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Superfund Record of Decision:

Bofors Nobel, MI

50272-101

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15. Supplementary Notes

16. Abstract (Limit: 200 words)

The 85-acre Bofors Nobel site is an active specialty chemical production plant in Edelston Township, Muskegon County, Michigan. An inactive landfill is also located in the eastern portion of the site. Onsite wetlands lie within πthe floodplain of Big Black Creek, which runs through the southern portion of the site. The site overlies a lacustrine aquifer, a potential drinking water source, which has been contaminated as a result of site activities. During the 1960s and early 1970s, sludge, wastewater, and waste liquids from plant operations were discharged into 10 onsite lagoons. Subsequent investigations by EPA have identified eight of the onsite lagoons as potential sources of ground water contamination. In 1976, the State restricted wastewater discharge from the site, and a ground water pump and treatment system was installed to treat contaminated ground water in the lacustrine aquifer. This Record of Decision (ROD) addresses remediation of the lagoons, as well as upgrading the current ground water treatment system. A subsequent final ROD will address other contaminated soil and complete restoration of the aquifer. The primary contaminants of concern affecting the soil, sludge, and ground water are VOCs including benzene.

(See Attached Page)

17. Document Analysis a. Descriptors

Record of **Decision** - Bofors Nobel, MI
First **Remedial Action**
Contaminated **Media:** soil, sludge, gw
Key Contaminants: VOCs (benzene)

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report) None	21. No. of Pages 73
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(See ANSI-Z39.18) *See Instructions on Reverse* OPTIONAL FORM 272 (4-77) (Formerly NTIS-35) Department of Commerce

EPA/ROD/R05-90/150
Bofors Nobel, MI
First Remedial Action

Abstract (Continued)

The selected remedial action for this site includes excavating approximately 101,000 cubic yards of sludge and berm material highly contaminated with VOCs, treating the contaminated material onsite using incineration and low temperature thermal desorption, disposing of the residual ash in an onsite landfill, and treating scrubber water from the incinerator by precipitation; treating landfill leachate in the ground water treatment system; excavating approximately 372,000 cubic yards of less VOC-contaminated soil and sludge and disposing of these wastes onsite in the landfill; pumping and treatment of ground water using ozone oxidation or a comparable treatment with onsite discharge to surface water; monitoring ground water, surface water, and air; and implementing site access restrictions including fencing. The estimated present worth cost for this remedial action is $70,874,000, which includes an annual O&M cost of $313,000 for 43 years.

PERFORMANCE STANDARDS OR GOALS: Landfilled material must exhibit an excess lifetime cancer risk of less than 10^{-6}. Chemical-specific soil cleanup levels were developed based on the type and location of contaminated media within or adjacent to the lagoons including benzene 410 to 4,500 ug/kg. Ground water cleanup levels are based on proposed Best Available Technology discharge standards including benzene 5.0 ug/l.

DECLARATION FOR THE RECORD OF DECISION

SITE NAME AND LOCATION

Bofors-Nobel Site
Muskegon, Michigan

STATEMENT OF BASIS AND PURPOSE

This decision document presents the selected remedial action for the Bofors-Nobel site, in Muskegon, Michigan, chosen in accordance with CERCLA, as amended by SARA and, to the extent practicable, the National Oil and Hazardous Substances Pollution Contingency Plan. This decision is based on the administrative record file for this site.

The State of Michigan concurs on the selected remedy.

ASSESSMENT OF THE SITE

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this Record of Decision (ROD), may present an imminent and substantial endangerment to public health, welfare, or the environment.

DESCRIPTION OF THE REMEDY

This operable unit is the first of two operable units for the site. This operable unit addresses contaminated sludges and soils in the lagoon area, a major source of contamination at the site. The second operable unit will involve remediation of contaminated soils in the vicinity of the operating manufacturing facility and remediation of the contaminated groundwater. The response action for this operable unit addresses the principal threat remaining at the site by treating the most highly contaminated sludge. Treatment residuals, less-contaminated sludge, and soils contaminated at low levels will be disposed of in an on-site landfill that will meet the intent of RCRA subtitle C requirements.

