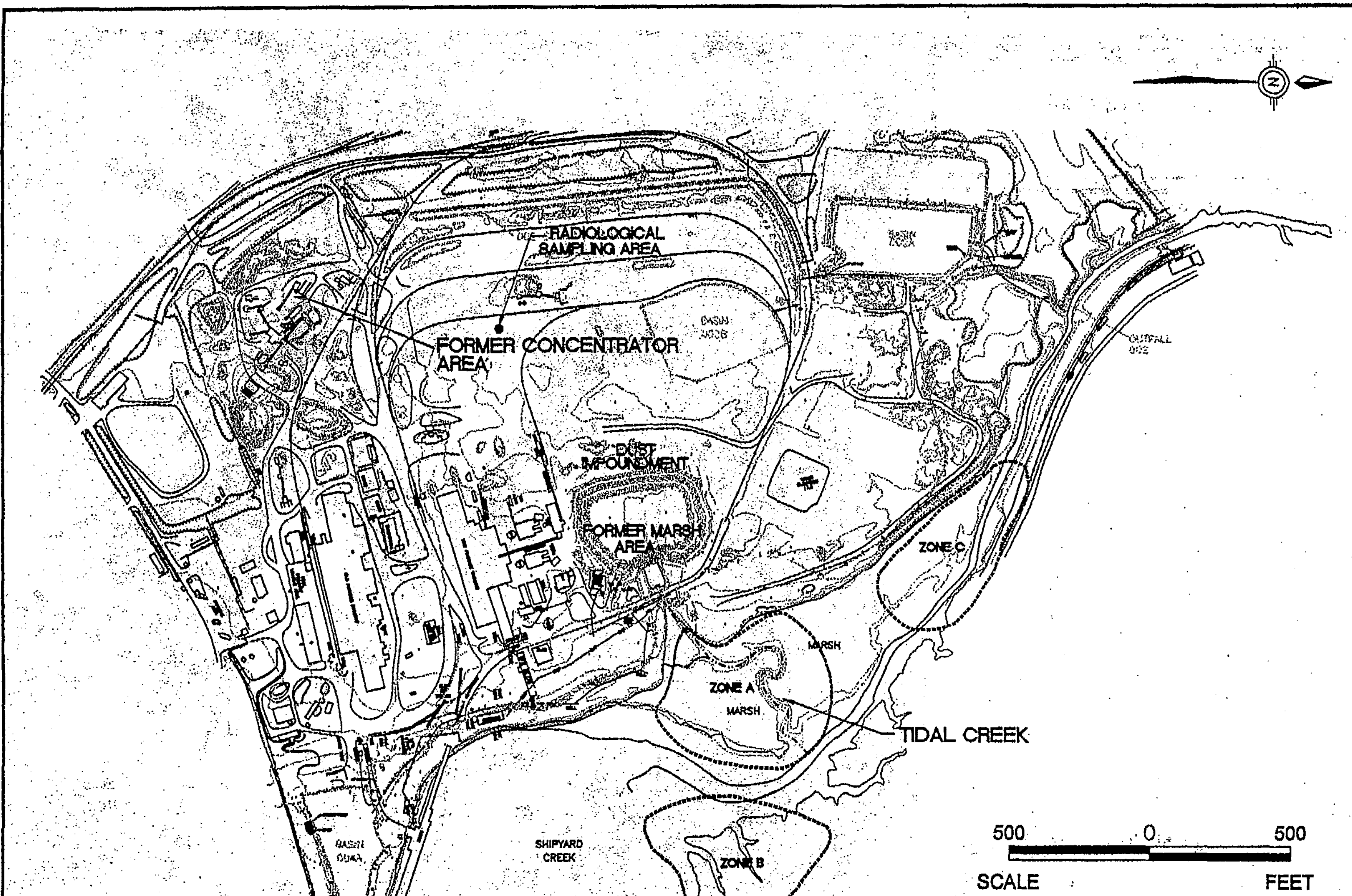
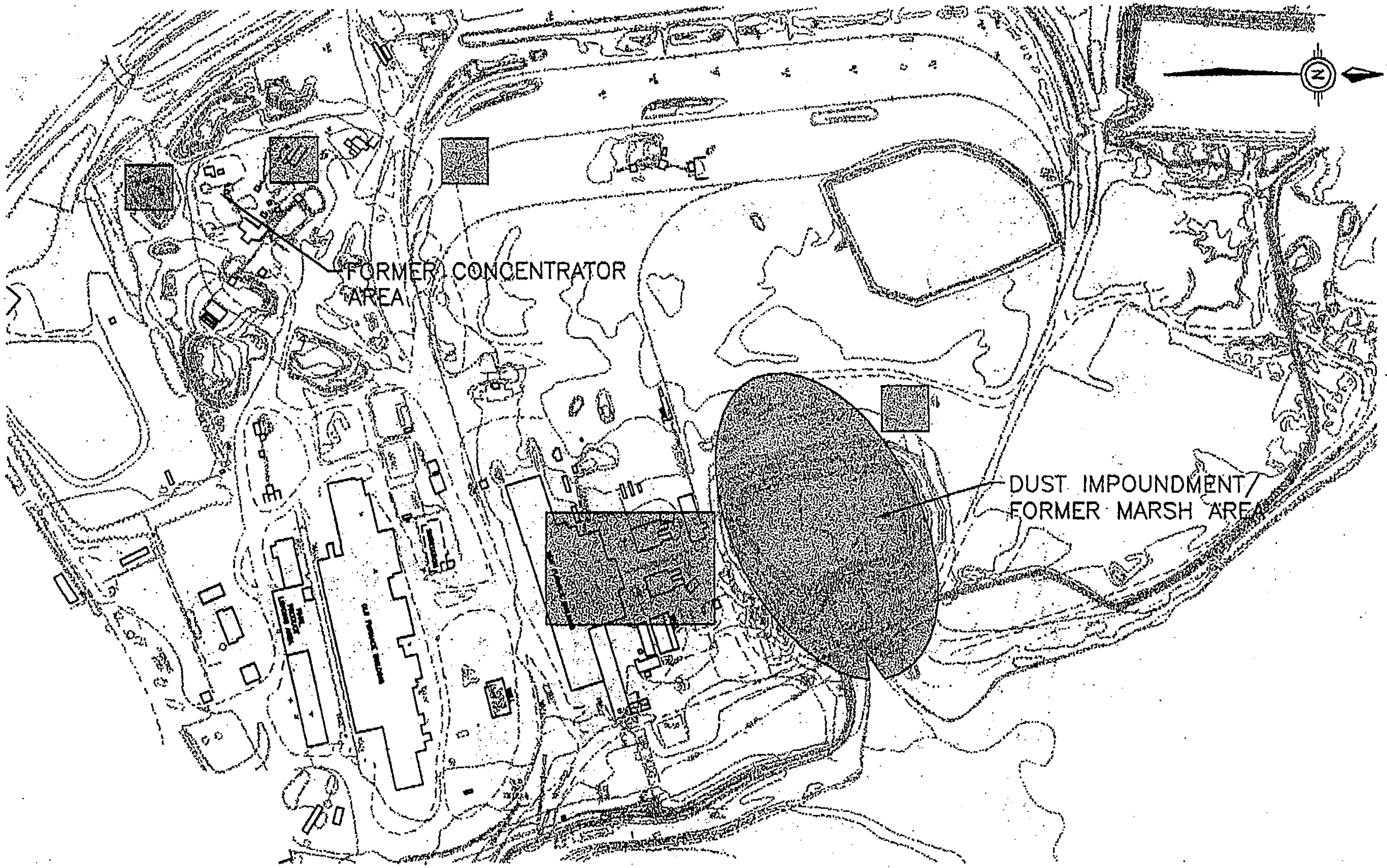


FIGURE 2
MACALLOY CORPORATION SITE

DWG DATE: 02/28/02 | NAME: 2417021B013



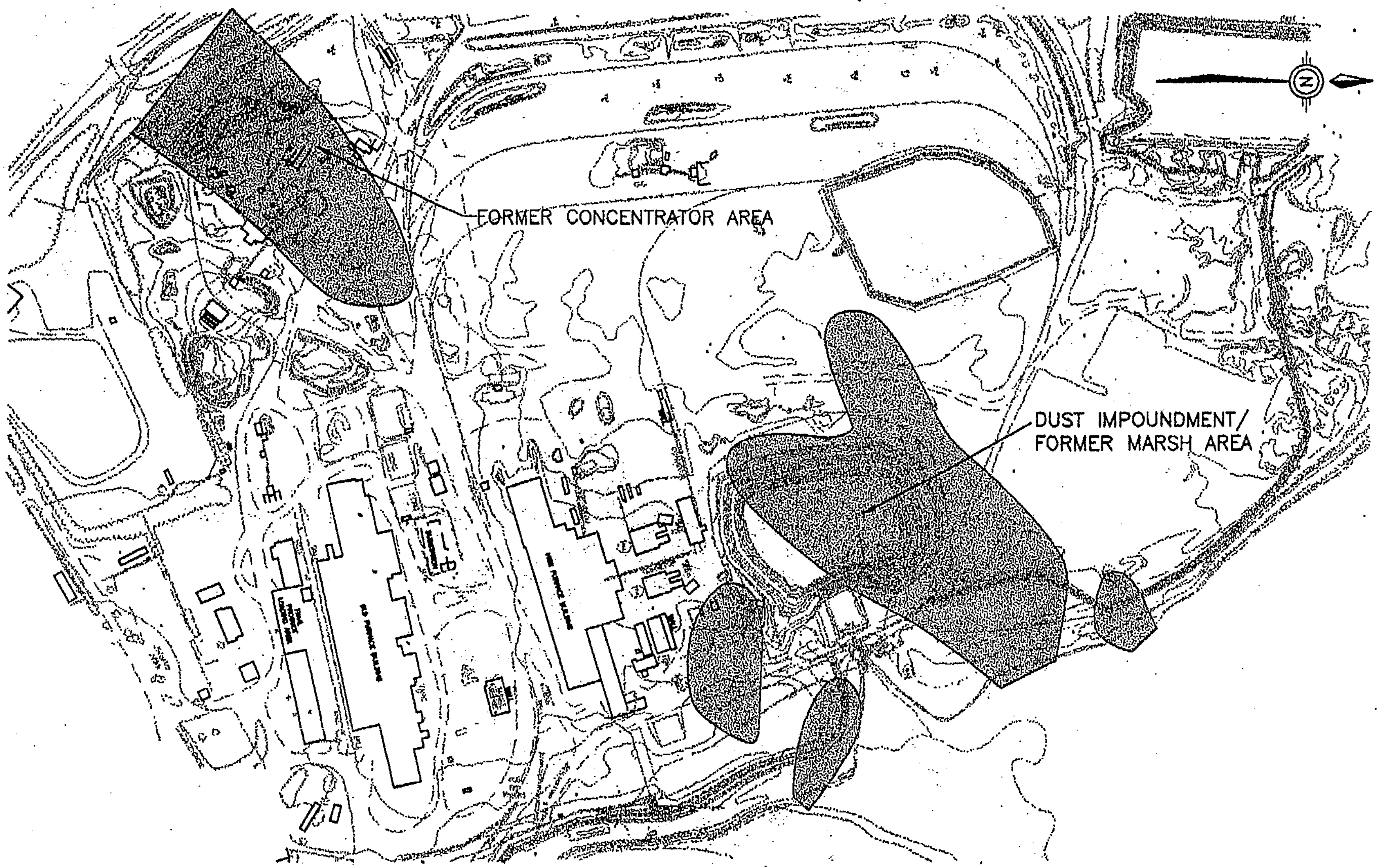
LEGEND

– HEXAVALENT CHROMIUM CONTAMINATED SOIL

350 0 350
SCALE FEET

FIGURE 3
EXTENT OF SOIL CONTAMINATION

DWG DATE: 02/28/02	NAME: 2417021B012



LEGEND

– HEXAVALENT CHROMIUM GROUNDWATER PLUMES

350 0 350

SCALE FEET

FIGURE 4
GROUNDWATER PLUMES

DWG. DATE: 02/28/02 | NAME: 2417021B011

RADIOLOGICAL MATERIAL ALTERNATIVES
Continued from page 10
cover would consist of a seeded, 2-foot-thick soil layer designed to reduce surface radiation below remedial goals. Because the radioactive soil and debris would remain in place, institutional controls would be required to restrict use in this area and prevent future land users from digging there. Long-term monitoring would be required to ensure the protectiveness of the cover.

SEDIMENT ALTERNATIVES

Alternative M1: No Action
Estimated Capital Cost: $0
Estimated Annual O&M Cost: $12,000 every 5 years
Estimated Present Worth Cost: $26,000
Estimated Construction Time Frame: None
Estimated Time to Achieve RAOs: Not applicable

In the no-action alternative, no remedial actions are taken to contain, remove, or treat contaminated sediment. This alternative consists of leaving the contaminated sediment in place in anticipation that natural sedimentation will bury or contain pollutants, forming a natural cap of clean sediment over the contaminated sediments, and reducing or eliminating the transfer of pollutants from the sediments to overlying water and biota.

The 001 outfall, the source of sediment contamination in the tidal creek, has been eliminated. The contaminated sediments are in a relatively low-energy, non-erosive environment that will not likely be disturbed by future dredging or construction. However, data are not currently available for sedimentation rates in the tidal creek. Therefore, it is not possible to quantify current natural sedimentation rates or to accurately estimate the time required to naturally cover existing sediments.

For the cost estimate, five-year monitoring was assumed to consist of sediment chemistry sampling for the three chemicals of concern — total chromium, nickel, and zinc.

Alternative M2: Enhanced Monitored Natural Recovery
Estimated Capital Cost: $50,000
Estimated Annual O&M Cost: $82,000
Estimated Present Worth Cost: $626,000
Estimated Construction Time Frame: 2 weeks
Estimated Time to Achieve RAOs: 10 years

This alternative is similar to the no-action alternative described in the previous section in that contaminated sediments would remain in place to attenuate naturally to mitigate risks to benthic organisms. However, this alternative is distinguished from the no-action alternative in three important ways.

- It provides for more extensive monitoring of natural creek recovery.
- It assesses the rate of natural sedimentation and provides for enhanced sedimentation through the use of sediment barriers, if necessary.
- It provides a way to assess the success/failure of the alternative, leading to a decision of no further action, continued monitoring, or implementation of an engineered remedial option.

Under this alternative, contaminated sediments would be left in place and the site would be monitored annually to evaluate the effectiveness of natural processes in reducing risk to the environment. Each annual monitoring event would include five elements:

1. Sediment sampling and analysis for chemicals of concern to evaluate changes in concentrations.
2. Laboratory testing to assess their potential **bioavailability.**
3. Acute and chronic toxicity testing to evaluate changes in toxicity over time.
4. Sampling of sediment-dwelling organisms to evaluate changes in species composition, abundance, and diversity over time.
5. Measurements of sediment accumulation above marker horizons placed during the initial monitoring event to assess the rate of natural sedimentation.

After the initial monitoring event, sediment barriers such as biodegradable wooden board baffles would be installed at selected intervals to enhance sedimentation within the tidal creek if necessary.

Continued on page 12

SEDIMENT ALTERNATIVES
Continued from page 11

Alternative M3: Cap
Estimated Capital Cost: $498,000
Estimated Annual O&M Cost: $5,000 (years 1-3, 5, and 10); $52,000 (cap repair: year 10)
Estimated Present Worth Cost: $559,000
Estimated Construction Time Frame: 1 month
Estimated Time to Achieve RAOs: 30 years

The contaminated sediment in the tidal creek would be capped to prevent exposure to benthic organisms. The cap would consist of a nonwoven **geotextile**, a coarse sand layer filled to an elevation equal to the adjacent marsh (approximately 3 feet), and marsh grasses planted throughout the former tidal creek area. Though erosion is not a primary design consideration, the newly planted grasses will provide erosion control for the targeted area.

The cap would require annual monitoring for three years following installation to ensure its integrity; inspections would be conducted in years 5 and 10 as well.

If there are no signs of significant erosion during the first 10 years, the cap would only be reinspected following a major storm event. If monitoring indicates excessive erosion, lost material would be replaced with new backfill and marsh grass. Depth gauges would be placed in the channel to help assess erosive changes.

Alternative M4: Removal with Upland Disposal
Estimated Capital Cost: $492,000
Estimated Annual O&M Cost: $0
Estimated Present Worth Cost: $492,000
Estimated Construction Time Frame: 1 month
Estimated Time to Achieve RAOs: 1 month

The top 18 inches of contaminated sediment in the tidal creek (approximately 1,000 cubic yards) would be removed using hydraulic dredging equipment and pumped to an onsite dewatering area, which drains to onsite storm water detention basins. Once dewatered, the removed sediment would be sampled for total metals and hexavalent chromium.

Depending on the analytical results, dredged material would be left in place or managed with onsite contaminated soil (see soil alternatives). Confirmation samples would be collected after dredging is complete to assess whether additional sediment must be removed. During dredging, sediment resuspension and removal rates would be monitored. Engineering controls would be implemented to control sediment resuspension in the water. Dredging in the Tidal Creek will be conducted in a manner that minimizes physical disturbance and impacts to the adjacent vegetated salt marsh.

STORM WATER MANAGEMENT

Estimated Capital Cost: $1,010,000
Estimated Annual O&M Cost: $246,000
Estimated Present Worth Cost: $1,256,000
Estimated Construction Time Frame: 2 months
Estimated Time to Achieve RAOs: 1 year

Storm water at the Macalloy site will be managed to mitigate the discharge of pollutants into Shipyard Creek. The remedy will include a comprehensive site-wide storm water management and sediment control plan to meet the requirement of the **South Carolina Storm Water Management and Sediment Reduction Act**, as administered by the Office of Ocean and Coastal Resource Management.

The storm water management plan, in conjunction with selected soil and groundwater remedies, will be developed to achieve the storm water remedial goal for hexavalent chromium discharges from Macalloy to Shipyard Creek and will control sediment (total suspended solids) concentrations in the discharge, thereby reducing lead, arsenic, copper, and zinc to levels meeting remedial goals.

Storm water runoff from disturbed areas will be collected and routed through detention basins or other sediment removal devices to decrease suspended solids in the discharge. Currently, offsite storm water runoff commingles with storm water from disturbed onsite areas, increasing the quantity of water that must be managed.

This increase jeopardizes the effectiveness of the detention basins at removing solids.

To address this concern, the proposed storm water management plan will include an upgradient offsite collection ditch to intercept offsite storm water before it commingles with onsite runoff.

For onsite storm water management, perimeter berms and ditches will collect runoff and route it through a series of detention basins for sediment removal and discharge flow control. The perimeter berms and ditches also will prevent onsite storm water from leaving the property except at specified locations.

Continued on page 13

STORM WATER MANAGEMENT
Continued from page 12

A monitoring program will be developed to evaluate the effectiveness of the storm water plan, along with soil and groundwater remedies, in meeting the storm water remedial goals. The program will include automatic samplers that monitor and record rainfall and flow at each outfall. Monthly storm water samples will be collected and analyzed to assess effectiveness in meeting storm water remedial goals.

Toxicity tests will be performed quarterly on a species to be determined. South Carolina regulations recommend *Ceriodaphnia dubia* for freshwater and *Mysidopsis bahia* for saltwater. A detailed sampling and analysis plan will be developed during remedial design to outline the methods and procedures for storm water system monitoring.

The sampling plan will be implemented for one year after remedial construction is completed. After that time, the frequency and scope of the sampling plan will be re-evaluated.