The major components of the selected remedy include:

- Excavation and treatment, via on-site thermal treatment, of approximately 101,000 cubic yards of the most-contaminated sludge from the lagoon area;

- Disposal of approximately 19,000 cubic yards of less-contaminated sludge, approximately 353,000 cubic yards of contaminated soils, and solid treatment residuals in an

- Upgrading of existing groundwater pumping and treatment system.

STATUTORY DETERMINATIONS

The selected remedy is protective of human health and the environment, complies with Federal and State requirements that are legally applicable or relevant and appropriate to the remedial action, and is cost-effective. This remedy utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable and satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility, or volume as a principal element. Because this remedy will result in hazardous substances remaining on-site above health-based levels, a review will be conducted within five years after commencement of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

Valdas V. Adamkus
Regional Administrator

September 17, 1990
Date

STATE OF MICHIGAN

JAMES J. BLANCHARD, Governor

DEPARTMENT OF NATURAL RESOURCES

STEVENS T MASON BUILDING
P O BOX 30028
LANSING, MI 48909

DAVID F HALES, Director

September 14, 1990

Mr. Valdas Adamkus, Regional Administrator
U.S. Environmental Protection Agency
Region V, 5RA-14
230 South Dearborn Street
Chicago, Illinois 60604

Dear Mr. Adamkus:

SUBJECT: Bofors-Nobel Site
Muskegon County, Michigan

The Michigan Department of Natural Resources (MDNR), on behalf of the State of Michigan, has reviewed the proposed Record of Decision (ROD) for the Bofors-Nobel site. The site response has been organized into two operable units:

A. Lagoon Area Operable Unit which addresses contamination in the sludges, lagoons, soils under and around the lagoons, and upgrading of the existing groundwater pumping and treatment system.

B. Groundwater and Plant Area Operable Unit which addresses contamination of the groundwater under the site and contamination in the soils in the plant area.

This ROD concerns the first of these two operable units which addresses the major source of contamination at the site. Michigan concurs with Alternative 4 selected in the ROD. The remedy addresses the principal threat at the site by treating the most highly contaminated sludges and soils by on-site incineration/low-temperature thermal desorption, and upgrading of the existing extraction and treatment system for the groundwater. Treatment residuals, and sludges and soils with lower levels of contamination will be disposed of in an on-site landfill constructed in accordance with RCRA Subtitle C landfill requirements.

The selected remedial action for this operable unit will provide protection of human health and the environment through treatment and engineering controls.

It is the department's judgement that this action will significantly reduce or eliminate the risks posed by the lagoon area sludges and soils.

I look forward to implementation of this remedy for the lagoon area of the Bofors-Nobel Site, and to selection and implementation of a final remedy for the site.

Sincerely,

David F. Hales
Director
517-373-2329

cc: Mr. Jonas Dikinis, US EPA
Ms. Mary Elaine Gustafson, US EPA
Dr. James Truchan, MDNR
Mr. William Bradford, MDNR
Mr. Gerard Heyt, MDNR
Mr. Roger Przybysz, MDNR

DECISION SUMMARY FOR THE RECORD OF DECISION

SITE NAME, LOCATION, AND DESCRIPTION

The Bofors-Nobel (Bofors) site is located 6 miles east of downtown Muskegon on Evanston Road in Egelston Township, Muskegon County, Michigan (see Figure 1). This 85-acre site includes a currently operating specialty chemical production facility, an unused landfill, a currently operating groundwater pumping and treatment system, and 10 abandoned sludge lagoons. The southern portion of the site is bounded by Big Black Creek. Pertinent site features are shown on Figure 2. There are wetlands on either side of Big Black Creek, within the Big Black Creek floodplain. The approximate location of wetlands within the site boundary is shown in this figure. A lacustrine aquifer underlies the site and is contaminated from previous site activities. The existing groundwater pumping and treatment system prevents off-site migration of the contaminated groundwater into Big Black Creek. This portion of the aquifer is not currently being used. A clay till approximately 150 feet thick underlies this lacustrine aquifer and separates it from the underlying Marshall Sandstone, a drinking water aquifer. There appears to be an upward hydraulic gradient through the till.