EVALUATION OF ALTERNATIVES

Each remedial alternative was evaluated according to the nine criteria described below and summarized on the next page. A detailed comparison of each alternative according to these criteria can be found in the FS.

1. Overall Protection of Human Health and the Environment: All of the alternatives, except the no-action alternatives (S1, G1, R1, and M1), would provide adequate protection of human health and the environment. Because the no-action alternatives are not considered adequately protective, they were eliminated from consideration under the remaining eight criteria in this Proposed Plan.

Soil Alternatives S2a, S2b, and S2c provide protection of human health and the environment through treatment by reducing hexavalent chromium to trivalent chromium, which is less toxic and mobile. Soil Alternative S3 provides protection by removing contaminated soil from the site and disposing of it in a landfill. Soil Alternative S4 protects by minimizing infiltration of water and thus the leaching of soil contaminants to groundwater; however, long-term maintenance and monitoring would be required to ensure that the cap remained effective.

All of the groundwater alternatives would eliminate human and environmental risks from direct contact with contaminated groundwater through treatment. Alternatives G2a, G2b, and G2c reduce hexavalent chromium in the groundwater to trivalent chromium. Alternatives G3 and G4 prevent migration of hexavalent chromium to Shipyard Creek, but do not include source area treatment.

Alternative R2 eliminates direct exposure to radiological material by removing it from the site. Alternative R3 minimizes exposure by capping; however, long-term maintenance of the cap is required to ensure protectiveness.

Overall Protection of Human Health and the Environment

Sediment capping Alternatives M2 and M3 protect the environment by reducing contaminant exposure to benthic organisms. M2 is natural capping by enhanced sedimentation and M3 is an engineered cap. Both require monitoring to ensure the cap's effectiveness. Alternative M4 offers protection by removing contaminated sediments through dredging and upland disposal.

2. Compliance with Applicable or Relevant and Appropriate Requirements (ARARs): All remedial alternatives would meet their respective ARARs from federal and state laws.

3. Long-term Effectiveness and Permanence: Soil Alternatives S2a, S2b, S2c and S3 would eliminate the threats to site groundwater posed by the leaching of hexavalent chromium from soil. Further controls would not be necessary to ensure long-term effectiveness and permanence. (Groundwater monitoring as part of the groundwater remedy would be used to assess the effectiveness of the S2 alternatives.) Alternative S4 (capping) would minimize the leaching of contaminants to groundwater; however, long-term maintenance and monitoring would be necessary to ensure long-term effectiveness and permanence.

Groundwater Alternatives G2a, G2b, and G2c would reduce threats to human health and the environment without needing long-term controls to ensure long-term effectiveness and permanence. Groundwater monitoring would be required for five years. Alternatives G3 and G4 prevent offsite migration of contaminants but do not address source

Continued on page 14 after the text box.

Summary of Evaluation Criteria

How Evaluation Criteria are Used

In selecting a preferred cleanup alternative, the EPA uses the criteria presented here.

The first two must be met before an alternative is considered further.

The next five are used to further evaluate options.

The final two are then used to evaluate the remaining options after comments have been received from the community and the state.

- **Overall Protection of Human Health and the Environment**
  Assesses degree to which alternative eliminates, reduces, or controls health and environmental threats through treatment, engineering methods, or institutional controls.
- **Compliance with Applicable or Relevant and Appropriate Requirements**
  Assesses compliance with federal/state requirements.
- **Long-Term Effectiveness and Permanence**
  Degree to which a remedy can maintain protection of health and environment after cleanup goals have been met.
- **Reduction of Toxicity, Mobility, or Volume Through Treatment**
  The treatment's expected performance in reducing contaminant nature, movement, or amounts.
- **Short-Term Effectiveness**
  Potential impacts of construction or implementation of the remedy in the process of achieving cleanup goals.
- **Implementability**
  Refers to the technical feasibility and administrative ease of using the remedy.
- **Cost**
  Weighing remedy benefits against the implementation cost.
- **State Acceptance**
  Consideration of state's opinion of the Preferred Alternative.
- **Community Acceptance**
  Consideration of public comments.

3. Long-term Effectiveness and Permanence:
Continued from page 13
contamination. Long-term operation, maintenance, and monitoring of Alternatives G3 and G4 would be required to ensure long-term effectiveness.

Contaminant removal Alternatives R2 (radiological materials) and M4 (sediment) reduce threats without additional long-term controls. Capping Alternatives R3, M2, and M3 require monitoring to ensure long-term effectiveness and permanence.

4. Reduction of Toxicity, Mobility, or Volume of Contaminants through Treatment: The S2 alternatives would reduce the toxicity and mobility of contaminated site soil through treatment. Although some reduction in toxicity and mobility is expected with S3 (pretreatment may be required prior to disposal) and S4 (treatment of the berm material and isolated areas), these alternatives do not incorporate treatment into the remedy to the same degree as the S2 alternatives.

All of the groundwater alternatives achieve some reduction in toxicity, mobility, or volume through treatment. However, Alternatives G3 and G4 also require containment as part of the remedy. Treatment is not a component of any of the radiological material or sediment alternatives.

5. Short-Term Effectiveness: All soil alternatives involve some excavation of contaminated soil and thus present some potential for short-term exposure.

Alternative S3 also presents short-term risk during transportation to an offsite disposal facility. The contaminants are not volatile so the risk of release is principally limited to wind-blown soil transport or surface water runoff. Control of dust and runoff will limit the amount of material that may migrate to a potential receptor.

Precautions taken during the construction of groundwater alternatives would eliminate any short-term risk to the public. Short-term risks to workers associated with normal construction hazards and potential contact with contaminated water would be eliminated through appropriate controls and adherence to proper health and safety protocols.

Continued on page 15

5. Short-Term Effectiveness:
Continued from page 14

Radiological materials Alternative R2 presents greater short-term risks since material is excavated and transported offsite. However, these risks can be effectively managed with proper engineering controls and health and safety protocols.

Sediment Alternatives M3 and M4 pose a greater short-term risk to the environment than M2, which relies on natural processes to reduce risks. M3 and M4 will result in short-term elimination of benthic organisms in the creek. M3 will also replace the tidal creek habitat with tidal marsh. Dredging could result in possible contamination of the water column or impact adjoining wetlands. However, these risks can be minimized with proper engineering controls during dredging.

6. Implementability: All technologies and remedies are readily available and generally proven. All alternatives have few associated administrative difficulties.

7. Cost: Alternative S4 is the least costly of the soil alternatives, although it requires long-term maintenance to ensure long-term effectiveness. Groundwater Alternatives G2 and G4 are less costly than Alternative G3. However, Alternative G4 provides containment only and requires long-term operation and maintenance. R2 is the least costly radiological material remedy and Alternative M4 is the least costly sediment remedy.

8. State Agency Acceptance: The SCDHEC has reviewed this Proposed Plan and concurs with the EPA's Preferred Alternative.

9. Community Acceptance: Community acceptance of the Preferred Alternative will be evaluated after the public comment period ends and will be described in the **Record of Decision** for the site.

SUMMARY OF PREFERRED ALTERNATIVE

The components summarized in the table on the next page have been selected by the EPA to constitute the Proposed Cleanup Plan for the Macalloy Site.

Figure 3 shows the soil that will be excavated and treated under the EPA's preferred soil remedy. This alternative was selected over the other soil alternatives because it is expected to achieve substantial and long-term risk reduction through treatment without long-term maintenance or monitoring (other than groundwater monitoring, which will be implemented with the groundwater remedy).

Mechanical mixing offers better control of mixing and blending ratios than in situ methods and, unlike other ex situ methods such as a pugmill, can be used to treat contaminated soil in place below the water table. It is also less sensitive to the size, hardness, and abrasiveness of the material being treated. The cost-effectiveness of the ex-situ method will be evaluated during the remedial design.

Figure 4 illustrates the areas of impacted groundwater that will be treated by enhanced in situ reduction. The preferred groundwater alternative was selected over the other alternatives because it is expected to achieve substantial risk reduction through treatment of contaminants in groundwater. Unlike the other alternatives, which provide containment only, enhanced in situ reduction is a rapid treatment alternative that also achieves source treatment. A chemical reductant was selected based on the results of a recent EPA pilot study.

Figure 2 shows the area of radiological impacted material that will be excavated and disposed of in a landfill. The preferred radiological material alternative was selected because it was the least costly alternative and, unlike capping, does not require long-term monitoring.

Figure 2 also shows the tidal creek that will be dredged. The preferred sediment alternative was selected over the other alternatives because it was the least costly option and, unlike the other two alternatives, does not require long-term monitoring. Five-year monitoring and review will be conducted for Zone C. Monitoring activities will include sediment chemistry and toxicity testing.

Based upon the currently available information, the EPA believes the Preferred Alternative provides the best balance of tradeoffs among the nine evaluation criteria. EPA's Preferred Alternative is protective of human health and the environment, complies with ARARs, is cost-effective, utilizes permanent solutions and resource recovery technologies to the maximum extent practicable, and satisfies the preference for treatment as a principal element. The Preferred Alternative can change in response to public comment or new information.

Continued on page 16 after the text box

EPA'S PROPOSED CLEANUP PLAN FOR THE MACALLOY SITE

Media	Alternative/Description		Total Present Worth
Soil	Alternative S2b: Onsite chemical reduction and stabilization/solidification: ex situ treatment with mechanical mixing	$	7,883,000
Groundwater	Alternative G2b: Enhanced in situ reduction: chemical reductant	$	2,053,000
Radiological Material	Alternative R2: Excavation with offsite disposal	$	15,000
Sediment	Alternative M4: Removal with upland disposal	$	492,000
	Zone C: Five-year monitoring and review	$	20,000
Storm Water	Comprehensive storm water management plan	$	1,256,000
	TOTAL REMEDY COST	**$**	**11,719,000**

COMMUNITY PARTICIPATION

The EPA provides information regarding cleanup of the Macalloy site to the public through public meetings, the Administrative Record file, and announcements published in the Charleston Post and Courier. The EPA encourages community involvement in the cleanup process. Dates for the public comment period and the date, location, and time of the public meeting are provided on the front page of this Proposed Plan.

All comments, written and oral, should be directed to Craig Zeller, Remedial Project Manager for the site, at the address, telephone number, or E-address on the next page. Upon timely request, the EPA will extend the public comment period by 30 days. Background and other information on the Macalloy site cleanup (including investigation reports and work plans) can be found in the Administrative Record and information repositories established for the public by EPA. These repositories can be visited at the locations below.

ADMINISTRATIVE RECORD AND INFORMATION REPOSITORIES:

Charleston County Main Library
68 Calhoun Street
Charleston, SC 29401
(843) 805-6930

EPA Region 4 Records Center
Attn: Debbie Jourdan
61 Forsyth Street, SW
Atlanta, GA 30303
(404) 562-8862

FOR MORE INFORMATION CONTACT:

Craig Zeller, P.E.
Remedial Project Manager
EPA Region 4
Atlanta Federal Center
61 Forsyth Street, SW, Atlanta, GA 30303
(404) 562-8827; 1-800-435-9233
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or

Scott Wilson
SCDHEC
Bureau of Land and Waste Management
2600 Bull Street, Columbia, SC 29201
(803) 896-4077
wilsonrs@columb34.dhec.state.sc.us

GLOSSARY

Acute Toxicity —The ability of a substance to cause severe biological harm or death soon after a single exposure or dose. Also, any poisonous effect resulting from a single short-term exposure to a toxic substance.

Administrative Record — A file containing all information used by the EPA to select a response action under CERCLA. This file must be available for public review and a copy is to be established at or near the site, usually at the information repository. A duplicate file is maintained in a central location such as a regional EPA and/or state office.

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GLOSSARY *Continued from page 16*

Applicable or Relevant and Appropriate Requirements (ARARs) — Cleanup plans selected under CERCLA must comply with other pertinent federal, state, and local environmental laws, or justify a waiver where appropriate. These other laws are collectively referred to as ARARs.

Arsenic — A metal naturally found in the earth's crust and mostly used as a preservative for wood. Though no longer permitted, arsenic has been used as a pesticide for agriculture. Arsenic is a lung, skin, and gastrointestinal irritant; exposure to arsenic can result in cancer or death in some cases.

Background Levels —Two types of background levels may exist for chemical substances: concentrations occurring naturally in the environment and concentrations present in the environment due to human-made, non-site sources (e.g., automobiles, industries).

Baseline Risk Assessment — An evaluation of the potential risk to human health and the environment in the absence of remedial action or cleanup.

Benthic Organisms — Organisms that live in, on, or beneath sediment.

Berm — An elongated pile of soil or other material used to control and direct the flow of surface water runoff. At Macalloy, berms were used to impound waste materials.

Bioavailability — A measure of a chemical's ability to be absorbed and metabolized by an organism.

Central Tendency Exposure —The average exposure expected to occur in a population.

Chronic Toxicity — The capacity of a substance to cause long-term poisonous adverse effects in humans, animals, fish, and other organisms.

Clean Air Act — The Clean Air Act restricts the types and amounts of pollutants that may be released into the air and requires permits for large, and sometimes small, polluters.

Clean Water Act — The Clean Water Act is the primary federal law that protects the nation's waters, including lakes, rivers, aquifers and coastal areas.

Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) —A federal environmental law passed in 1980 and modified in 1986 by the Superfund Amendments and Reauthorization Act. The act created a trust fund, known as Superfund, to investigate and clean up abandoned or uncontrolled hazardous waste sites.

Copper — A reddish metal that occurs naturally in rock, soil, water, sediment and air. It is extensively mined and processed in the U.S. and is primarily used as the metal or alloy in the manufacture of wire, sheet metal, pipe, and other metal products. Its also used to treat plant diseases or for water treatment and as a preservative for wood, leather, and fabrics. High doses of the metal can cause liver and kidney failure and death.

Ex Situ — Removed from its original place at the site or in the subsurface in order to perform the remedial action.

Geotextile — A synthetic material used as a filter to keep fine-grained material from passing through.

Hexavalent Chromium — A metal commonly produced by the chemical industry for chrome plating, manufacturing dyes and pigments, leather tanning, and wood preserving. Hexavalent chromium is also generated during the chromium refining process as an unwanted byproduct. Adverse effects from hexavalent chromium exposure includes skin irritation, asthma, and lung cancer.

In situ— Remaining in its original place at the site or in the subsurface in order to perform the remedial action.

Information Repository — A public collection containing information, technical reports, and reference documents for a site.

Institutional Controls — Non-engineering measures intended to effect human activities in such a way as to prevent or reduce exposure to hazardous substances.

Land Disposal Restrictions—Rules that require certain wastes to be treated before they may be disposed of in the land.

Leach/Leachate — to transport a dissolved or suspended substance when water passes through a soil or other permeable material; water that becomes contaminated as it trickles through wastes or other contaminated media. Leaching may result in hazardous substances entering surface water, groundwater, or soil.

Lead— A heavy metal that is hazardous to health if breathed or swallowed. Its use in gasoline, paints, and plumbing compounds has been sharply restricted by federal laws and regulations.

Maximum Contaminant Level (MCL)—The maximum permissible level of a contaminant in water that is delivered to any user of a public water system.

Micrograms per liter (μg/L) —A common unit of measure for chemical concentrations in water. Also referred to as "parts per billion."

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GLOSSARY

Continued from page 17

Milligrams per kilogram (mg/kg) — A common unit of measure for chemical concentrations in soil. Also referred to as "parts per million."

National Contingency Plan (NCP) —The federal regulation that guides the Superfund program.

National Pollutant Discharge Elimination System (NPDES) — A provision of the Clean Water Act that prohibits discharge of pollutants into waters of the United States unless a special permit is issued by EPA or a state, where delegated.

National Priorities List — EPA's list of uncontrolled or abandoned hazardous waste sites eligible for long-term cleanup under the Superfund Remedial Program.

Nickel — A metal naturally found in the earth's crust that is commonly used with other metals to form alloys to make stainless steel, coins, and jewelry. . The most common adverse health affect is an allergic reaction which often results in a skin rash. Very high concentrations can adversely affect the circulatory and renal systems.

Plume — A visible or measurable discharge of a contaminant from a given point of origin. It can be visible or thermal in water, or visible in air like a smoke plume.

Present Worth Analysis — A method for evaluating expenditures that occur over different time periods. By discounting all costs to a common base year, the costs for different remedial action alternatives can be compared on the basis of a single figure for each alternative.

Principal Threat Waste— Source materials considered to be highly toxic or highly mobile that generally cannot be reliably contained, or would present a significant risk to human health or the environment should exposure occur.

Proposed Plan— A public participation requirement in which the lead agency summarizes for the public the evaluation of cleanup alternatives, the preferred cleanup strategy, and the rationale for the preference. This document must actively solicit public review and comment on all alternatives under consideration.

Radionuclides —Any man-made or natural element that emits radiation and that may cause cancer after many years of exposure.

Reasonable Maximum Exposure —The maximum exposure reasonably expected to occur in a specified population.

Record of Decision — A public document that explains which cleanup alternative will be used at a National Priorities List site and the reasons for choosing it over other alternatives.

Remedial Investigation/Feasibility Study (RI/FS) — Two distinct, but related studies, normally conducted together. The Remedial Investigation is intended to define the nature and extent of contamination at a site by the collection and analyses of environmental samples. The Feasibility Study, based upon the results of the RI, is an engineering study designed to identify, develop and evaluate feasible cleanup options.

Resource Conservation and Recovery Act (RCRA) — A federal environmental law passed in 1976 and amended in 1984 that established a regulatory system to track hazardous substances from the time of generation to disposal. RCRA specifies treatment, storage, and disposal requirements for hazardous waste that are applicable to cleanup actions under CERCLA.

Safe Drinking Water Act—This act protects the quality of drinking water in the U.S. This law focuses on all waters actually or potentially designed for drinking use, whether from aboveground or underground sources.

South Carolina Storm Water Management and Sediment Reduction Act — A state law intended ensure that storm water does not have an adverse impact on rivers, streams, marshes, and other sensitive areas of the coast. It requires the development and implementation of a plan to control sediment and prevent silt and mud from entering surrounding wetlands and water bodies.

Total Chromium — Includes all forms of the element including metal chromium, trivalent chromium, and hexavalent chromium. Trivalent chromium occurs naturally in the environment and is an essential nutrient required by the human body to promote the action of insulin in body tissues so that sugar, protein, and fat can be used by the body. Hexavalent chromium is generally produced by industrial processes. Metal chromium is used as an alloy in stainless steel.

Zinc — A bluish-white shiny metal common in the earth's crust and frequently used to protect metal from corrosion, make alloys such as brass and bronze, and manufacture dry cell batteries. Though it is an essential food element, exposure to elevated levels on zinc can cause stomach cramps, nausea, and vomiting. Ingesting high levels of zinc for several months may cause anemia, damage the pancreas, and decrease levels of high-density lipoprotein cholesterol.

USE THIS SPACE TO WRITE YOUR COMMENTS

Your input on the Proposed Cleanup Plan for the Macalloy Corporation Site is important to EPA. The public's comments help EPA select a final cleanup remedy for the site.

You may use the space below to write your comments, then fold and mail. Comments must be postmarked by May 11, 2002. Please contact Craig Zeller at 404-562-8827 if you have any questions about the comment period.