Big Black Creek is currently being used for recreational purposes. This includes fishing and swimming. In addition, there is evidence of transient residences on the south side of the creek.

Approximately 1,800 people live within a 1.25-mile radius of this site. The primary route of exposure for this population is through inhalation of contaminated air from the site. Contaminated groundwater will not migrate off-site assuming the existing pumping and treatment system remains operational.

SITE HISTORY AND ENFORCEMENT ACTIVITIES

Lakeway Chemicals began producing industrial chemicals at the site in 1960. Throughout the 1960s and early 1970s, ten on-site lagoons were used for disposal of sludge, wastewater, and various waste liquids. This practice resulted in contamination of the groundwater underneath the site and, subsequently, Big Black Creek. Because of this contamination, the State of Michigan placed various restrictions on wastewater disposal from the site. In 1976, wastewater from the plant was accepted at the Muskegon County Wastewater Treatment Plant, and purge wells were installed at the site to extract contaminated groundwater.

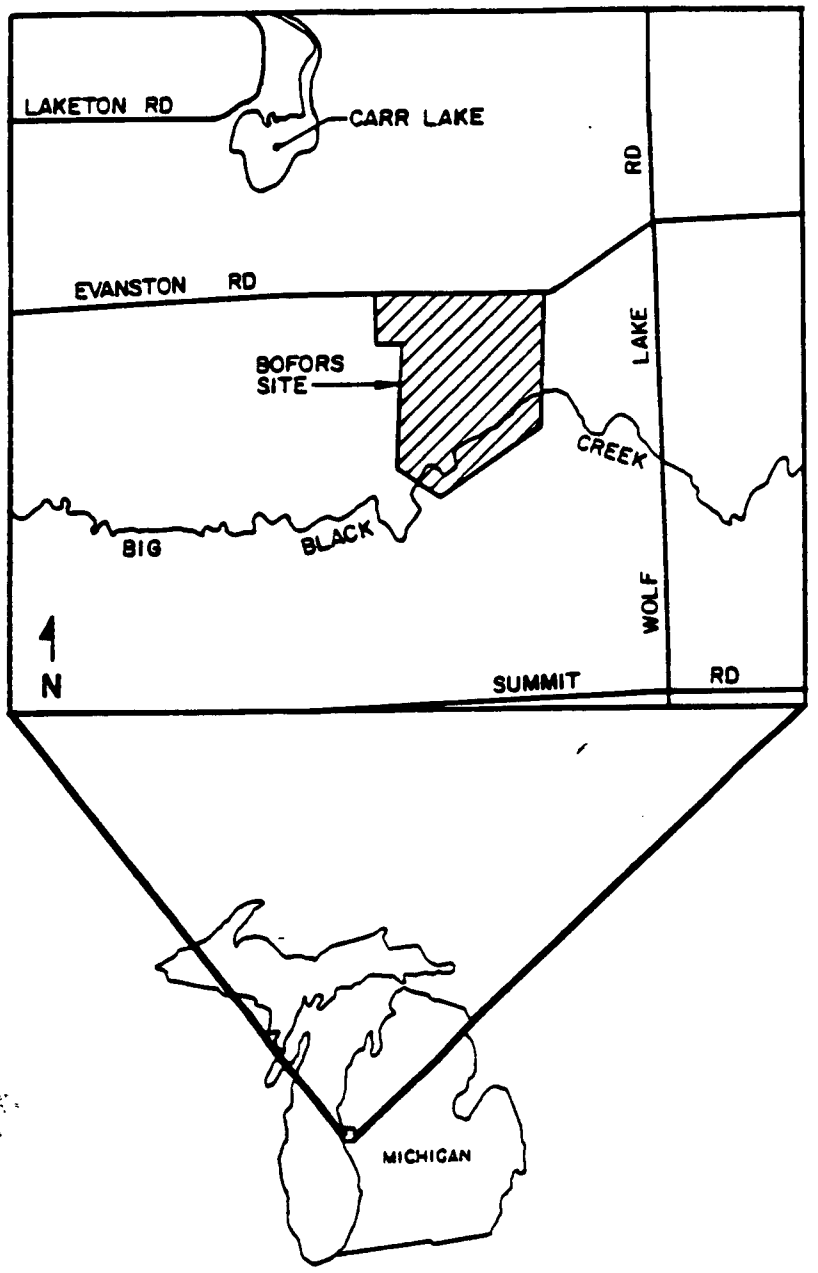


Figure 1 Site Location Map

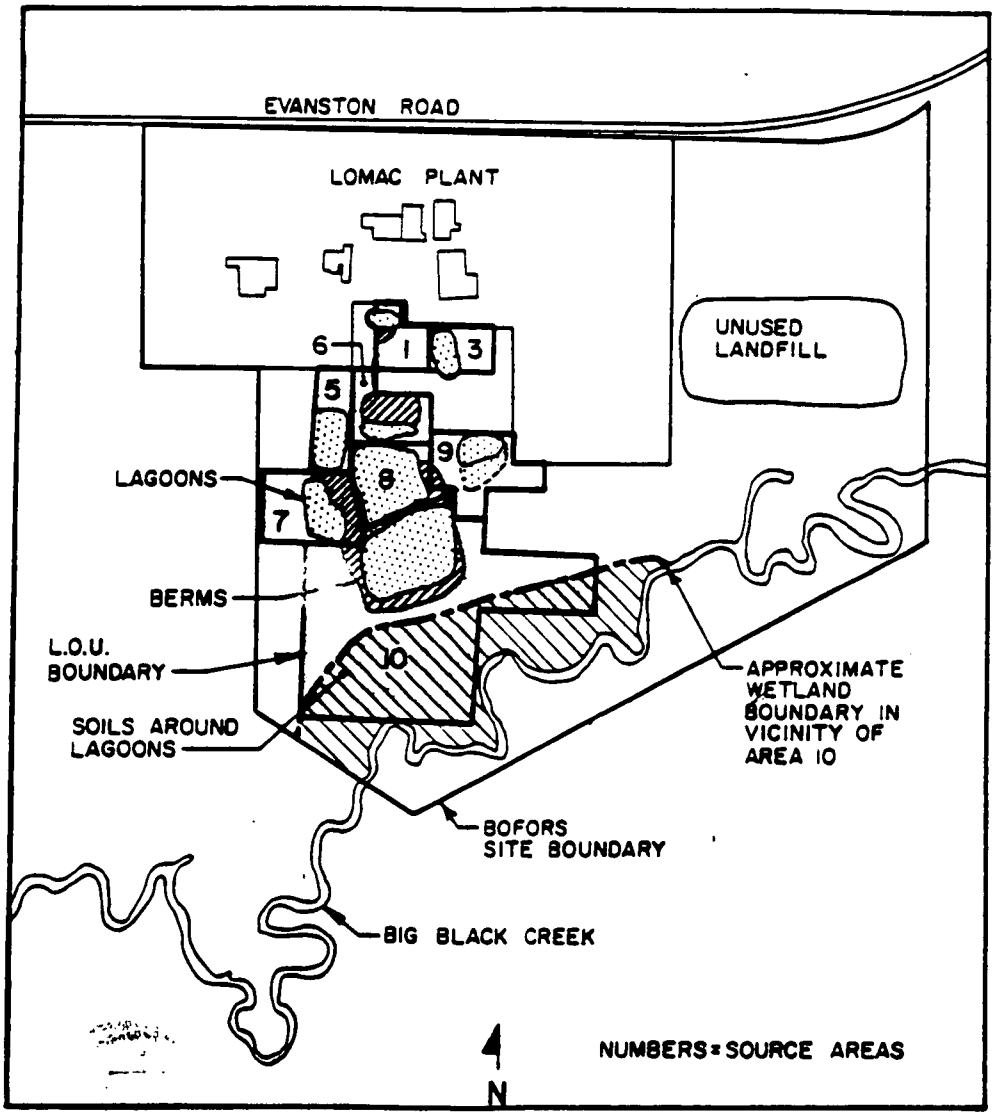


Figure 2 Site Detail Map

Bofors Industries, Inc., merged with Lakeway in 1977 and with Nobel Industries in 1981. In 1985, Bofors-Nobel (Bofors) filed for bankruptcy for reasons including reported environmental expenditures in excess of $60 million. As part of the bankruptcy settlement, the State of Michigan received $15 million and the U.S. Environmental Protection Agency (U.S. EPA) received $5 million to be used toward site remediation. As a result of legal action in bankruptcy court, Bofors was allowed to sell the operating chemical plant to Lomac, Inc. (Lomac). As part of the sale, agreements were reached between Lomac, the Michigan Department of Natural Resources (MDNR), and U.S. EPA that Lomac would not be liable for cleanup of contamination existing prior to the sale of the plant area property. These agreements allowed Lomac to operate the plant independently of previous site activities. The site was nominated for the National Priorities List (NPL) and was placed on the NPL in March 1989. The Remedial Investigation/Feasibility Study (RI/FS) was initiated in August 1987.

Bofors Lakeway, Inc., was a wholly-owned subsidiary of Bofors America, Inc. (BAI). BAI was a wholly-owned subsidiary of Nobel Industries Sweden A.B. (Nobel). Nobel is a Swedish corporation. On May 18, 1990, U.S. EPA sent CERCLA Statute 104(e) information requests to BAI and to Nobel. BAI responded to those CERCLA Statute 104(e) information requests in part on June 21, 1990. BAI filed a supplemental response on August 27, 1990. U.S. EPA is currently evaluating those responses. U.S. EPA is planning to fund the Remedial Design (RD) immediately.

HIGHLIGHTS OF COMMUNITY PARTICIPATION

The RI/FS and Proposed Plan for the Bofors site were released to the public in July 1990. These two documents were made available to the public in both the administrative record and an information repository maintained at the U.S. EPA Docket Room in Region 5 and at the Hackley Public Library in Muskegon, Michigan. The notice of availability for these two documents was published in the Muskegon Press on July 21, 1990. A public comment period was held from July 23 through August 23, 1990. In addition, a public meeting was held on August 1, 1990. At this meeting, representatives from U.S. EPA and MDNR answered questions about problems at the site and the remedial alternatives under consideration. A response to the comments received during this period is included in the Responsiveness Summary, which is part of this Record of Decision (ROD). This decision document presents the selected remedial action for the Bofors site in Muskegon, Michigan, chosen in accordance with CERCLA, as amended by SARA and, to the extent practicable, the National Contingency Plan (NCP). The decision for this site is based on the administrative record.

SCOPE AND ROLE OF OPERABLE UNIT WITH SITE STRATEGY