If you have access to E-Mail, you may send comments to: *Zeller.Craig@epa.gov.*

Fold on dashed line, staple, stamp and mail.
Name:______________________________
Address:____________________________
City:___________State:__Zip:________

Place
Stamp
Here

Craig Zeller, P.E.
Remedial Project Manager
U.S. EPA Region 4
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, GA 30303

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Craig Zeller, Remedial Project Manager
Macalloy Corporation Site 2002

PROPOSED PLAN PUBLIC MEETING

MACALLOY CORPORATION NPL SITE)
CHARLESTON, SOUTH CAROLINA)

Given before Jodie Bargesser, Court Reporter and Notary Public, at the Commissioner of Public Works Building, 103 St. Philip Street, South Carolina, on Thursday, April 18, 2002, commencing at 7:05 o'clock p.m.

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SPEAKER

EPA Speaker: Craig Zeller, P.E.
EPA Region 4
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, Georgia 30303

It was stipulated by and between counsel for the parties that this verbatim transcript was taken pursuant to notice and that all questions asked are recorded; that the transcript is taken pursuant to the laws required by the Superfund Law, for the purposes allowed therein.

PRESENTATION BY CRAIG ZELLER:

Thanks for showing up. Thanks for your interest. My name is Craig Zeller. I'm an EPA Project Manager out of Atlanta. I'm the Project Manager here on the Macalloy Corporation Site.

Like I said, thanks for coming out. This is a Proposed Plan Public Meeting that is required by the Superfund Law, the CERCLA Statute. Jodie is our court reporter. Again, we are required to have by law -- the law states that we have to have a verbatim transcript of this proposed plan and any public comments we receive tonight.

On that track, I have hopefully a thirty to twenty minute presentation depending on how fast I get through this. I'll try not to bore you too much with details. And then I'm going to spend the second half of this meeting, the majority of the time really, hearing from you and answering any specific questions you may have. I'll just try to cover the broad brush of things. If there are any other detailed questions, we can stay around as long as there are questions.

We're going to try to cover today about

five just general topics. We'll talk briefly about the site history, what the Macalloy Corporation and previous corporations did on this piece of property. We'll talk about what we found during our remedial investigation and the feasibility study process that has been going on now for the past two years. Then get into the cleanup alternatives that were evaluated to address the impacts to human health and the environment. I'll talk about what the EPA's preferred clean-up plan is and then transition into a discussion of where do we go from here, try to bleed in some redevelopment questions and what we're trying to do as far as turning the property into beneficial use. And then, as I mentioned, have a Q and A session.

The Macalloy Property is about 147 acres. It is about 125 acres of upland, the rest is marshland. It is bordered on the south by Pittsburgh Avenue, on the west by CSX rail lines, generally on the east by Shipyard Creek.

The site has been used really since the start of the World War II war effort in 1941. An outfit named Pittsburgh Metallurgical, on behalf of really the federal government, started up this plant to make what was a strategic metal. They made ferro chrome alloy. Generally, four ingredients went into this process: it's chromite ore, bauxite, silicon sand and carbon coke. This material is melted or smelted in a big roaster that is actually similar to an electric art furnace. And out the other end came ferro chrome alloy and slag, which is a waste product.

British Oxygen took over that plant in 1966. Right after, about thirteen years after that in '79, Macalloy purchased the property and ran that similar operation they changed over the course of operational history up until July of '98 when they decided to close and no longer produce ferro chrome alloy.

The U.S. Government has been involved in this plant, really from it's inception as I mentioned as a strategic metal. They contracted for the production of this material. And, as a result, they are also thought to be a responsible party for the situation that we are seeing out here now.

During the course of operational history, general guidelines and statutes that some of us all know and love were involved in the regulation of those processes out there: The Resource Conservation and Recovery Act, which is a hazardous waste law that deals with active industry and generation; The Clean Water Act because Macalloy had four discharge points into Shipyard Creek that received various process waters, surface water run-off and one discharge was actually a sewer treatment discharge there; and also the Clean Air Act because of the smelting that went on. There was a significant amount of air pollution control dust that was generated. You'll find out later that the air pollution control dust is what is causing us today a lot of problems right now.

EPA first got involved in this site really at the start of '98; as far as when I say EPA, that means CERCLA program. We initiated a surface water control plan that was initiated in June of '98. It was completed, I think later about December of that year, November of that year. What it entailed was the construction of a bunch of dikes and berms and a series of contention basins to keep surface waters from uncontrollably flowing off the site and to try and confine that run-off at the two point discharges. I'll point those out later. At that time, the transition began to occur from the RCRA reparative action that was underway with the state of South Carolina oversite and the RCRA side of the house, it became apparent that perhaps CERCLA was a more appropriate mechanism for this site in the interest of moving on so that the community involvement activities and it can try and turn this property as quickly as possible so that we can return it to beneficial use. As a result of that, the site is proposed for inclusion on the National Priorities List, which is the Superfund List, in '99 of October. It became final the following February of 2000.

At that point in time -- let me back up here for a second. This is the Macalloy property that is taken from an airplane not too long ago, I think it was in '98. There are some features that I want to point out. I don't have a pointer, but in the middle area right here is the furnace building and this big white mound of covered debris is what's left of the air pollution control dust onsite. Shipyard Creek, a small, little tidal creek that's coming off that discharges into Shipyard Creek. This entire area through here was filled at one point in time at the start of plant operations in '41 and I'll show you some pictures on that. Two big basins that were installed in 1998 to control surface water down here on the water front portion of the site -- this is basin four and basin two on the northwestern portion of the site. Again, right now we have water coming off the property here and also here. Everything else running through this area there have been a series of berms to keep water from flowing off the site in a sheet flow manner. CSX Railroad up there at the top and Union Heights neighborhood in the background and again the furnace building. This is the original furnace building and this is the new furnace building that was constructed in the late seventies due to the need to put in pollution control equipment. We can come back to that picture later.

After the site was listed on a Superfund List there in February 2000 there was a -- the next step in that process that is required is a

Remedial Investigation Feasibility Study. This whole process was conducted under the oversight of EPA and the South Carolina Department of Health and Environmental Control. The Macalloy Corporation actually paid for and funded this investigation by hiring EnSafe, a consulting firm out of Memphis, Tennessee. The overall objectives of this RI/FS process of basically three was to: determine the nature and content of contamination as a result of past practices out there; risks posed to human health and the environment. Okay, we got contamination present on the site, but what are the risks to humans and the risks to the ecology? And the last step of the process is to develop and evaluate protective clean up alternatives to address those risks.

The key technical documents -- everything I'm saying here today are basically wrapped up in these major documents right here. There's a bunch of other material out there. These are probably the key documents. This material and other material have been compiled into an administrative record. That administrative record is actually available at the Charleston

County Main Library on 68 Calhoun Street in a CD-ROM. It's now been burned onto a CD for storage instead of having a file that is five feet long and sits in fifteen of these three-ringed binders. It can be a little bit easier accessed now.

But the RI/FS Work Plan was the first document that laid out our strategy for the Phase I Sampling Program. Phase I generally consisted of the brown water and soil work and some risk assessment looking at exposure to that stuff, generally human health concerns.

Phase II was designed to fill in data gaps that we had from Phase I. Phase II generally and mostly focused on that -- the investigation was ecology and the risk posed to the tidal marshes in the Shipyard Creek area.

Following the Phase II effort, there was the FS Report and the FS Report is the document that compiled all the soil alternatives, the groundwater alternatives, the surface water alternatives and then develops cost and develops conceptual plans as far as what would be what leads you to the preferred plan of alternatives. So out of those alternatives, that are in the FS

Report, EPA selects the preferred alternative to address these risks from that so-called menu of alternatives and then we issue a Proposed Plan. The Proposed Plan is why we are here today. It was issued just April of this year which is the month we are in now.

Just to continue on with the findings of the RI/FS here, the human health risk assessment that the EPA conducts looks at cancer and non-cancer end points. The clean up levels we developed for Macalloy are based on future industrial use. That's based on the current zoning and some discussion we've had with North Charleston, which is where this site lies as far as what their plans are in the grand scheme of things.

We did evaluate the consumption of ground water, which was a conservative evaluation. The groundwater underlying Macalloy from the first fifty feet or so, is not a potable drinking water source. There are no wells installed into it. There is no drinking that water, but again we want to look at that if someone were to drink that what would the risk be because of that.

The other exposure pathways we looked at then was the ingestion and inhalation and dermal contact with surface soils, besides the ground water. And that was under an industrial worker working out there for two-hundred-and-fifty days a year. We looked at what potential risks would be to a worker under that scenario and if that worker was also drinking groundwater. And due to some concerns with shellfish and previous releases to Shipyard Creek we did look at a scenario of recreational fishermen ingesting potentially impacted shellfish from Shipyard Creek.

This is the result of the Human Health Risk Assessment: Regarding surface soils and ground water, the carcinogenic risks are within our acceptable risk range. EPA has established an acceptable risk range which is an incremental chance of developing cancer from exposure to site contaminants. That risk range to be protected one times ten to the minus four or one times ten to the minus six. And that is as a result of site contaminants your chances of developing cancer are not increased by one in one millionth or one in one-hundred-thousandth. Did I get that right? One in ten-thousand?

Excuse me. I thought that was wrong.

Non-carcinogenic risks: ironically, there are no unacceptable risks to exposure to surface soil for a future industrial worker. The HI is .1. Anything hazard indexed over one indicates there is a potential for risks there. Most of the risks, ninety-one percent of the risks are driven by groundwater ingestion and primarily by hexavalent chromium which is a site contaminant primarily generated from the production of ferro chromium alloy. There is a minor contribution by arsenic and antimony and also iron and manganese.

From the shellfish ingestion scenario, we looked at it said a recreational harvest from Shipyard Creek exclusively. The scenarios that we looked at was that a recreational fisherman would be eating equal parts of oyster, crab and shrimp. And then also one-hundred percent type of each of those shellfish. The ingestion rates that we used was a twenty-pound per year ingestion rate and then a six-point-five pounds a year. In other words, this recreational fisherman would be eating that much shellfish from Shipyard Creek. The reason we used two different rates there was the upper bound, the twenty-pound per year, the ninety-five percent was called the Reasonable Maximum Exposure, that's the high end. The average exposure we would expect of the population then is what they call the Central Tendency Exposure and that's where fifty-percent of the people would be expected to eat six-point-five pounds per year.

So the results of that analysis once we collected shrimp, we collected shellfish, we collected blue crab or oyster and that tissue was analyzed for all the contaminants we expected to find there, we ran the numbers and what is told us is that if a person ate equal parts of those shellfish there was -- it equals an acceptable risk. If that same fisherman then ate one hundred percent oyster and crab, there was also an acceptable risk. We did see that at the RME of twenty-pounds per year, an unacceptable risk due to the presence of arsenic. Arsenic is not a Macalloy contaminant. What we did find is that our background sample locations in Rathall Creek and Foster Creek, that's further up in the water shed in the Wando, also showed similar risks due to the ingestion of arsenic in shellfish. So this is really what we're calling kind of a background issue. And there was an acceptable risk at the Central Tendency Exposure, which again is the average exposure not the upper end.

With regard to the Ecological Risk Assessment, there was a preliminary ecological risk assessment that the EPA conducted back in 1998 when they started the surface water work. That was a comprehensive study that looked at Shipyard Creek from the head waters of it all the way down to the mouth of -- with the Cooper River, confluxes with the Cooper River. Based on the results of that, PERE is what we called it, we did a follow up ecological risk assessment of Phase II of this RI. We split it up into Zones A, B and C in upper Shipyard Creek. I'll show you where those are. Zone A is the former Process Water Discharge that use to feed back into a bigger part of the marsh. We thought that to be our high contaminant gradient area. We expected to find some concerns in there. Zone C was our middle gradient station. It was downgrading at the former 002 discharge. We expected this to kinda be our medium contaminant gradient. And Zone B was our low contaminant gradient. We saw some minor hits in the preliminary flood to risk assessment and in Zone B we kinda figured that to be our low contaminant gradient. And as you noticed we did not do any sampling in Shipyard Creek during Phase II and that was as a result of the conclusions drawn on the Preliminary Ecological Risk Assessment that we did not find high levels of chromium in Shipyard Creek or other contaminants relating to Macalloy. So we felt that study was thorough enough of Shipyard Creek and the turning basin itself.

What we did do was conduct what they call a multiple lines-of-evidence approach. It uses sediment chemistry, so you're analyzing for your just pure analytical constituents that you can expect to find there. We looked at chronic toxicity which is long-term exposure to the grass shrimp and looked at the reproductive success of the grass shrimp. Grass shrimp is a very important bio-end of the food web in the tidal marshes that makes up some upwards of eighty-percent of the bio-masses of these spartina marshes. We also looked at acute toxicity anthropods. The species we used in this case was amballisca. We did a grass shrimp population study. We looked at kinda the abundance of grass shrimp we did find. It was kinda used to collaborate what we were finding in the chronic toxicity tests for grass shrimp. That was purely a population study where we did some seining through the marshes and looking for: did we have juvenile adults? did we have juveniles? did we have adults? did we have any shrimp? That kind of thing.

We did do some tissue analysis then on mud minnows, mummy chugs is what the ecologists like to call them. And we also did some analysis of fiddler crabs. Anybody that has been in the marsh around here long enough knows that the marsh is usually teeming with fiddler crabs. So we did some collection of those and then analyzed those to see if they had any chromium and other possibly organics in the tissue as well. Then we did some food chain models and provided a food web model assuming that birds and other upper atrophic receptors would be eating those mud minnows and possible eating those fiddler crabs and see if they were at risk to birds, terrestrial receptors on land. Then we also -- what we did find then, based on that multiple lines evidence approach, we did see some chronic impacts to grass shrimp in Zone A. Zone A is that small tidal creek that comes off the property that did receive processed discharge water from what we think is the source area there right now with Macalloy. Those product impacts did show up as well in the preliminary ecological risk evaluation that they had to reproduce now twice. We feel pretty confident that there are some chronic impacts to grass shrimp reproduction in that Zone. Again, they are chronic and they are not acute. Acute means they would be -- you would see them in very short term exposure. We are not seeing impacts out there in Zone A in the short term. It is a long term exposure concern. In monitoring -- regarding Zone C, we did see some minor impacts there regarding the grass shrimp that they were not as say severe, or reproducible in Zone A, so what we decided to do in Zone C there is to retain that for future monitoring as we go forward from here.

This is some points I want to just show

you on the map. This is in your proposed plan if you had one. I already pointed out Zones A, B and C. Before our former marsh area -- we'll probably spend most of our time talking about the tidal creek in that is right through this area. We have a good portion of source material waste, generally hexavalent chromium in that area. The former concentrator area was where some recovery of metal slag waste was conducted to catch and potentially throw back in the furnace. I just wanted to show you that area. We have some minor concerns of some radiological debris that we believe came to the site on rail cars. It was discovered in the old materials storage area. We believe that came into some raw material. I'll talk about that a little later on.

Soil Impacts. Now we're going to try and get into the results of the RI as far as the immediate specific description. Our biggest concern with soil is, as I mentioned, from an industrial standpoint. There are no risks to an industrial worker under current scenario. But we are worried about soil leaching to ground water. Based on roughly thirty samples that we collected and did some leach tests on where we actually collected chrome soil samples from Macalloy and then tried to determine what would leach out of that material in a natural environment. What we determined is that twenty-three parts per million of hexavalent chromium in the soil, when it leaches, will leach just under the maximum contaminant level for the MCL for chromium which is one hundred parts per million. So there is twenty-three ppm for hexchrome has been determined to be protected of the underlying groundwater. Now in looking at that number of twenty-three, we have one-hundred-fifteen thousand cubic yards of material on-site, soil, that is over that twenty-three mark. Sixty-thousand cubic yards of that material is below ground. Fifty-five thousand tons of that material is above ground. Okay? Above the surface. Another way to look at it is forty thousand cubic yards of that material is remaining burn material that is air pollution control dust that has been stock piled on site over the course of the years. There's forty thousand cubic yards of vadose subsoil, that is dry soil, unsaturated soil above the water table. But below the surface, about another forty thousand cubic yards of that material. So you see that we have about eighty thousand tons or a large portion of that material is in that former marsh area underneath that current impoundment. We have eighteen thousand five hundred cubic yards estimated in the casting bay, what was called the electric static precipitator area. We've got fifteen thousand cubic yards in a former line to pallet on site or what remains of it. And we have three small spots consisting of five hundred cubic yards a piece that really represent one sample, that collectively amount to fifteen hundred cubic yards. And then we have one hundred and ten cubic yards of radiological debris in the western portion of the site along the railroad tracks. Again, we believe that material is some old refractor brick. It's been excavated. It's very shallow. It's roughly eighteen inches below ground surface. It's much different than the surrounding material in the area. It is debris. We've estimated that volume at about one hundred and ten cubic yards. That's over twice the background quote, what would be expected in this area.

This is a picture that is under the post plan. This shows where our impacts are. As I mentioned, here's our fifteen thousand cubic yard pile of the former lined impalement.. The eighty thousand cubic yards is here. The eighteen thousand five hundred cubic yards is there and then up here in the concentrator is the remaining fifteen hundred cubic yards.

Regarding site geology, Charleston's blessed with a very nice confining unit in this area. It is down about fifty feet below land surface. It is a very thick clay layer. It is about two hundred and sixty feet thick. What it does is prevent contaminants from going any deeper than that. In our case, above the Cooper, there is a lower sand unit. It is not very thick, on the average of about five feet thick, and above that is an intermediate clay defining unit that is about twenty feet down on average. What we have found is that shallow, intermediate -- that intermediate clay defining unit has prevented hexavalent chromium in the ground waters from going beneath that unit. So all of our impacts are in this upper sand unit, in the shallow aquifer which has a saturated thickness ranging from seven to twenty feet.

We do have elevations across the site range from ten to fifteen feet above sea level, mean sea level. And there is a layer of fill across the site -- I have got a slide that I'm going to show you in a bit. Groundwater impact has an east to northeast flow direction toward Shipyard Creek. The horizontal flow velocity is very slow, about ten feet to hundred feet per year in that order of magnitude. Contamination of nature is limited to shallow aquifers. Contamination is primarily hexavalent chromium although there are some other sporadic exceedences.

The remedial goal that we have set for chromium six is a hundred parts per billion. The maximum hit that we had during the remedial investigation was thirty-eight thousand six hundred parts per billion. So, you can see that we are quite a ways above our goal. I believe there was some recent pilot work that our Ada, Oklahoma laboratory has been doing. We've seen some concentration as high as fifty-four parts per billion. So you get the idea where we're at.

We do have a confirmed groundwater to surface water pathway. What we believe is happening is that during periods of heavy rainfall, the groundwater table is going to surge up. That groundwater table then contributes hexavalent chromium to the various surface water ditches that are on site and we still pick up hexavalent chromium from time to time during periods of high rainfall. We believe that is the cause of it. So the plan here is to fix that groundwater problem, and we fully believe those surface water exceedences for chrome six will go away.

This is a -- think of this as a topo map in reverse. This is the lake fill area. Instead of this coming out, we are looking down at a big giant hole. This is the layer of fill that we had in that former marsh. This area right here is the impoundment. It's what's covered right now with the dust material. You can see we have as much fill there as thirty feet in thickness. This corresponds -- here's the 001 tidal creek that I mentioned before in Zone A that we are proposing to clean up. And you can see, we believe this contour looks pretty close to some aerial photography that we have beginning where the former marsh was before it was filled in by Pittsburgh Metallurgical and British Oxygen Corporation.