As with many Superfund sites, the problems at the Bofors site are complex. As a result, U.S. EPA organized the work into two operable units (OUs). These are:

- Lagoon Area Operable Unit (L.O.U.): contamination in the sludges, in the lagoons, in the soils under and around the lagoons, and upgrading of the existing groundwater pumping and treatment system.

- Groundwater and Plant Area Operable Unit (GW/PA O.U.): contamination of the groundwater under the site and contamination in the soils in the plant area.

This ROD concerns the first of these two operable units. This operable unit addresses the principal threat through source control. The location of the L.O.U. is shown in Figure 2.

As shown in Figure 2, the L.O.U. includes eight of the 10 lagoon contaminant source areas investigated. The remaining two lagoons did not contain detectable levels of contamination. The southern portion of the L.O.U. is bounded by a groundwater extraction system that controls the groundwater contaminant plume.

This area of the site poses a principal threat to human health and the environment because of the risks from contaminant migration from the sludges and soils into the lacustrine aquifer directly under site, that is a potential source of drinking water. The contaminated groundwater, if it discharges into Big Black Creek, also poses risk from ingestion of contaminated creek water. There is also a threat because of the risks from inhalation of volatilized contaminants from the sludges and soils. The purpose of this response is to reduce contaminant migration into the groundwater, surface water, and air, and prevent direct contact with the contaminants.

SUMMARY OF SITE CHARACTERISTICS

The RI included the following tasks:

- Lagoon sludges and soils characterization
- Plant area soil characterization
- Air sampling and analysis
- Surface water and sediment characterization
- Surficial soil characterization
- Aquifer characterization
- Groundwater sampling and analysis
- Wetlands survey
- Baseline risk assessment
- Treatability studies

The results are summarized as follows.