These are groundwater plumes. If you can see, our major impacts again are under the dust impalement. We do have a limited groundwater plume up near the former concentrator area. It does seem to dissipate rather quickly but we are going to address that area. We have roughly twelve million gallons of contaminated groundwater by hexavalent chromium in that saturated aquifer thickness that ranges between seven and twenty feet.

For the surface water storm water situation, process water discharges were stopped that year in July of 1998 when Macalloy ceased production. They have since been consolidated to two out falls. We have seen a tremendous improvement in water quality over that interim storm water period. Historic monitoring that we have conducted out there under the Clean Water Act, the DES program, we have seen exceedences of criteria out there for five inorganics. They include: lead, arsenic, hexavalent chromium, copper and zinc. So those are the numbers that we are interested in reducing. So we have set clean-up goals for those five contaminants. They are listed here. They are ambient water quality standards protective of salt water. They are acute standards because this is a storm water discharge which is a short intermittent discharge and not a continuous situation. So these are acute ambient water quality standards protective of salt water. You can see the numbers right there. The interesting thing about it is that hexavalent chromium is the highest number which is one point one bpm which we believe is rather high. And we would be insulted, I guess and feel like we hadn't done our job out here if we can't get that to non-detect.

The other contaminants, particularly arsenic as we mentioned and copper are not necessarily thought to be Macalloy contaminants related to ferro chrome alloy production, but this five point eight number for copper could cause us some problems. We'll see, but we're going to try and get this site cleaned up and see if we can't beat this number. We're going to monitor that for a good number of years and see how we do.

Sediment in Zone A is about one thousand cubic yards. We're going to excavate eighteen inches deep. And then as I mentioned, that material is going to be taken -- I'll talk about what we're going to do for setting up the area that we're going to focus in on here is about one thousand cubic yards of material, eighteen inches deep. Previous sediment coring in the area has indicated that below eighteen inches -- we've done some coring as deep as three feet out there and haven't seen any impacts at that level. That's why we're going to take the eighteen inches, the upper biologically active zone. And, as I mentioned before, during Zone C we show some moderate impacts for future monitoring.

Now the soil alternatives. We are going to get down to the feasibility study. We talked briefly about the impacts that we found out here and how -- excuse me. We talked about the soil alternatives that EPA, DHEC and Macalloy assembled to address those soil risks. The first alternative that we look at is required by Superfund. It's the base line evaluation. It's called the no action. If we take no action what is it going to cost? It usually doesn't cost much, but absolutely nothing is done to the soil. But the no action alternative in this case as we talked about is not protected. It is one when we are retained -- we are required to look at.

We looked at generally three other type of remedies. The first was an on-site chemical reduction remedy and we looked at three different types here. Chemical reduction -- we need to take a step back and talk about chromium chemistry for a quick second. Hexavalent chromium we have lots of. Hexavalent chromium is the bad actor in chromium. When you reduce chromium you convert it to what is called trivalent chromium, or chrome plus three. Chrome plus three is relatively immobile on the environment and is also much less toxic than hexavalent chromium. You can go down to a General Nutrition Center store and buy yourself tablets, supplementals of trivalent chromium that's thought to be at low levels of the central nutrient. So our goal here is to simply change from the bad to the somewhat good. In this case, we're going to reduce chrome six and make it all chrome three. In the first alternative we looked at three different ways to do that. The first alternative S2a was a combination of ex-situ measures which is out of the hole, and then in-situ measures which are in place. So under S2a we looked at dealing with everything that is above ground by ex-situ measures. We'll dig it up or we'll move it some place and mix it with something to reduce it. And then everything that is below ground, fifty-five thousand that is below ground, we'll deal with in-situ measures, or in place, by mixing or some other measure.

S2b, soil remedy 2b, that we looked at was ex-situ by mechanical mixing. This was ex-situ, or out of hole, treatment of the entire one hundred fifteen thousand cubic yards by mechanical mixing, trying to incorporate this reagent via backhoes, via mixing heads for high rotary mixers, maybe augers. We looked at a variety of things there.

And the last two alternatives, or soil

alternatives C, was ex-situ mixed in by a pug mill. A pug mill is nothing more than a big giant blender that can handle soil and debris. And it is just mixed through there in a big giant pug mill. Alternative S3 we looked at was excavation with offsite disposal. This was digging up the one hundred fifteen thousand cubic yards, treated where it needed to be to meet the appropriate requirements and then that material would be disposed of offsite in a RCRA's subtitled D landfill which is a lined landfill, but it is not a hazardous waste landfill. We would dig up the material, treat what needed to be treated to meet the regulations and then it would go to a RCRA's subtitled D landfill.

And the last alternative that we looked at was the -- just a capping alternative. Everything that is above ground would be treated and spread over to reduce it to chrome 3. Then that material, that is above ground, would be spread over a twelve acre area and covered with a hot mix asphalt cap. And we did look at having to replace that cap twice over time. But you can see what we've done here is try to a regular alternative that looked at just capping; we looked at digging it up and hauling it outside; and then we looked at dealing with the problem on site as well as the no action.

With regard to groundwater -- the story with chromium and groundwater is kind of the same story. You want to take this chromium and reduce it from hexavalent to trivalent. The first alternative, the first set of alternatives that we looked at was Groundwater 2A. Obviously we still have the Groundwater 1 which is no action. We called for calling this enhanced in-situ reduction because we are seeing some natural reduction of chromium, it's just not happening as fast as we would like to see it. So, we are going to enhance that in-situ process and speed that process up, hopefully within a year or to address that whole situation in one year as opposed to waiting for say maybe thirty years for it to happen. The way we are going to do this is look at a variety of reductants in this instance. We looked at hydrogen release compound or HRC which is a proprietary reagent of re-genesis. We looked at chemical reduction which is using chemicals to actually achieve that reduction from six to three. And we looked at carbohydrate reduction. There are many reductants out there. In the interest of carbohydrate we looked at molasses and also citric acid. It can also reduce chromium.

The third alternative to groundwater we looked at of the series of three was a zero valent iron permeable reactive barrier. What a PRB is, is it's much more permeable than the surrounding aquifer and as groundwater moves through this wall or this barrier under natural flow conditions, it is actually treated in this reactive wall and on the downgrading side of the wall comes out clean groundwater. In this case, zero valent iron would be our reductant. It's been used in several other sites across the nation and has proven very effective in reducing hexavalent chrome concentrations to non-detect.

The last alternative that we looked at in groundwater was called groundwater containment. In this instance it was pump and treat. Basically it's groundwater containment via recovery wells and some trenches, recovery trenches. There was a groundwater pump and treat system onsite that was installed under the

DHEC Ricour Program. It was installed in '96 and ran for about four years. It was effective at keeping it onsite, but we cannot sustain the pump rates in that fill material to get the necessary draw down in these wells. But we did want to look at the groundwater recovery, and the pump and treat has a containment option. Again, to cover the full array of alternatives available.

For radiological material situation, I mentioned that we have one hundred ten cubic yards of that in the western area of the site. Again we looked at no action. And we looked at excavation off-site disposal of this material just like the other soil alternatives and then we looked at soil cover, just covering this material in place.

For the sediment alternatives, as I mentioned we have about one thousand cubic yards eighteen inches deep in that former process water discharge area, that small tidal creek. We looked at no action for this tidal creek as well. We looked at enhanced monitored natural recovery which would basically be more monitoring on an annual basis to see if nature was taking care of the problem out there. We believe sedimentation was going to reduce some of the risks we are seeing there. We did look at capping that tidal creek, bringing that elevation of that tidal creek up to the surrounding spartina vegitation, covering it with sand and then replanting it with spartina, just to cover the problem in place. In that instance we would lose the tidal creek but gain additional spartina wetlands. And then we also looked at excavation of that material and then upland disposal with the remaining soil on site.

From the storm water perspective, we only looked at one alternative. It basically incorporates a perimeter ditch that will receive surface water and then handle that material sediment and solids that discharges into Shipyard Creek. The goal here is to achieve ambient water quality standards that we talked about before. The standard that the OSHA Coastal Resource Management Group has here in Charleston is the surface water plan must meet a ten year/twenty-four hour storm requirement and that is six point eight inches of rain. So that is a fair amount of water to handle at one time.

Okay, so we take all these alternatives and they go into a remedy evaluation phase. And these are the nine criteria that Superfund Statutes says that we must look at. There's nine of them. The first two are what are called threshold criteria. It's overall protection of human health and environment and compliance with Applicable and Relevant and Appropriate Requirements. Those two must be met for a remedy to be selected by the EPA, that is why they are called thresholds. Alternatives three through seven are called the modifying criteria and those are used to kind of balance the various strengths and weaknesses of these various alternatives. What we look at is the long term effectiveness and permanence of these remedies. There is a preference for reduction of toxicity mobility and volume through the treatment of that source material. We look at the short-term effectiveness of the remedy implementation and will it be protected while we are implementing the remedy. Is it implementable? Can it be done? Has it been done before? Has it been tried and failed? Is the material readily available? Is the equipment readily available? That kind of stuff. And then we also look at cost. How much will these things cost? Then the last two are called -- I guess the modifying criteria or -- is that right? Yeah, the modifying criteria which is the state agency acceptance and the community acceptance. In this case the state agency is the South Carolina Department of Health and Environment Control. They are here tonight and they have been a partner with us in this entire process and they have concurred with the remedy thus far. So, they have generally accepted what we are proposing to do tonight. And then number nine, is kind of why we are here tonight and why we are holding a thirty-day public comment period, is the community acceptance and what the various community interests are at Macalloy.

So, with all that being said what we are proposing to do is Soil Alternative S2B, which is on-site chemical reduction by mechanical mixing. The present worth cost of that is seven point eight million dollars.

With regard to groundwater, after

considering all the alternatives available and some pilot work that we've been, recently been doing out there we were -- as far as in-situ reduction we are going with enhanced -- proposing to with enhanced in-situ reduction by a chemical. The other chemical reductants that we looked at seemed to be effective. We liked the thoroughness and the robustness of the chemical reductant is why we're kind of going with that. Another reason why we're proposing to go with on-site chemical reduction by mechanical mixing was that it is believed that we might be able to advance some of the soil treatment into the water table there by minimizing some of the groundwater that we are going to have to treat to get the in-situ reduction. We're trying to -- we may be able to advance that into the groundwater table say, five or ten feet and then eliminate that saturated layer that we are going to have to do by injection. Because under the injection standpoint there are many, many thousands -- I'd say over one thousand injection points that may be required to reduce that chromium six in that saturated zone. So you can see why we might be interested in trying to eliminate or minimize those injection points.

From a radiological perspective, we are proposing a fifteen thousand dollar clean-up alternative. It's excavation with off-site disposal. That material has been characterized and that will be protective.

Sediment alternative -- we decided to go with marsh alternative M4 or are proposing to go with that. It's removal with upland, on-site disposal. That material of one thousand cubic yards is going to be very soupy. It will look like baby food. So we need to get it off-site and try to get it de-watered and possibly mix it with some of the on-site soil to strengthen it up and give it some bulking. And we'll treat it with the other material on-site.

As I mentioned, we have talked about a final review -- monitoring for Zone C and storm water management. This is our storm water plan. As I mentioned, it is a perimeter ditch that is going to surround the Macalloy site like a moat if you want to use that term. What we are proposing to do -- one of the big things we have to do is convert some off-site water. We have some off-site water coming in from the CSX railroad area and a little bit from the Spruill Avenue and Union Heights area. We want to divert that water. It is just more of a quantity issue. We believe that we can handle the quantity of water generated on the Macalloy site, but we need to divert this water around so we can get adequate settling for surface water that hits our site. So what we are proposing to do would be a diversion dike -- divert water from this area of the water shed around the property and discharge into Shipyard Creek. And what we are going to -- excavate a new drainage conveyance that will route water through the existing basin in 2A which was installed in the '98 time frame. We'll get some settling of some suspended soils and storm water there. It will continue around the property and discharge into Shipyard Creek. Just upstream right now where we are currently discharging in this area, we are going to move the discharge to this area. This yellow is the ditch. So that's our concept of storm water plan right now. And it's the big component. It's about one point three million dollars worth.

Okay, so where do we go from here? The thirty day public comment period that is required by CERCLA was started April 11^{th}. We're about, roughly about one week into that. It's a thirty day comment period that runs through May 11^{th}. If somebody has further questions and they need more time to say digest the information we're talking about here today, there can be a thirty day extension to that comment period for a total of sixty days. If people are interested in seeing more of this data you can call me. I can get you any additional reports that we may have. But as I mentioned, the administrative record and everything I have right now is at the Calhoun Library, the Calhoun Street Library, the main library on 68 Calhoun, the Charleston County Main Library.

Based on those comments received, we will finalize the record of decision. We expect -- depending on how the comment period goes, we expect to have that record of decision in June of 2002. That will be the final clean up plan, depending on what we receive in public comment. There will be a responsive summary in that record of decision which is a response, a formal response, to all written comments received during the comment period.

And from there we are going to get into construction, which is what we are very excited about. We are looking forward to getting this property cleaned up. This is somewhat of a general schedule that we are looking at. We're looking at about a six month planning period to get construction documents, to get a new remedial design contractor on board. Do that procurement and then start doing some design, getting some specs. And getting something that we can -- some blueprints that we can take to the streets and hopefully competitively bid this job. And then in January of 2003 is when we are planning to start that. And with a little bit of luck we might start construction out here at Macalloy in about a year or perhaps less than a year from where we are right now.

And with that -- I guess one thing that I would like to add in closure is that we have heard from -- I guess Dave Lawn and everybody that has been associated with this job understands that the redevelopment of this property is the primary objective. That it does have some attributes with access to Shipyard Creek, with access to CSX rail and access to I-26. It does seem to have some future there. I would like to say to anybody that is interested in future land use, the time to come to the table is now. As I mentioned, we are setting up plans to do some remedial designs. Designs change from time to time, but we are going to start laying plans where soil is going. If someone has future visions for this property or plans on purchasing this property, we would like to hear from you as soon as you are ready.

So with that, I have covered a lot of stuff pretty fast. Some of it I covered good. Some of it I covered it probably not so well. I will try to clear up any questions if there are any. Before you ask any questions, if you would just mind saying your name it would be greatly appreciated.

Q: Tim Nelson.

A: Tim Nelson?

Q: How do we speed that schedule up?

A: We speed that schedule up by condensing the transition time; getting our remedial design contractor on board and then getting that design. Because I don't think that that design -- the design of this stuff should not take that long. It's a matter of how quickly the EPA can get this record of decision finalized and get a contractor procured and get on with the construction phase. To talk about where we head from here, I'll give you an idea of what our goal is or what we're expecting to do --

Q: I guess my question is that all along we were talking six to eight weeks from remedial design to construction.

A: It's a conservative schedule. Some of the people we talked to today were also -- they looked at us and said can we do that faster. And I think we can do that faster. A six to eight week design phase is quick. I don't think we were talking about that fast. Do you think we can do it that fast?

Q: I know we can.

A: Well, we are working on scopes of work as we speak for the design of this. Not too long ago, about say a year ago, the EPA did receive roughly nine point six million dollars of funding from the Department of

Defense. That nine point six million dollars was allocated to the Macalloy site to address the Department of Defense liability under CERCLA. As I mentioned, this material was made for the US Government. And that has essentially cashed the US Government out at this point in time. We are looking at -- you can see our total revenue cost is eleven point seven million dollars. The EPA has been involved with this site for some time and we have racked up a past cost bill of around one million dollars. So as you can see, we are a little bit short. Nine point six million dollars is not going to get us all the way where we need to be.

Now the State of South Carolina Department of Health and Environmental Control has around a million dollars, roughly, perhaps a little bit over that. They have financial insurance money of Macalloy's that was secured by the department when Macalloy was under regulation by RCRA. It was called financial insurance money. We have had discussions with DHEC and it seems that all signs are positive to getting that money thrown into the clean up pot for Macalloy as well.

We plan to pursue some other responsible parties that are not here or have not been at the table now for the last couple of years. I guess first that's British Oxygen Corporation, BOC, and also Airco or it was Airco at the time. Airco was a predecessor to Macalloy and we believe that they should be at the table negotiating with this here as well. And we are looking into other -- Pittsburgh Metallurgical still survives. Pittsburgh Met was the initial and the original owner-operator of the site. We are looking into the participation of Pittsburgh Met as well.

So that being said, there is some money available which is a good position to be in right now with Superfund. Superfund is perhaps not as super as it once was. So what we plan to do is -- ENSAFE has been Macalloy's contractor over the course of the last I guess really three or four years. ENSAFE also happens to be a contractor for Southern Division Naval Facilities Command here in Charleston. ENSAFE was a delta contractor on the clean up of the naval base. ENSAFE did win that contract in a competitive bid process. The contract is good for a few more years. So we are in negotiations right now with the Southern Division Navy about transitioning and accessing ENSAFE through the existing Navy contract. So we think that we could do that. Depending on how quickly complete that transition, get ENSAFE on board, if we do this, it would be very positive from a number of stand points. One, involving the Navy in this through their contractor -- with bringing the Navy in it's going to add an extra layer of QAQC to ensure that we are getting good management of this contract and ensure that the tax dollars that have been appropriated for this site are going towards the best and most efficient cost effective clean up that we can get. By accessing ENSAFE, we've been very pleased with their performance. They've been a very objective and sound contractor. By bringing them on board we don't have to educate a new contractor and spend a month getting this new contractor up to speed. We are only accessing ENSAFE for those reasons in that when these designs and specs come available for the soil remedy and the groundwater remedy and everything else, they will competitively bid and in full accordance with government regulations and the federal acquisition requirements. So, we expect those bids to come available -- right now we're hoping to start that bid process, and this is conservative, maybe January of 2003. As we just talked here, we hope to speed that up if we can.

Any other questions. Gosh, you guys are letting me off easy. Tony?

Q: Tony Hunt.

A: Tony Hunt.

Q: Craig, I've got a couple -- uh, you mentioned that there are two creeks that you used for backgrounds for the organics.

What were those creeks again?
A: It is Rathall Creek. Rathall Creek is the first creek north -- it's off the Wando and it's the first creek north of 526, I-526 on the Mt. Pleasant side.
And Foster's Creek I believe is up off the Cooper. But I would have to pull a map on that Foster's Creek location. Is it up on the Wando too?
Unidentified Speaker: Yes.
A: It's on the left side. It's further -- it's north of Rathall, right?
Unidentified Speaker: Yes.
A: I wouldn't recommend Rathall. I would recommend Foster's. We've had some problems with Rathall over time. Foster's seems to be working pretty well.
Q: I have one other question. This is a different subject. As far as land use controls, are there anything like that associated with the remedy -- you said there is industrial zoning by the city of North Charleston. Is Macalloy required to put anything in the deed to say that these remedies are in place and --

A: Very good question. Yes. It's called deed restriction and there will be deed placed on the property that says that this property has been cleaned up for industrial land use. If land use should change to residential future clean up needs to be considered or implemented or that type of thing. So, we are cleaning this up to industrial standards. We have reason to believe it is going to remain industrial land use for some time. Should that change, that's why that deed is placed on there to notifying a perspective purchaser what he would be buying. Well, I appreciate it. Thanks for coming out and thanks for your interest.

Q: Eddie Buxton. If there was a perspective buyer for this, what would they have to do to drive pilings? Can they drive piles in these areas? Is that going to be limited to certain areas?