Contamination and Affected Media

The lagoon area sludges and soils and the groundwater showed detectable levels of contaminants related to the site. The surface water sampling and analysis showed no detected contamination. The air analysis indicated contamination only from the operating plant. Therefore, only a summary of contamination for the lagoon area sludges and soils and the groundwater is presented.

Lagoon Area Sludges and Soils

In the lagoon area, 10 potential source areas were identified. In these 10 source areas, the sludge from the lagoons, the soil beneath the lagoons, and the soil around the lagoons were sampled and analyzed. The organic compounds detected for the lagoon sludges and soils beneath and around the lagoons are presented in Table 1. As discussed previously and as shown in Table 1, detectable levels of contamination were found in eight of the 10 lagoon areas. These source areas were subdivided into four possible subareas: lagoon sludge, contaminated soil beneath the lagoon sludge, contaminated soil around the lagoon sludge, and, in some cases, a berm. These source areas and subareas are shown in Figure 2. The source areas were subdivided because the magnitude of contamination varies considerably among the eight source areas and their subareas. From a treatment standpoint, risks were calculated for each source area and subarea separately to aid in selecting the most cost-effective remedial alternatives which provide the greatest protection of human health and the environment. Contaminated soils around the lagoons were identified using results from a 1-acre grid sampling interval; this explains the irregular source area configurations shown in the figure. The compounds of concern developed from the baseline risk assessment are listed below:

- Methylene Chloride
- Benzene
- 3,3'-Dichlorobenzidine (DCB)
- Aniline
- Azobenzene
- Benzidine

These six compounds of concern were chosen because they are highly toxic and drive the risk assessment for this site. Methylene chloride, DCB, aniline, and azobenzene are potential human carcinogens. Benzene and benzidine are known human carcinogens.

Units: ppb

TABLE 1
SUMMARY OF MAXIMUM LAGOON SLUDGE AND SOIL COMPOUNDS AND CHEMICALS
ORGANIC COMPOUNDS

	LAGOON 1				LAGOON 3				LAGOON 5				LAGOON 6			
	SL	SB	SA	B	SL	SB	SA	B	SL	SB	SA	B	SL	SB	SA	B
Methylene Chloride	0	0	NA	0	0	0	NA	0	4	4	NA	0	2200	0	NA	1,100
Tetrachloroethylene	0	0	NA	0	0	0	NA	0	0	0	NA	0	0	0	NA	0
Acetone	0	70	NA	0	0	0	NA	0	0	0	NA	0	0	0	NA	0
Benzene	0	0	NA	0	980000	130	NA	0	23	0	NA	0	0	0	NA	0
2-Butanone	0	0	NA	0	0	0	NA	0	0	0	NA	0	0	0	NA	0
Ethylbenzene	91	0	NA	26	0	0	NA	0	0	0	NA	0	9200	0	NA	4,600
Toluene	6600	170	NA	4,450	1100000	0	NA	0	17	3	NA	0	130000	0	NA	65,000
Xylene (o,m,p)	120	36	NA	60	0	0	NA	0	14	0	NA	0	58000	1200	NA	29,000
2-Chloroaniline	260000	2300	NA	130,000	220000	270000	3500	0	0	0	540	0	22000	21000	540	11,000
3,3'-Dichlorobenzidine	10000	0	27000	5,000	830000	1100000	2700000	0	930000	33000	150000	0	21000	390000	150000	10,500
1,2,4-Trichlorobenzene	0	0	NA	0	0	350	0	0	0	0	150	0	0	0	150	0
Bis(2-chlorophenyl)-diazene-1-oxide	0	0	NA	0	15000000	340000	450000	0	73000	0	9800	0	730000	81000	9800	365,000
3,3'-Dichlorobenzidine Isomers	65000	3800	NA	32,500	260000	93000	0	0	950000	52000	0	0	1000000	264000	0	500,000
(3-chlorophenyl)(4-chlorophenyl) -methanone	300000	5500	NA	150,000	6100000	1900000	2900000	0	330000	2900	11000	0	1300000	280000	11000	650,000
Aniline	0	880	NA	0	0	9200	550	0	0	0	0	0	0	0	0	0
Azobenzene	0	93	NA	0	12000000	1000000	99000	0	170000	5500	3800	0	680000	22000	3800	340,000
Benzidine	0	0	0	0	3400000	580000	410	0	0	2100	0	0	70000	7800	0	35,000
Alkyl Benzene Isomers	0	0	NA	0	0	148000	468000	0	0	0	0	0	123000	86400	0	61,500
Azoxybenzene	0	0	NA	0	690000	460000	170000	0	0	0	0	0	0	0	0	0
Sulfur	0	5100	NA	0	0	0	0	0	0	0	0	0	0	0	0	0
1,1'-Sulfonylbis(2-methyl)-Benzene	0	0	NA	0	0	0	0	0	0	0	0	0	0	0	0	0