A: I think you would have to talk about that -- depth of piles and what we don't want to do for instance, one thing that comes to mind, you wouldn't want to pierce that shallow confining area and potentially introduce chrome six into that lower sand as needed above the Cooper. This reduction is thought to be irreversible. It's not like we're dealing with the -- but it's something that we're going to have to talk about. It's something that's very conceivable, but I think we want to know more details; depths and all that stuff, locations and everything. We might be able to work something. We would have to know more details behind it. We can address these specific type of questions as they come up for sure. And that's to be expected. That's why we tackle a lot of those issues as we go through this stuff. But that's -- the issues that we are having right now is that we unintentionally pierce the clay layer and send some chrome six down lower. We wouldn't want to do that. Once we treat that stuff -- we're not expecting -- there's no evidence that once you get rid of this trivalent it's going to come back to six. I think once we've treated that material it will be okay. And then there's some stuff you can do as far driving piles and stuff that we'll make sure you do.

(Meeting concluded at 8:00 o'clock p.m.)

STATE OF SOUTH CAROLINA)
: C-E-R-T-I-F-I-C-A-T-E
COUNTY OF Charleston)

I, Jodie Bargesser, Court Reporter and Notary Public, certify that I did have Craig Zeller to appear before me at 7:05 o'clock p.m. on Thursday, April 18, 2002, at the Commissioner of Public Works Building, 103 St. Philip Street, Charleston, South Carolina and the pages constitute a true and accurate transcript of the presentation given at that time and place.

IN WITNESS WHEREOF, I have hereunto set my hand and seal this the 6th day of May, 2002.

Jodie Bargesser

Notary Public for South Carolina
My Commission Expires: 4-22-2012

PROPOSED PLAN PUBLIC MEETING

MACALLOY CORPORATION NPL SITE)
CHARLESTON, SOUTH CAROLINA)

Given before Jodie Bargesser, Court Reporter and Notary Public, at the Commissioner of Public Works Building, 103 St. Philip Street, South Carolina, on Thursday, April 18, 2002, commencing at 7:05 o'clock p.m.

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SPEAKER

EPA Speaker: Craig Zeller, P.E.
EPA Region 4
Atlanta Federal Center
61 Forsyth Street, SW
Atlanta, Georgia 30303

It was stipulated by and between counsel for the parties that this verbatim transcript was taken pursuant to notice and that all questions asked are recorded; that the transcript is taken pursuant to the laws required by the Superfund Law, for the purposes allowed therein.

PRESENTATION BY CRAIG ZELLER:

Thanks for showing up. Thanks for your interest. My name is Craig Zeller. I'm an EPA Project Manager out of Atlanta. I'm the Project Manager here on the Macalloy Corporation Site.

Like I said, thanks for coming out. This is a Proposed Plan Public Meeting that is required by the Superfund Law, the CERCLA Statute. Jodie is our court reporter. Again, we are required to have by law -- the law states that we have to have a verbatim transcript of this proposed plan and any public comments we receive tonight.

On that track, I have hopefully a thirty to twenty minute presentation depending on how fast I get through this. I'll try not to bore you too much with details. And then I'm going to spend the second half of this meeting, the majority of the time really, hearing from you and answering any specific questions you may have. I'll just try to cover the broad brush of things. If there are any other detailed questions, we can stay around as long as there are questions.

We're going to try to cover today about

five just general topics. We'll talk briefly about the site history, what the Macalloy Corporation and previous corporations did on this piece of property. We'll talk about what we found during our remedial investigation and the feasibility study process that has been going on now for the past two years. Then get into the cleanup alternatives that were evaluated to address the impacts to human health and the environment. I'll talk about what the EPA's preferred clean-up plan is and then transition into a discussion of where do we go from here, try to bleed in some redevelopment questions and what we're trying to do as far as turning the property into beneficial use. And then, as I mentioned, have a Q and A session.

The Macalloy Property is about 147 acres. It is about 125 acres of upland, the rest is marshland. It is bordered on the south by Pittsburgh Avenue, on the west by CSX rail lines, generally on the east by Shipyard Creek.

The site has been used really since the start of the World War II war effort in 1941. An outfit named Pittsburgh Metallurgical, on behalf of really the federal government, started

up this plant to make what was a strategic metal. They made ferro chrome alloy. Generally, four ingredients went into this process: it's chromite ore, bauxite, silicon sand and carbon coke. This material is melted or smelted in a big roaster that is actually similar to an electric art furnace. And out the other end came ferro chrome alloy and slag, which is a waste product.

British Oxygen took over that plant in 1966. Right after, about thirteen years after that in '79, Macalloy purchased the property and ran that similar operation they changed over the course of operational history up until July of '98 when they decided to close and no longer produce ferro chrome alloy.

The U.S. Government has been involved in this plant, really from it's inception as I mentioned as a strategic metal. They contracted for the production of this material. And, as a result, they are also thought to be a responsible party for the situation that we are seeing out here now.

During the course of operational history, general guidelines and statutes that some of us

all know and love were involved in the regulation of those processes out there: The Resource Conservation and Recovery Act, which is a hazardous waste law that deals with active industry and generation; The Clean Water Act because Macalloy had four discharge points into Shipyard Creek that received various process waters, surface water run-off and one discharge was actually a sewer treatment discharge there; and also the Clean Air Act because of the smelting that went on. There was a significant amount of air pollution control dust that was generated. You'll find out later that the air pollution control dust is what is causing us today a lot of problems right now.

EPA first got involved in this site really at the start of '98; as far as when I say EPA, that means CERCLA program. We initiated a surface water control plan that was initiated in June of '98. It was completed, I think later about December of that year, November of that year. What it entailed was the construction of a bunch of dikes and berms and a series of contention basins to keep surface waters from uncontrollably flowing off the site and to try

and confine that run-off at the two point discharges. I'll point those out later. At that time, the transition began to occur from the RCRA reparative action that was underway with the state of South Carolina oversite and the RCRA side of the house, it became apparent that perhaps CERCLA was a more appropriate mechanism for this site in the interest of moving on so that the community involvement activities and it can try and turn this property as quickly as possible so that we can return it to beneficial use. As a result of that, the site is proposed for inclusion on the National Priorities List, which is the Superfund List, in '99 of October. It became final the following February of 2000.

At that point in time -- let me back up here for a second. This is the Macalloy property that is taken from an airplane not too long ago, I think it was in '98. There are some features that I want to point out. I don't have a pointer, but in the middle area right here is the furnace building and this big white mound of covered debris is what's left of the air pollution control dust onsite. Shipyard Creek, a small, little tidal creek that's coming off that discharges into Shipyard Creek. This entire area through here was filled at one point in time at the start of plant operations in '41 and I'll show you some pictures on that. Two big basins that were installed in 1998 to control surface water down here on the water front portion of the site -- this is basin four and basin two on the northwestern portion of the site. Again, right now we have water coming off the property here and also here. Everything else running through this area there have been a series of berms to keep water from flowing off the site in a sheet flow manner. CSX Railroad up there at the top and Union Heights neighborhood in the background and again the furnace building. This is the original furnace building and this is the new furnace building that was constructed in the late seventies due to the need to put in pollution control equipment. We can come back to that picture later.

After the site was listed on a Superfund List there in February 2000 there was a -- the next step in that process that is required is a

Remedial Investigation Feasibility Study. This whole process was conducted under the oversight of EPA and the South Carolina Department of Health and Environmental Control. The Macalloy Corporation actually paid for and funded this investigation by hiring EnSafe, a consulting firm out of Memphis, Tennessee. The overall objectives of this RI/FS process of basically three was to: determine the nature and content of contamination as a result of past practices out there; risks posed to human health and the environment. Okay, we got contamination present on the site, but what are the risks to humans and the risks to the ecology? And the last step of the process is to develop and evaluate protective clean up alternatives to address those risks.

The key technical documents -- everything I'm saying here today are basically wrapped up in these major documents right here. There's a bunch of other material out there. These are probably the key documents. This material and other material have been compiled into an administrative record. That administrative record is actually available at the Charleston

County Main Library on 68 Calhoun Street in a CD-ROM. It's now been burned onto a CD for storage instead of having a file that is five feet long and sits in fifteen of these three-ringed binders. It can be a little bit easier accessed now.

But the RI/FS Work Plan was the first document that laid out our strategy for the Phase I Sampling Program. Phase I generally consisted of the brown water and soil work and some risk assessment looking at exposure to that stuff, generally human health concerns.

Phase II was designed to fill in data gaps that we had from Phase I. Phase II generally and mostly focused on that -- the investigation was ecology and the risk posed to the tidal marshes in the Shipyard Creek area.

Following the Phase II effort, there was the FS Report and the FS Report is the document that compiled all the soil alternatives, the groundwater alternatives, the surface water alternatives and then develops cost and develops conceptual plans as far as what would be what leads you to the preferred plan of alternatives. So out of those alternatives, that are in the FS

Report, EPA selects the preferred alternative to address these risks from that so-called menu of alternatives and then we issue a Proposed Plan. The Proposed Plan is why we are here today. It was issued just April of this year which is the month we are in now.

Just to continue on with the findings of the RI/FS here, the human health risk assessment that the EPA conducts looks at cancer and non-cancer end points. The clean up levels we developed for Macalloy are based on future industrial use. That's based on the current zoning and some discussion we've had with North Charleston, which is where this site lies as far as what their plans are in the grand scheme of things.

We did evaluate the consumption of ground water, which was a conservative evaluation. The groundwater underlying Macalloy from the first fifty feet or so, is not a potable drinking water source. There are no wells installed into it. There is no drinking that water, but again we want to look at that if someone were to drink that what would the risk be because of that.

The other exposure pathways we looked at then was the ingestion and inhalation and dermal contact with surface soils, besides the ground water. And that was under an industrial worker working out there for two-hundred-and-fifty days a year. We looked at what potential risks would be to a worker under that scenario and if that worker was also drinking groundwater. And due to some concerns with shellfish and previous releases to Shipyard Creek we did look at a scenario of recreational fishermen ingesting potentially impacted shellfish from Shipyard Creek.

This is the result of the Human Health Risk Assessment: Regarding surface soils and ground water, the carcinogenic risks are within our acceptable risk range. EPA has established an acceptable risk range which is an incremental chance of developing cancer from exposure to site contaminants. That risk range to be protected one times ten to the minus four or one times ten to the minus six. And that is as a result of site contaminants your chances of developing cancer are not increased by one in one millionth or one in one-hundred-thousandth. Did I get that right? One in ten-thousand?

Excuse me. I thought that was wrong.

Non-carcinogenic risks: ironically, there are no unacceptable risks to exposure to surface soil for a future industrial worker. The HI is .1. Anything hazard indexed over one indicates there is a potential for risks there. Most of the risks, ninety-one percent of the risks are driven by groundwater ingestion and primarily by hexavalent chromium which is a site contaminant primarily generated from the production of ferro chromium alloy. There is a minor contribution by arsenic and antimony and also iron and manganese.

From the shellfish ingestion scenario, we looked at it said a recreational harvest from Shipyard Creek exclusively. The scenarios that we looked at was that a recreational fisherman would be eating equal parts of oyster, crab and shrimp. And then also one-hundred percent type of each of those shellfish. The ingestion rates that we used was a twenty-pound per year ingestion rate and then a six-point-five pounds a year. In other words, this recreational fisherman would be eating that much shellfish from Shipyard Creek. The reason we used two

different rates there was the upper bound, the twenty-pound per year, the ninety-five percent was called the Reasonable Maximum Exposure, that's the high end. The average exposure we would expect of the population then is what they call the Central Tendency Exposure and that's where fifty-percent of the people would be expected to eat six-point-five pounds per year.

So the results of that analysis once we collected shrimp, we collected shellfish, we collected blue crab or oyster and that tissue was analyzed for all the contaminants we expected to find there, we ran the numbers and what is told us is that if a person ate equal parts of those shellfish there was -- it equals an acceptable risk. If that same fisherman then ate one hundred percent oyster and crab, there was also an acceptable risk. We did see that at the RME of twenty-pounds per year, an unacceptable risk due to the presence of arsenic. Arsenic is not a Macalloy contaminant. What we did find is that our background sample locations in Rathall Creek and Foster Creek, that's further up in the water shed in the Wando, also showed similar risks due to the

ingestion of arsenic in shellfish. So this is really what we're calling kind of a background issue. And there was an acceptable risk at the Central Tendency Exposure, which again is the average exposure not the upper end.

With regard to the Ecological Risk Assessment, there was a preliminary ecological risk assessment that the EPA conducted back in 1998 when they started the surface water work. That was a comprehensive study that looked at Shipyard Creek from the head waters of it all the way down to the mouth of -- with the Cooper River, confluxes with the Cooper River. Based on the results of that, PERE is what we called it, we did a follow up ecological risk assessment of Phase II of this RI. We split it up into Zones A, B and C in upper Shipyard Creek. I'll show you where those are. Zone A is the former Process Water Discharge that use to feed back into a bigger part of the marsh. We thought that to be our high contaminant gradient area. We expected to find some concerns in there. Zone C was our middle gradient station. It was downgrading at the former 002 discharge. We expected this to kinda be our medium contaminant gradient. And Zone B was our low contaminant gradient. We saw some minor hits in the preliminary flood to risk assessment and in Zone B we kinda figured that to be our low contaminant gradient. And as you noticed we did not do any sampling in Shipyard Creek during Phase II and that was as a result of the conclusions drawn on the Preliminary Ecological Risk Assessment that we did not find high levels of chromium in Shipyard Creek or other contaminants relating to Macalloy. So we felt that study was thorough enough of Shipyard Creek and the turning basin itself.

What we did do was conduct what they call a multiple lines-of-evidence approach. It uses sediment chemistry, so you're analyzing for your just pure analytical constituents that you can expect to find there. We looked at chronic toxicity which is long-term exposure to the grass shrimp and looked at the reproductive success of the grass shrimp. Grass shrimp is a very important bio-end of the food web in the tidal marshes that makes up some upwards of eighty-percent of the bio-masses of these spartina marshes. We also looked at acute

toxicity anthropods. The species we used in this case was amballisca. We did a grass shrimp population study. We looked at kinda the abundance of grass shrimp we did find. It was kinda used to collaborate what we were finding in the chronic toxicity tests for grass shrimp. That was purely a population study where we did some seining through the marshes and looking for: did we have juvenile adults? did we have juveniles? did we have adults? did we have any shrimp? That kind of thing.

We did do some tissue analysis then on mud minnows, mummy chugs is what the ecologists like to call them. And we also did some analysis of fiddler crabs. Anybody that has been in the marsh around here long enough knows that the marsh is usu ally teeming with fiddler crabs. So we did some collection of those and then analyzed those to see if they had any chromium and other possibly organics in the tissue as well. Then we did some food chain models and provided a food web model assuming that birds and other upper atrophic receptors would be eating those mud minnows and possible eating those fiddler crabs and see if they were at risk

to birds, terrestrial receptors on land. Then we also -- what we did find then, based on that multiple lines evidence approach, we did see some chronic impacts to grass shrimp in Zone A. Zone A is that small tidal creek that comes off the property that did receive processed discharge water from what we think is the source area there right now with Macalloy. Those product impacts did show up as well in the preliminary ecological risk evaluation that they had to reproduce now twice. We feel pretty confident that there are some chronic impacts to grass shrimp reproduction in that Zone. Again, they are chronic and they are not acute. Acute means they would be -- you would see them in very short term exposure. We are not seeing impacts out there in Zone A in the short term. It is a long term exposure concern. In monitoring -- regarding Zone C, we did see some minor impacts there regarding the grass shrimp that they were not as say severe, or reproducible in Zone A, so what we decided to do in Zone C there is to retain that for future monitoring as we go forward from here.

This is some points I want to just show

you on the map. This is in your proposed plan if you had one. I already pointed out Zones A, B and C. Before our former marsh area -- we'll probably spend most of our time talking about the tidal creek in that is right through this area. We have a good portion of source material waste, generally hexavalent chromium in that area. The former concentrator area was where some recovery of metal slag waste was conducted to catch and potentially throw back in the furnace. I just wanted to show you that area. We have some minor concerns of some radiological debris that we believe came to the site on rail cars. It was discovered in the old materials storage area. We believe that came into some raw material. I'll talk about that a little later on.

Soil Impacts. Now we're going to try and get into the results of the RI as far as the immediate specific description. Our biggest concern with soil is, as I mentioned, from an industrial standpoint. There are no risks to an industrial worker under current scenario. But we are worried about soil leaching to ground water. Based on roughly thirty samples that we collected and did some leach tests on where we actually collected chrome soil samples from Macalloy and then tried to determine what would leach out of that material in a natural environment. What we determined is that twenty-three parts per million of hexavalent chromium in the soil, when it leaches, will leach just under the maximum contaminant level for the MCL for chromium which is one hundred parts per million. So there is twenty-three ppm for hexchrome has been determined to be protected of the underlying groundwater. Now in looking at that number of twenty-three, we have one-hundred-fifteen thousand cubic yards of material on-site, soil, that is over that twenty-three mark. Sixty-thousand cubic yards of that material is below ground. Fifty-five thousand tons of that material is above ground. Okay? Above the surface. Another way to look at it is forty thousand cubic yards of that material is remaining burn material that is air pollution control dust that has been stock piled on site over the course of the years. There's forty thousand cubic yards of vadose subsoil, that is dry soil, unsaturated soil above the water

table. But below the surface, about another forty thousand cubic yards of that material. So you see that we have about eighty thousand tons or a large portion of that material is in that former marsh area underneath that current impoundment. We have eighteen thousand five hundred cubic yards estimated in the casting bay, what was called the electric static precipitator area. We've got fifteen thousand cubic yards in a former line to pallet on site or what remains of it. And we have three small spots consisting of five hundred cubic yards a piece that really represent one sample, that collectively amount to fifteen hundred cubic yards. And then we have one hundred and ten cubic yards of radiological debris in the western portion of the site along the railroad tracks. Again, we believe that material is some old refractor brick. It's been excavated. It's very shallow. It's roughly eighteen inches below ground surface. It's much different than the surrounding material in the area. It is debris. We've estimated that volume at about one hundred and ten cubic yards. That's over twice the background quote, what would be

expected in this area.

This is a picture that is under the post plan. This shows where our impacts are. As I mentioned, here's our fifteen thousand cubic yard pile of the former lined impalement. The eighty thousand cubic yards is here. The eighteen thousand five hundred cubic yards is there and then up here in the concentrator is the remaining fifteen hundred cubic yards.

Regarding site geology, Charleston's blessed with a very nice confining unit in this area. It is down about fifty feet below land surface. It is a very thick clay layer. It is about two hundred and sixty feet thick. What it does is prevent contaminants from going any deeper than that. In our case, above the Cooper, there is a lower sand unit. It is not very thick, on the average of about five feet thick, and above that is an intermediate clay defining unit that is about twenty feet down on average. What we have found is that shallow, intermediate -- that intermediate clay defining unit has prevented hexavalent chromium in the ground waters from going beneath that unit. So all of our impacts are in this upper sand unit,

in the shallow aquifer which has a saturated thickness ranging from seven to twenty feet.

We do have elevations across the site range from ten to fifteen feet above sea level, mean sea level. And there is a layer of fill across the site -- I have got a slide that I'm going to show you in a bit. Groundwater impact has an east to northeast flow direction toward Shipyard Creek. The horizontal flow velocity is very slow, about ten feet to hundred feet per year in that order of magnitude. Contamination of nature is limited to shallow aquifers. Contamination is primarily hexavalent chromium although there are some other sporadic exceedences.

The remedial goal that we have set for chromium six is a hundred parts per billion. The maximum hit that we had during the remedial investigation was thirty-eight thousand six hundred parts per billion. So, you can see that we are quite a ways above our goal. I believe there was some recent pilot work that our Ada, Oklahoma laboratory has been doing. We've seen some concentration as high as fifty-four parts per billion. So you get the idea where we're at.

We do have a confirmed groundwater to surface water pathway. What we believe is happening is that during periods of heavy rainfall, the groundwater table is going to surge up. That groundwater table then contributes hexavalent chromium to the various surface water ditches that are on site and we still pick up hexavalent chromium from time to time during periods of high rainfall. We believe that is the cause of it. So the plan here is to fix that groundwater problem, and we fully believe those surface water exceedences for chrome six will go away.

This is a -- think of this as a topo map in reverse. This is the lake fill area. Instead of this coming out, we are looking down at a big giant hole. This is the layer of fill that we had in that former marsh. This area right here is the impoundment. It's what's covered right now with the dust material. You can see we have as much fill there as thirty feet in thickness. This corresponds -- here's the 001 tidal creek that I mentioned before in Zone A that we are proposing to clean up. And you can see, we

believe this contour looks pretty close to some aerial photography that we have beginning where the former marsh was before it was filled in by Pittsburgh Metallurgical and British Oxygen Corporation.

These are groundwater plumes. If you can see, our major impacts again are under the dust impalement. We do have a limited groundwater plume up near the former concentrator area. It does seem to dissipate rather quickly but we are going to address that area. We have roughly twelve million gallons of contaminated groundwater by hexavalent chromium in that saturated aquifer thickness that ranges between seven and twenty feet.

For the surface water storm water situation, process water discharges were stopped that year in July of 1998 when Macalloy ceased production. They have since been consolidated to two out falls. We have seen a tremendous improvement in water quality over that interim storm water period. Historic monitoring that we have conducted out there under the Clean Water Act, the DES program, we have seen exceedences of criteria out there for five inorganics. They

include: lead, arsenic, hexavalent chromium, copper and zinc. So those are the numbers that we are interested in reducing. So we have set clean-up goals for those five contaminants. They are listed here. They are ambient water quality standards protective of salt water. They are acute standards because this is a storm water discharge which is a short intermittent discharge and not a continuous situation. So these are acute ambient water quality standards protective of salt water. You can see the numbers right there. The interesting thing about it is that hexavalent chromium is the highest number which is one point one bpm which we believe is rather high. And we would be insulted, I guess and feel like we hadn't done our job out here if we can't get that to non-detect.

The other contaminants, particularly arsenic as we mentioned and copper are not necessarily thought to be Macalloy contaminants related to ferro chrome alloy production, but this five point eight number for copper could cause us some problems. We'll see, but we're going to try and get this site cleaned up and

see if we can't beat this number. We're going to monitor that for a good number of years and see how we do.

Sediment in Zone A is about one thousand cubic yards. We're going to excavate eighteen inches deep. And then as I mentioned, that material is going to be taken -- I'll talk about what we're going to do for setting up the area that we're going to focus in on here is about one thousand cubic yards of material, eighteen inches deep. Previous sediment coring in the area has indicated that below eighteen inches -- we've done some coring as deep as three feet out there and haven't seen any impacts at that level. That's why we're going to take the eighteen inches, the upper biologically active zone. And, as I mentioned before, during Zone C we show some moderate impacts for future monitoring.

Now the soil alternatives. We are going to get down to the feasibility study. We talked briefly about the impacts that we found out here and how -- excuse me. We talked about the soil alternatives that EPA, DHEC and Macalloy assembled to address those soil risks. The first alternative that we look at is required by Superfund. It's the base line evaluation. It's called the no action. If we take no action what is it going to cost? It usually doesn't cost much, but absolutely nothing is done to the soil. But the no action alternative in this case as we talked about is not protected. It is one when we are retained -- we are required to look at.

We looked at generally three other type of remedies. The first was an on-site chemical reduction remedy and we looked at three different types here. Chemical reduction -- we need to take a step back and talk about chromium chemistry for a quick second. Hexavalent chromium we have lots of. Hexavalent chromium is the bad actor in chromium. When you reduce chromium you convert it to what is called trivalent chromium, or chrome plus three. Chrome plus three is relatively immobile on the environment and is also much less toxic than hexavalent chromium. You can go down to a General Nutrition Center store and buy yourself tablets, supplementals of trivalent chromium that's thought to be at low levels of the

central nutrient. So our goal here is to simply change from the bad to the somewhat good. In this case, we're going to reduce chrome six and make it all chrome three. In the first alternative we looked at three different ways to do that. The first alternative S2a was a combination of ex-situ measures which is out of the hole, and then in-situ measures which are in place. So under S2a we looked at dealing with everything that is above ground by ex-situ measures. We'll dig it up or we'll move it some place and mix it with something to reduce it. And then everything that is below ground, fifty-five thousand that is below ground, we'll deal with in-situ measures, or in place, by mixing or some other measure.

S2b, soil remedy 2b, that we looked at was ex-situ by mechanical mixing. This was ex-situ, or out of hole, treatment of the entire one hundred fifteen thousand cubic yards by mechanical mixing, trying to incorporate this reagent via backhoes, via mixing heads for high rotary mixers, maybe augers. We looked at a variety of things there.

And the last two alternatives, or soil

alternatives C, was ex-situ mixed in by a pug mill. A pug mill is nothing more than a big giant blender that can handle soil and debris. And it is just mixed through there in a big giant pug mill. Alternative S3 we looked at was excavation with offsite disposal. This was digging up the one hundred fifteen thousand cubic yards, treated where it needed to be to meet the appropriate requirements and then that material would be disposed of offsite in a RCRA's subtitled D landfill which is a lined landfill, but it is not a hazardous waste landfill. We would dig up the material, treat what needed to be treated to meet the regulations and then it would go to a RCRA's subtitled D landfill.

And the last alternative that we looked at was the -- just a capping alternative. Everything that is above ground would be treated and spread over to reduce it to chrome 3. Then that material, that is above ground, would be spread over a twelve acre area and covered with a hot mix asphalt cap. And we did look at having to replace that cap twice over time. But you can see what we've done here is try to a

regular alternative that looked at just capping; we looked at digging it up and hauling it outside; and then we looked at dealing with the problem on site as well as the no action.

With regard to groundwater -- the story with chromium and groundwater is kind of the same story. You want to take this chromium and reduce it from hexavalent to trivalent. The first alternative, the first set of alternatives that we looked at was Groundwater 2A. Obviously we still have the Groundwater 1 which is no action. We called for calling this enhanced in-situ reduction because we are seeing some natural reduction of chromium, it's just not happening as fast as we would like to see it. So, we are going to enhance that in-situ process and speed that process up, hopefully within a year or to address that whole situation in one year as opposed to waiting for say maybe thirty years for it to happen. The way we are going to do this is look at a variety of reductants in this instance. We looked at hydrogen release compound or HRC which is a proprietary reagent of re-genesis. We looked at chemical reduction which is using chemicals to actually achieve that reduction from six to three. And we looked at carbohydrate reduction. There are many reductants out there. In the interest of carbohydrate we looked at molasses and also citric acid. It can also reduce chromium.

The third alternative to groundwater we looked at of the series of three was a zero valent iron permeable reactive barrier. What a PRB is, is it's much more permeable than the surrounding aquifer and as groundwater moves through this wall or this barrier under natural flow conditions, it is actually treated in this reactive wall and on the downgrading side of the wall comes out clean groundwater. In this case, zero valent iron would be our reductant. It's been used in several other sites across the nation and has proven very effective in reducing hexavalent chrome concentrations to non-detect.

The last alternative that we looked at in groundwater was called groundwater containment. In this instance it was pump and treat. Basically it's groundwater containment via recovery wells and some trenches, recovery trenches. There was a groundwater pump and treat system onsite that was installed under the

DHEC Ricour Program. It was installed in '96 and ran for about four years. It was effective at keeping it onsite, but we cannot sustain the pump rates in that fill material to get the necessary draw down in these wells. But we did want to look at the groundwater recovery, and the pump and treat has a containment option. Again, to cover the full array of alternatives available.

For radiological material situation, I mentioned that we have one hundred ten cubic yards of that in the western area of the site. Again we looked at no action. And we looked at excavation off-site disposal of this material just like the other soil alternatives and then we looked at soil cover, just covering this material in place.

For the sediment alternatives, as I mentioned we have about one thousand cubic yards eighteen inches deep in that former process water discharge area, that small tidal creek. We looked at no action for this tidal creek as well. We looked at enhanced monitored natural recovery which would basically be more monitoring on an annual basis to see if nature

was taking care of the problem out there. We believe sedimentation was going to reduce some of the risks we are seeing there. We did look at capping that tidal creek, bringing that elevation of that tidal creek up to the surrounding spartina vegitation, covering it with sand and then replanting it with spartina, just to cover the problem in place. In that instance we would lose the tidal creek but gain additional spartina wetlands. And then we also looked at excavation of that material and then upland disposal with the remaining soil on site.

From the storm water perspective, we only looked at one alternative. It basically incorporates a perimeter ditch that will receive surface water and then handle that material sediment and solids that discharges into Shipyard Creek. The goal here is to achieve ambient water quality standards that we talked about before. The standard that the OSHA Coastal Resource Management Group has here in Charleston is the surface water plan must meet a ten year/twenty-four hour storm requirement and that is six point eight inches of rain. So that is a fair amount of water to handle at one time.

Okay, so we take all these alternatives and they go into a remedy evaluation phase. And these are the nine criteria that Superfund Statutes says that we must look at. There's nine of them. The first two are what are called threshold criteria. It's overall protection of human health and environment and compliance with Applicable and Relevant and Appropriate Requirements. Those two must be met for a remedy to be selected by the EPA, that is why they are called thresholds. Alternatives three through seven are called the modifying criteria and those are used to kind of balance the various strengths and weaknesses of these various alternatives. What we look at is the long term effectiveness and permanence of these remedies. There is a preference for reduction of toxicity mobility and volume through the treatment of that source material. We look at the short-term effectiveness of the remedy implementation and will it be protected while we are implementing the remedy. Is it implementable? Can it be done? Has it been done before? Has it been tried and failed? Is the material readily available? Is the equipment readily available? That kind of stuff. And then we also look at cost. How much will these things cost? Then the last two are called -- I guess the modifying criteria or -- is that right? Yeah, the modifying criteria which is the state agency acceptance and the community acceptance. In this case the state agency is the South Carolina Department of Health and Environment Control. They are here tonight and they have been a partner with us in this entire process and they have concurred with the remedy thus far. So, they have generally accepted what we are proposing to do tonight. And then number nine, is kind of why we are here tonight and why we are holding a thirty-day public comment period, is the community acceptance and what the various community interests are at Macalloy.

So, with all that being said what we are proposing to do is Soil Alternative S2B, which is on-site chemical reduction by mechanical mixing. The present worth cost of that is seven point eight million dollars.

With regard to groundwater, after

considering all the alternatives available and some pilot work that we've been, recently been doing out there we were -- as far as in-situ reduction we are going with enhanced -- proposing to with enhanced in-situ reduction by a chemical. The other chemical reductants that we looked at seemed to be effective. We liked the thoroughness and the robustness of the chemical reductant is why we're kind of going with that. Another reason why we're proposing to go with on-site chemical reduction by mechanical mixing was that it is believed that we might be able to advance some of the soil treatment into the water table there by minimizing some of the groundwater that we are going to have to treat to get the in-situ reduction. We're trying to -- we may be able to advance that into the groundwater table say, five or ten feet and then eliminate that saturated layer that we are going to have to do by injection. Because under the injection standpoint there are many, many thousands -- I'd say over one thousand injection points that may be required to reduce that chromium six in that saturated zone. So you can see why we might be

interested in trying to eliminate or minimize those injection points.

From a radiological perspective, we are proposing a fifteen thousand dollar clean-up alternative. It's excavation with off-site disposal. That material has been characterized and that will be protective.

Sediment alternative -- we decided to go with marsh alternative M4 or are proposing to go with that. It's removal with upland, on-site disposal. That material of one thousand cubic yards is going to be very soupy. It will look like baby food. So we need to get it off-site and try to get it de-watered and possibly mix it with some of the on-site soil to strengthen it up and give it some bulking. And we'll treat it with the other material on-site.

As I mentioned, we have talked about a final review -- monitoring for Zone C and storm water management. This is our storm water plan. As I mentioned, it is a perimeter ditch that is going to surround the Macalloy site like a moat if you want to use that term. What we are proposing to do -- one of the big things we have to do is convert some off-site water. We have

some off-site water coming in from the CSX railroad area and a little bit from the Spruill Avenue and Union Heights area. We want to divert that water. It is just more of a quantity issue. We believe that we can handle the quantity of water generated on the Macalloy site, but we need to divert this water around so we can get adequate settling for surface water that hits our site. So what we are proposing to do would be a diversion dike -- divert water from this area of the water shed around the property and discharge into Shipyard Creek. And what we are going to -- excavate a new drainage conveyance that will route water through the existing basin in 2A which was installed in the '98 time frame. We'll get some settling of some suspended soils and storm water there. It will continue around the property and discharge into Shipyard Creek. Just upstream right now where we are currently discharging in this area, we are going to move the discharge to this area. This yellow is the ditch. So that's our concept of storm water plan right now. And it's the big component. It's about one point three million dollars worth.

Okay, so where do we go from here? The

thirty day public comment period that is required by CERCLA was started April 11th. We're about, roughly about one week into that. It's a thirty day comment period that runs through May 11th. If somebody has further questions and they need more time to say digest the information we're talking about here today, there can be a thirty day extension to that comment period for a total of sixty days. If people are interested in seeing more of this data you can call me. I can get you any additional reports that we may have. But as I mentioned, the administrative record and everything I have right now is at the Calhoun Library, the Calhoun Street Library, the main library on 68 Calhoun, the Charleston County Main Library.

Based on those comments received, we will finalize the record of decision. We expect -- depending on how the comment period goes, we expect to have that record of decision in June of 2002. That will be the final clean up plan, depending on what we receive in public comment. There will be a responsive summary in that record of decision which is a response, a formal response, to all written comments received during

the comment period.

And from there we are going to get into construction, which is what we are very excited about. We are looking forward to getting this property cleaned up. This is somewhat of a general schedule that we are looking at. We're looking at about a six month planning period to get construction documents, to get a new remedial design contractor on board. Do that procurement and then start doing some design, getting some specs. And getting something that we can -- some blueprints that we can take to the streets and hopefully competitively bid this job. And then in January of 2003 is when we are planning to start that. And with a little bit of luck we might start construction out here at Macalloy in about a year or perhaps less than a year from where we are right now.

And with that -- I guess one thing that I would like to add in closure is that we have heard from -- I guess Dave Lawn and everybody that has been associated with this job understands that the redevelopment of this property is the primary objective. That it does have some attributes with access to Shipyard

Creek, with access to CSX rail and access to I-26. It does seem to have some future there. I would like to say to anybody that is interested in future land use, the time to come to the table is now. As I mentioned, we are setting up plans to do some remedial designs. Designs change from time to time, but we are going to start laying plans where soil is going. If someone has future visions for this property or plans on purchasing this property, we would like to hear from you as soon as you are ready.

So with that, I have covered a lot of stuff pretty fast. Some of it I covered good. Some of it I covered it probably not so well. I will try to clear up any questions if there are any. Before you ask any questions, if you would just mind saying your name it would be greatly appreciated.

Q: Tim Nelson.
A: Tim Nelson?
Q: How do we speed that schedule up?
A: We speed that schedule up by condensing the transition time; getting our remedial design contractor on board and then getting that design. Because I don't think that

that design -- the design of this stuff should not take that long. It's a matter of how quickly the EPA can get this record of decision finalized and get a contractor procured and get on with the construction phase. To talk about where we head from here, I'll give you an idea of what our goal is or what we're expecting to do --
Q: I guess my question is that all along we were talking six to eight weeks from remedial design to construction.
A: It's a conservative schedule. Some of the people we talked to today were also -- they looked at us and said can we do that faster. And I think we can do that faster. A six to eight week design phase is quick. I don't think we were talking about that fast. Do you think we can do it that fast?
Q: I know we can.
A: Well, we are working on scopes of work as we speak for the design of this. Not too long ago, about say a year ago, the EPA did receive roughly nine point six million dollars of funding from the Department of Defense. That nine point six million

dollars was allocated to the Macalloy site to address the Department of Defense liability under CERCLA. As I mentioned, this material was made for the US Government. And that has essentially cashed the US Government out at this point in time. We are looking at -- you can see our total revenue cost is eleven point seven million dollars. The EPA has been involved with this site for some time and we have racked up a past cost bill of around one million dollars. So as you can see, we are a little bit short. Nine point six million dollars is not going to get us all the way where we need to be.

Now the State of South Carolina Department of Health and Environmental Control has around a million dollars, roughly, perhaps a little bit over that. They have financial insurance money of Macalloy's that was secured by the department when Macalloy was under regulation by RCRA. It was called financial insurance money. We have had discussions with DHEC and it seems that all

signs are positive to getting that money thrown into the clean up pot for Macalloy as well.

We plan to pursue some other responsible parties that are not here or have not been at the table now for the last couple of years. I guess first that's British Oxygen Corporation, BOC, and also Airco or it was Airco at the time. Airco was a predecessor to Macalloy and we believe that they should be at the table negotiating with this here as well. And we are looking into other -- Pittsburgh Metallurgical still survives. Pittsburgh Met was the initial and the original owner-operator of the site. We are looking into the participation of Pittsburgh Met as well.

So that being said, there is some money available which is a good position to be in right now with Superfund. Superfund is perhaps not as super as it once was. So what we plan to do is -- ENSAFE has been Macalloy's contractor over the course of the last I guess really three or four

years. ENSAFE also happens to be a contractor for Southern Division Naval Facilities Command here in Charleston. ENSAFE was a delta contractor on the clean up of the naval base. ENSAFE did win that contract in a competitive bid process. The contract is good for a few more years. So we are in negotiations right now with the Southern Division Navy about transitioning and accessing ENSAFE through the existing Navy contract. So we think that we could do that. Depending on how quickly complete that transition, get ENSAFE on board, if we do this, it would be very positive from a number of stand points. One, involving the Navy in this through their contractor -- with bringing the Navy in it's going to add an extra layer of QAQC to ensure that we are getting good management of this contract and ensure that the tax dollars that have been appropriated for this site are going towards the best and most efficient cost effective clean up that we can get. By accessing ENSAFE, we've been very pleased with their performance.

They've been a very objective and sound contractor. By bringing them on board we don't have to educate a new contractor and spend a month getting this new contractor up to speed. We are only accessing ENSAFE for those reasons in that when these designs and specs come available for the soil remedy and the groundwater remedy and everything else, they will competitively bid and in full accordance with government regulations and the federal acquisition requirements. So, we expect those bids to come available -- right now we're hoping to start that bid process, and this is conservative, maybe January of 2003. As we just talked here, we hope to speed that up if we can.

Any other questions. Gosh, you guys are letting me off easy. Tony?

Q: Tony Hunt.

A: Tony Hunt.

Q: Craig, I've got a couple -- uh, you mentioned that there are two creeks that you used for backgrounds for the organics. What were those creeks again?

STATE OF SOUTH CAROLINA)
:C-E-R-T-I-F-I-C-A-T-E
COUNTY OF Charleston)

I, Jodie Bargesser, Court Reporter and Notary Public, certify that I did have Craig Zeller to appear before me at 7:05 o'clock p.m. on Thursday, April 18, 2002, at the Commissioner of Public Works Building, 103 St. Philip Street, Charleston, South Carolina and the pages constitute a true and accurate transcript of the presentation given at that time and place.

IN WITNESS WHEREOF, I have hereunto set my hand and seal this the 6th day of May, 2002.

Notary Public for South Carolina
My Commission Expires: 4-22-2012

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A: It is Rathall Creek. Rathall Creek is the first creek north -- it's off the Wando and it's the first creek north of 526, I-526 on the Mt. Pleasant side.
And Foster's Creek I believe is up off the Cooper. But I would have to pull a map on that Foster's Creek location. Is it up on the Wando too?
UnidentifiedSpeaker: Yes.
A: It's on the left side. It's further -- it's north of Rathall, right?
Unidentified Speaker: Yes.
A: I wouldn't recommend Rathall. I would recommend Foster's. We've had some problems with Rathall over time. Foster's seems to be working pretty well.
Q: I have one other question. This is a different subject. As far as land use controls, are there anything like that associated with the remedy -- you said there is industrial zoning by the city of North Charleston. Is Macalloy required to put anything in the deed to say that these remedies are in place and --
A: Very good question. Yes. It's called deed

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restriction and there will be deed placed on the property that says that this property has been cleaned up for industrial land use. If land use should change to residential future clean up needs to be considered or implemented or that type of thing. So, we are cleaning this up to industrial standards. We have reason to believe it is going to remain industrial land use for some time. Should that change, that's why that deed is placed on there to notifying a perspective purchaser what he would be buying. Well, I appreciate it. Thanks for coming out and thanks for your interest.
Q: Eddie Buxton. If there was a perspective buyer for this, what would they have to do to drive pilings? Can they drive piles in these areas? Is that going to be limited to certain areas?
A: I think you would have to talk about that -- depth of piles and what we don't want to do for instance, one thing that comes to mind, you wouldn't want to pierce that shallow confining area and potentially

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introduce chrome six into that lower sand as needed above the Cooper. This reduction is thought to be irreversible. It's not like we're dealing with the -- but it's something that we're going to have to talk about. It's something that's very conceivable, but I think we want to know more details; depths and all that stuff, locations and everything. We might be able to work something. We would have to know more details behind it. We can address these specific type of questions as they come up for sure. And that's to be expected. That's why we tackle a lot of those issues as we go through this stuff. But that's -- the issues that we are having right now is that we unintentionally pierce the clay layer and send some chrome six down lower. We wouldn't want to do that. Once we treat that stuff -- we're not expecting -- there's no evidence that once you get rid of this trivalent it's going to come back to six. I think once we've treated that material it will be okay. And then there's some stuff you can do as far

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driving piles and stuff that we'll make sure you do.

(Meeting concluded at 8:00 o'clock p.m.)

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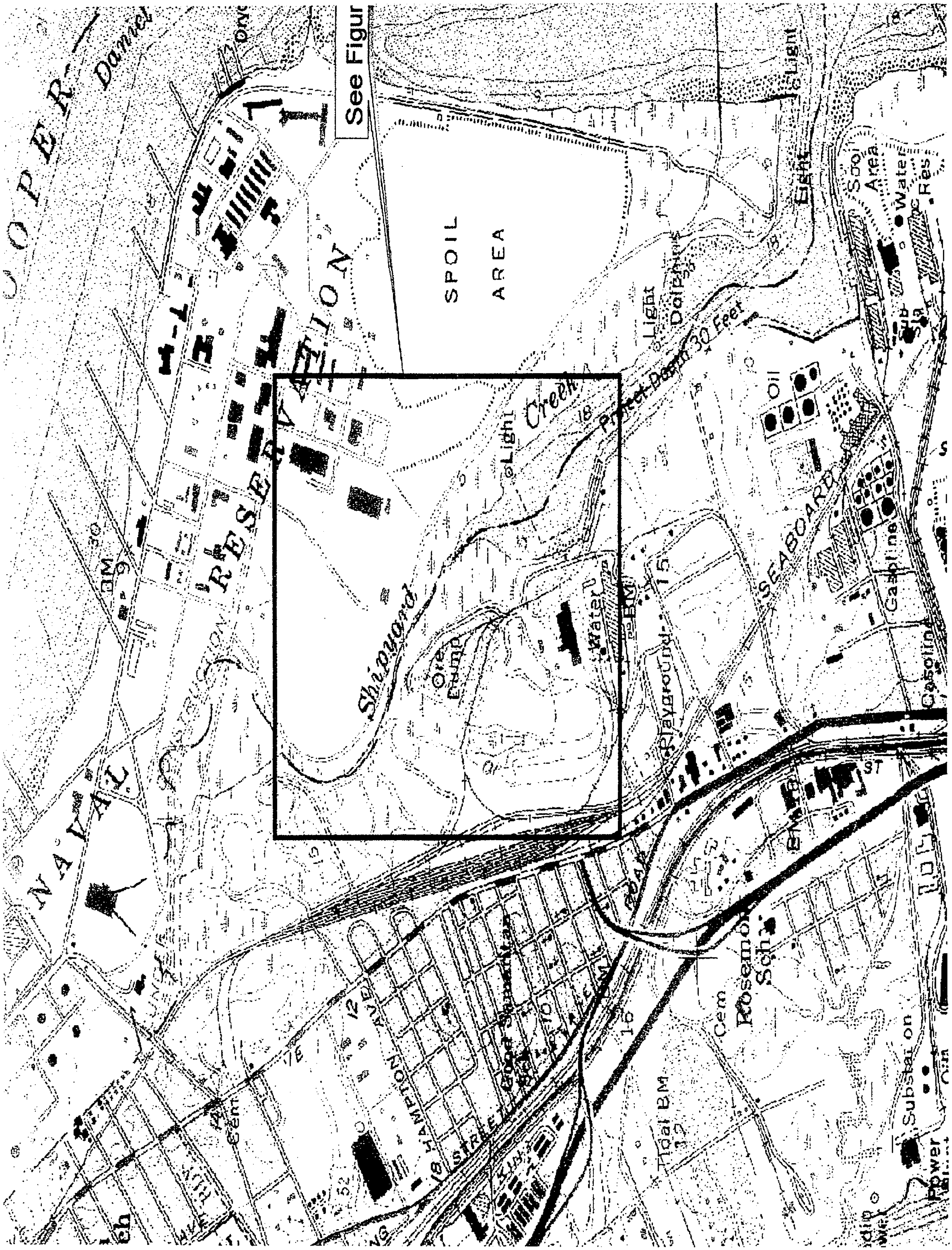
Proposed Plan Public Meeting
April 18, 2002
Macalloy Corporation NPL Site
Charleston, South Carolina

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

Meeting Objectives/Overview

- Site History
- Findings of RI/FS process
- Proposed Cleanup Plan
- Future Activities
- Questions & Answers


See Figur
SPOIL AREA
NAVAL RESERVATION
Shipyard Creek
Project Depth 30 Feet
Light
Dolphins
Oil
Water
Ore Pump
Playground
SEABOARD
Gasoline
HAMPTON AVE
Rosemont Sch
Cem
Tidal BM
Substation
Power

Site History

- Ferrochrome Alloy Production

- Pittsburg Metallurgical (1941-1966)
  - British Oxygen/Airco (1966-1979)
  - Macalloy (1979-July 1998)
  - U.S. Government/Defense Logistics Agency

- RCRA/Clean Water Act/Clean Air Act

- CERCLA Removal Action – June 1998

- Proposed NPL October 1999/Final February 2000

Findings of RI/FS

- Conducted under 3/29/00 AOC

- RI/FS Objectives
  - Nature & extent of contamination
  - Risks posed to human health/ environment
  - Develop & evaluate protective alternatives

Findings of RI/FS Continued

- Key Technical Documents
  - RI/FS Work Plan; EnSafe, May 10, 2000
  - Phase 1 RI Report; EnSafe, April 18, 2001
  - Phase 2 RI Work Plan; EnSafe May 7, 2001
  - Phase 2 RI Report; EnSafe, January 28, 2002
  - FS Report; Ensafe, March 29, 2002
  - Proposed Plan; EPA, April 2002

Findings of RI/Continued

- **Human Health Risk Assessment**
  - Cancer and non-cancer assessment
  - Cleanup levels based on likely future industrial scenario
  - Consumption of GW conservatively evaluated
  - Exposure pathways evaluated:
    - Ingestion/Inhalation/Dermal contact with surface soils/GW
    - Ingestion of shellfish from Shipyard Creek

Findings of RI/FS Continued

- **Surface Soils/GW Risk Results**
  - Carcinogenic Risks
    - Within acceptable range (5E-05)
  - Non-Carcinogenic Risks
    - Surface soil acceptable under industrial use (HI=0.1)
    - GW exposure HI=34
      - 91% of risk (HI=31) driven by hexavalent chromium
      - Minor contribution by arsenic, antimony, iron, manganese

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Findings of RI/FS Continued

- Shellfish Ingestion Risk Results
  - Recreational harvest from Shipyard Creek exclusively
  - Scenarios evaluated:
    - Equal parts oyster, crab, shrimp
    - Only one type of shellfish
  - Ingestion rates:
    - 20 lbs/yr. (95^{th} percentile/RME)
    - 6.5 lbs/yr. (50^{th} percentile/CTE)
  - Equal parts oyster, crab, shrimp = acceptable risk
  - 100% oyster, crab = acceptable risk
  - 100% shrimp = unacceptable risk due to arsenic at RME
    - Comparable to background risks
    - Acceptable risks at CTE

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Findings of RI/FS Continued

- Ecological Risk Assessment
  - Preliminary Ecological Risk Evaluation
  - Zones A, B, & C in upper Shipyard Creek
  - Multiple lines of evidence approach
    - sediment chemistry
    - chronic toxicity to grass shrimp
    - acute toxicity to amphipods
    - grass shrimp population study
    - tissue analysis for minnows & fiddler crabs
    - food chain models
  - Chronic impacts to grass shrimp in Zone A
    - total chromium, nickel, zinc in sediments
  - Future monitoring in Zone C

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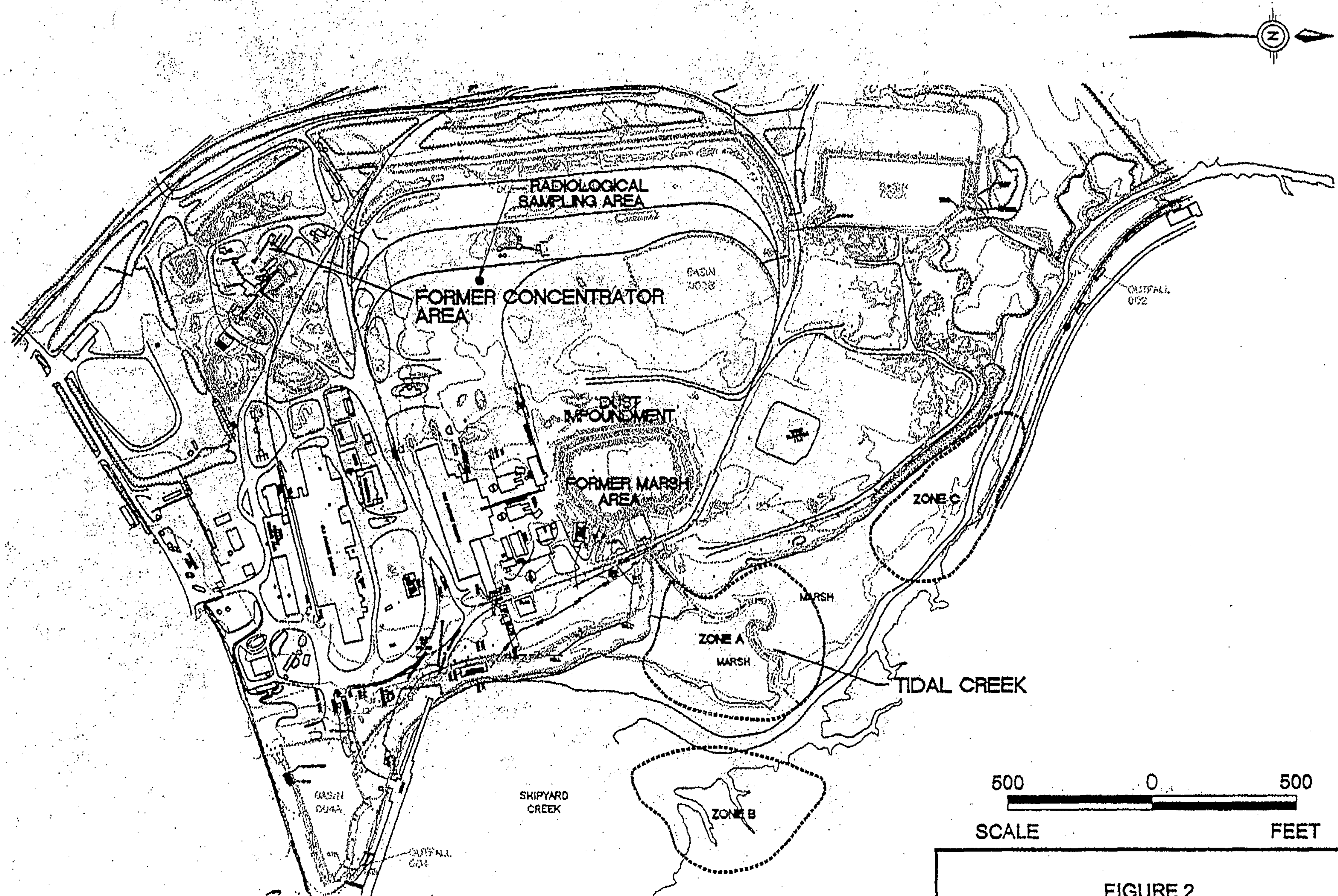

FIGURE 2
MACALLOY CORPORATION SITE

DWG DATE: 02/28/02	NAME: 2417021B013

Soil Impacts

- Leaching from Soil to GW
- Remedial goal of 23 mg/kg for hexavalent chromium
- Total of 115,000 cubic yards > 23 mg/kg
    - 40.000 CY remaining berm material
    - 40,000 CY vadose zone under impoundment
    - 18,500 CY casting bay/ESP storage area
    - 15,000 CY lined impoundment
    - 1,500 CY isolated areas
- 110 Cubic yards of radiological debris (>2X background)

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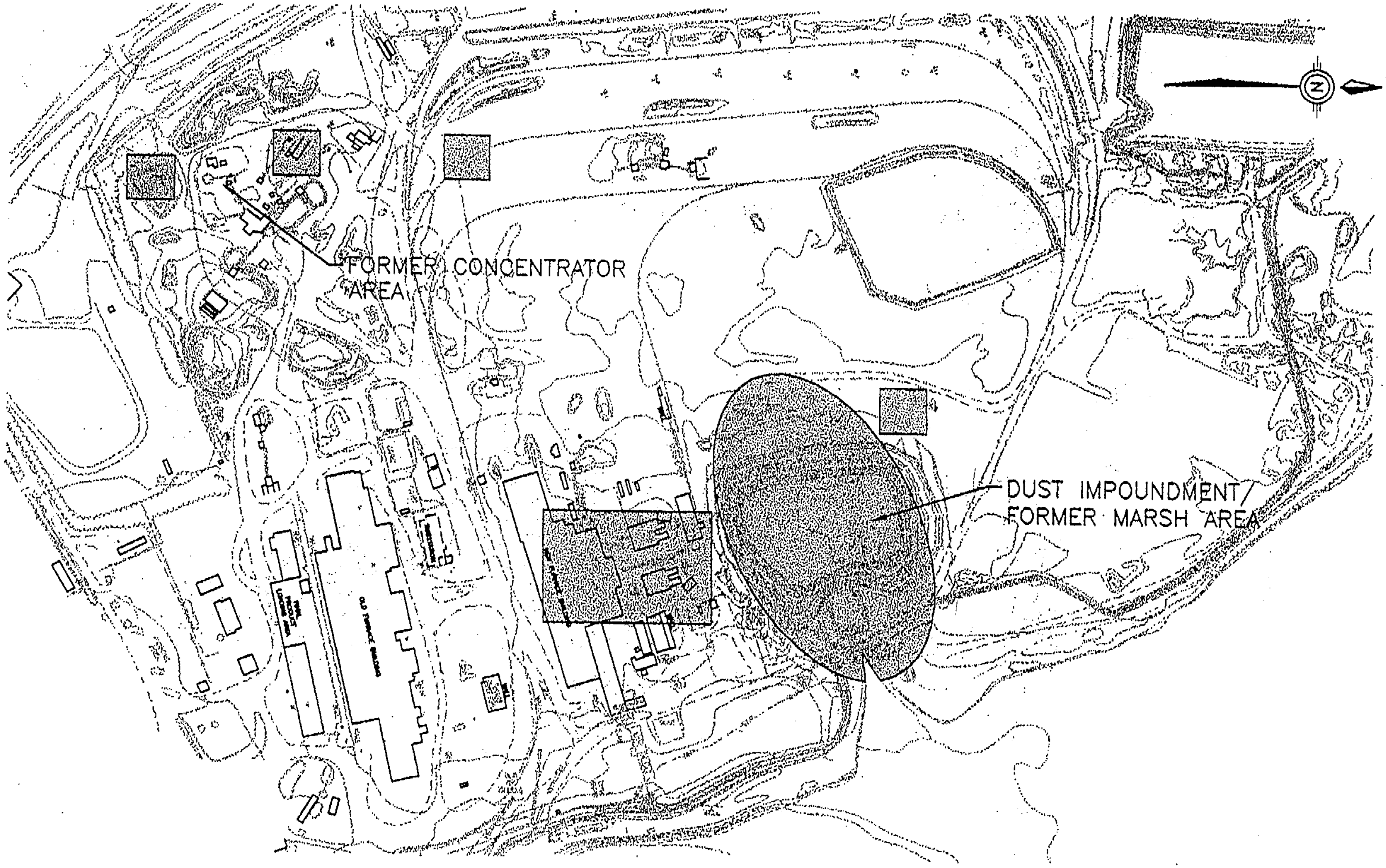

LEGEND

- HEXAVALENT CHROMIUM CONTAMINATED SOIL

350 0 350
SCALE FEET

FIGURE 3
EXTENT OF SOIL CONTAMINATION

DWG DATE: 02/28/02 | NAME: 2417021B012

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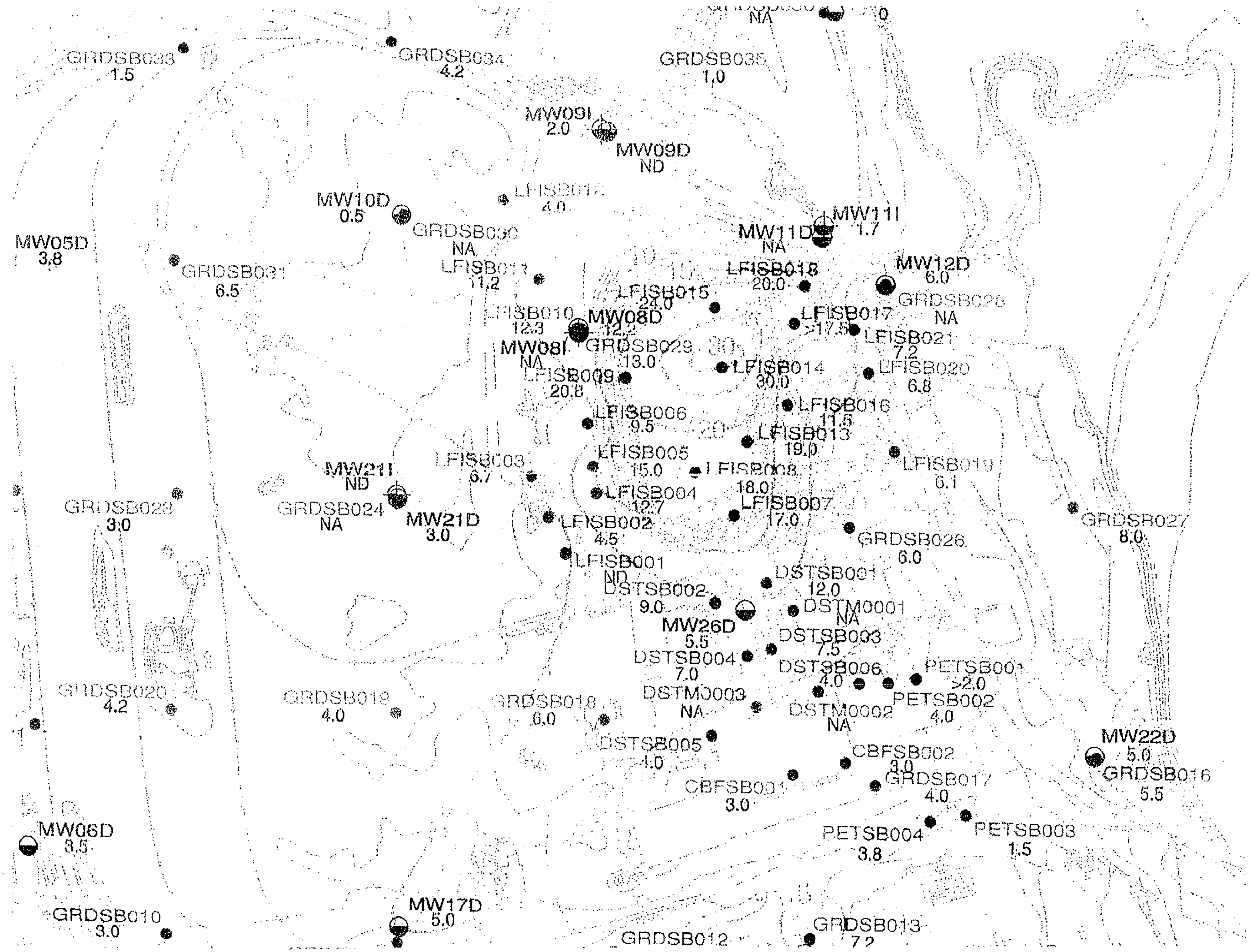
Site Geology

- Surface elevations 10-15 feet above mean sea level (msl)
- Layer of fill varies in thickness across site
- Upper sand unit (shallow aquifer)
  - saturated thickness ranging from 7 to 20 feet
- Intermediate clay/confining unit
  - approximately 20 feet below land surface (bls)
- Lower sand unit (deeper aquifer)
- Cooper Marl (confining unit) from 20 to 41 feet below msl

Groundwater Impacts

- East to NE flow direction towards Shipyard Creek
- Horizontal flow velocity 10-100 ft/year
- Contamination limited to shallow aquifer
- Hexavalent chromium primary concern
  - maximum concentration Cr+6 = 38,600 ug/l
  - remedial goal = 100 ug/L
- Confirmed GW to SW pathway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1.5
GRDSB034
4.2
GRDSB035
1.0
NA
MW09I
2.0
MW09D
ND
LFISB012
4.0
MW10D
0.5
GRDSB030
NA
MW11I
1.7
MW11D
NA
MW05D
3.8
GRDSB031
6.5
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LFISB019
6.1
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LFISB004
12.7
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3.0
GRDSB024
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MW21D
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LFISB007
17.0
LFISB002
4.5
GRDSB027
8.0
GRDSB026
6.0
LFISB001
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DSTSB001
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DSTSB002
9.0
DSTM0001
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GRDSB012
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7.2

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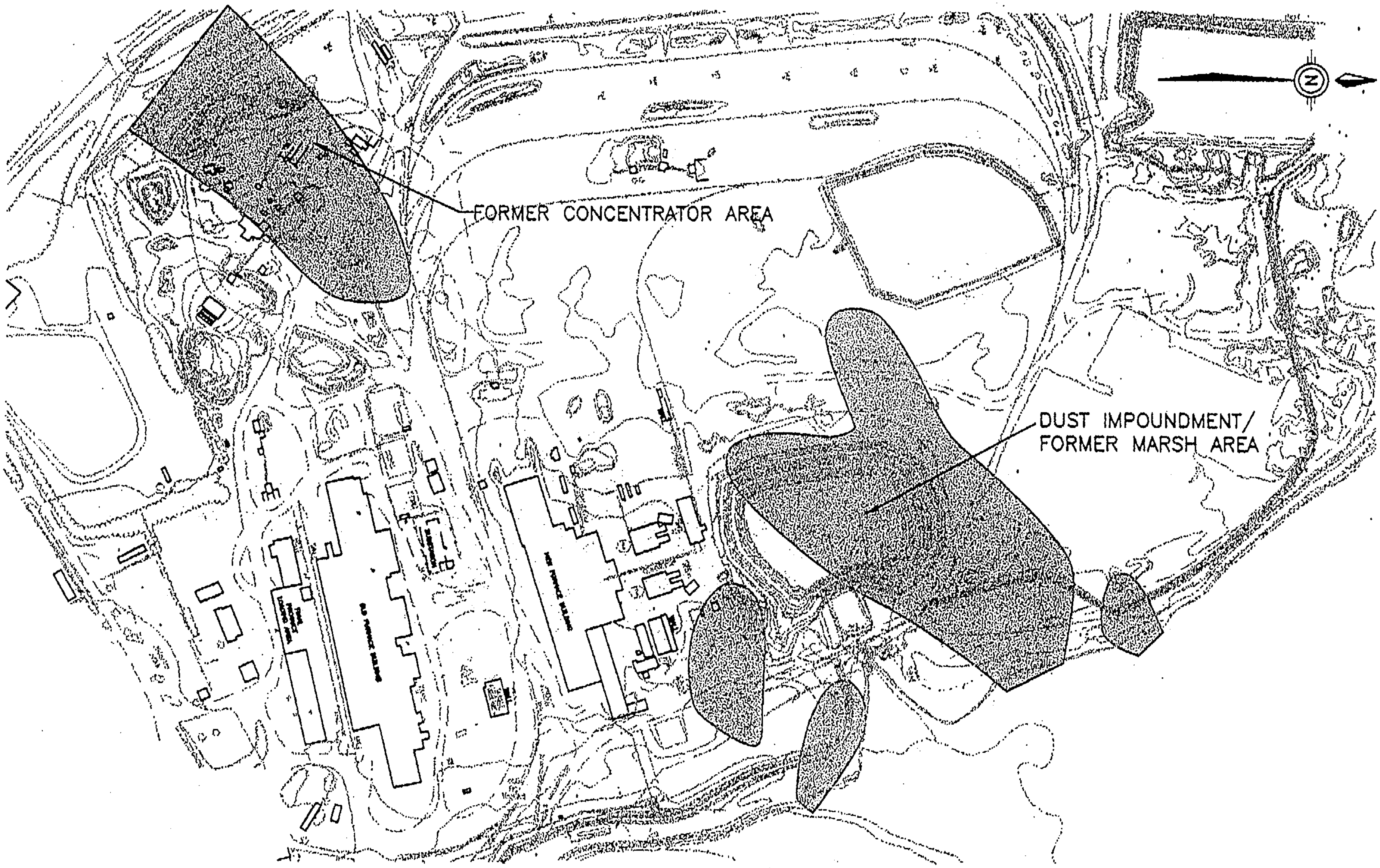

LEGEND

– HEXAVALENT CHROMIUM GROUNDWATER PLUMES

350 0 350

SCALE FEET

FIGURE 4
GROUNDWATER PLUMES

DWG DATE: 02/28/02	NAME: 2417021B01.1

59 466

Surface Water/Storm Water

- Process water discharges stopped in mid 1998
- Historic NPDES monitoring indicated exceedances for:
  - lead, arsenic, hexavalent chromium, copper, zinc
- Ambient water quality standards adopted as remedial goals
  - Lead = 220 ug/L
  - Arsenic = 69 ug/L
  - Copper = 5.8 ug/L
  - Zinc = 9.5 ug/L
  - Hexavalent Chromium = 1,100 ug/L

Sediment

- Zone A tidal creek
- Received process water discharges
- 1,000 cubic yards/18 inches deep
- Future monitoring in Zone C

Soil Alternatives

- No Action (S1)
- On-site Chemical Reduction
  - Ex-situ and in-situ (S2A)
  - Ex-situ by mechanical mixing (S2B)
  - Ex-situ by pug mill (S2C)
- Excavation with off-site disposal
- Hot Mix Asphalt Cap (S4)

Groundwater Alternatives

- No Action (G1)
- Enhanced In-situ Reduction
  - Hydrogen Release Compound (G2A)
  - Chemical Reduction (G2B)
  - Carbohydrate Reduction (G2C)
- Zero Valent Iron Permeable Reactive Barrier (G3)
- Groundwater Containment (G4)

Radiological Material Alternatives

- No Action (R1)
- Excavation and off-site disposal (R2)
- Soil Cover (R3)

Sediment Alternatives

- No Action (M1)
- Enhanced Monitored Natural Recovery (M2)
- Capping (M3)
- Excavation and upland disposal (M4)

Storm Water

- Comprehensive storm water management plan
- Goal to achieve ambient water quality criteria
- 10 year/24 hour storm (6.8 inches of rain)
- Meet OCRM requirements

Remedy Evaluation Criteria

1. Overall protection of human health/environment
2. Compliance with ARARs
3. Long-term effectiveness/permanence
4. Reduction of toxicity, mobility, or volume through treatment
5. Short-term effectiveness
6. Implementability
7. Cost
8. State agency acceptance
9. Community acceptance

Proposed Cleanup Plan

- **Soil: Alternative S2B**
  - On-site chemical reduction by mechanical mixing
  - Present Worth Cost = $7,883,000
- **Groundwater: Alternative G2B**
  - Enhanced in-situ reduction; chemical reductant
  - Present Worth Cost = $2,053,000
- **Radiological Material: Alternative R2**
  - Excavation with off-site treatment
  - Present Worth Cost = $15,000

Proposed Cleanup Plan Continued

- **Sediment Alternative: M4**
  - Removal with upland (on-site) disposal
  - Five year review monitoring for Zone C
  - Present Worth Cost = $512,000

- **Storm Water Management Plan**
  - Present Worth Cost = $1,256,000

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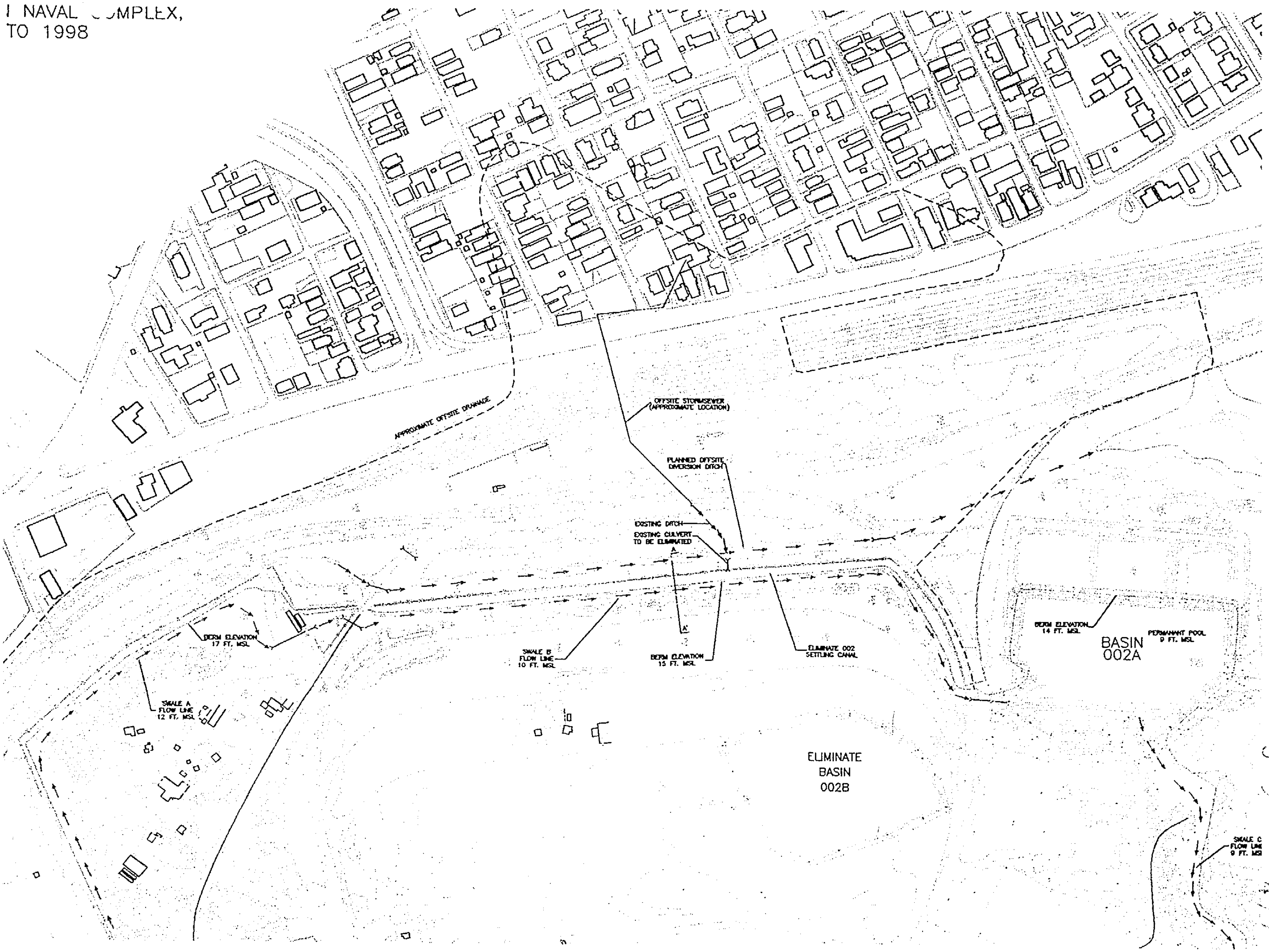

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MARSH
MARSH
WEST
ROAD
FLOW LINE 9 FT. MSL
BOTTOM OF BASIN 8 FT. MSL
IMPOUNDMENT
ELIMINATE 001 POND
MODIFIED BASIN 004B
BERM ELEVATION 13 FT. MSL
BOTTOM OF BASIN 8 FT. MSL
SHIPYARD CREEK
STORM WATER OUTFALL WITH FLOW VELOCITY CONTROL STRUCTURE
WALL
NEW FURNACE BUILDING
WALL
OUTFALL 003 (SANITARY WASTE WATER)
BERM ELEVATION 11 FT. MSL
OUTFALL 004
SUBSTATION
NEW STORM SEWER SECTION
NEW CATCH BASIN
OLD FURNACE BUILDING
REDUCE BASIN 004A SIZE
ABANDONED STORM SEWER SECTION
FINAL PRODUCT LOADING AREA

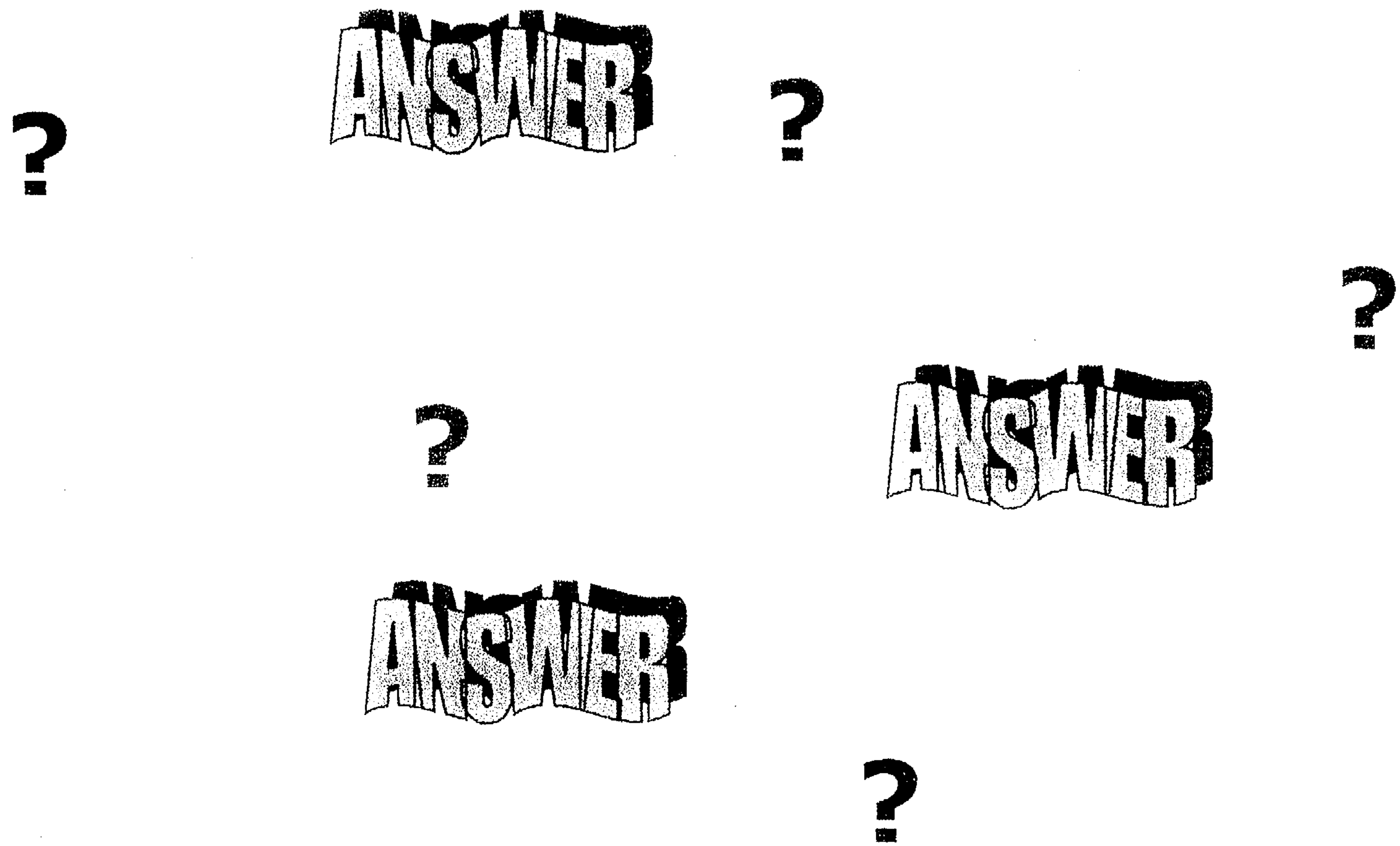
Community Participation

- 30 day public comment period (April 11 – May 11, 2002)
- 30 day extension upon timely request
- Administrative Record

Future Schedule

- Record of Decision (June 2002)
- Responsiveness Summary
- Remedial Design (June 2002 – December 2002)
- Remedial Action Bid Process (January 2003)
- Construction Start (Spring 2003)
- Future Property Redevelopment

Questions and Answers?



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