	LAGOON 7				LAGOON 8				LAGOON 9				LAGOON 10			
	SL	SB	SA	B	SL	SB	SA	B	SL	SB	SA	B	SL	SB	SA	B
Methylene Chloride	18	0	0	0	1200	0	0	600	0	0	0	0	0	0	0	0
Tetrachloroethylene	0	0	82	0	680	0	0	340	0	0	0	0	0	0	0	0
Acetone	0	0	0	0	0	0	0	0	91	0	0	0	0	11	0	0
Benzene	0	0	0	0	2800	0	0	1,400	890	0	120000	0	8	8	0	4
2-Butanone	0	0	0	0	0	0	0	0	25	0	0	0	0	0	0	0
Ethylbenzene	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Toluene	0	0	0	0	80000	0	0	40,000	1200	18000	1800000	0	9	210	0	5
Xylene (o,m,p)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2-Chloroaniline	0	0	240	0	12000	12000	1800	6,000	2300000	58000	380000	0	24000	4300	0	12,000
3,3'-Dichlorobenzidine	260000	10000	150000	0	1500000	90000	680000	750,000	11000000	78000	180000	0	2900000	7100	380000	1,450,000
1,2,4-Trichlorobenzene	0	0	0	0	7100	7100	0	3,550	83000	0	250000	0	0	0	0	0
Bis(2-chlorophenyl)-diazene-1-oxide	62000	0	0	0	0	0	7700	0	0	0	45000	0	0	0	0	0
3,3'-Dichlorobenzidine Isomers	100000	5100	0	0	1700000	73000	0	850,000	2300000	0	1900	0	3500000	113200	170000	1,750,000
(3-chlorophenyl)(4-chlorophenyl) -methanone	520000	9400	64000	0	26000	19000	34000	13,000	0	0	6200000	0	180000	9300	88000	95,000
Aniline	0	0	0	0	1700	0	350	850	*3900000	9800	0	0	*1700	3400	350	850
Azobenzene	22000	0	130	0	33000	4300	3400	16,500	8200000	74000	780	0	230000	50000	3400	115,000
Benzidine	0	0	0	0	13000	0	0	6,500	*1300000	5500	1300	0	*13000	2200	0	6,500
Alkyl Benzene Isomers	0	0	0	0	147000	147000	107000	73,500	0	0	14800000	0	0	4400	0	0
Azoxybenzene	0	0	0	0	0	0	0	0	0	0	36000	0	85000	10000	0	42,500
Sulfur	0	8300	0	0	0	0	0	0	0	0	1500	0	0	0	0	0
1,1'-Sulfonylbis(2-methyl)-Benzene	0	0	0	0	0	0	0	0	0	0	0	0	82000	0	0	41,000

SL: Sludge.
SB: Soil beneath lagoons
SA: Soil around lagoons.
B. Berms
*: Data obtained from composite sample of Lagoons 8 and 10 sludge.

The Toxicity Characteristic Leaching Procedure (TCLP) was performed on selected lagoon area sludges and soils to evaluate the potential mobility of metals in the waste material. The results of TCLP testing were compared to TCLP standards which can be used as a measure of metal mobility. The concentrations of metals in the waste were found to be below the TCLP standards. Therefore, metals in the sludges and soils are not anticipated to be compounds of concern at this site.

As discussed previously, these lagoon area sludges and soils are a major source of contamination to the groundwater under the site and, therefore, a source of contamination for Big Black Creek if the groundwater pumping and treatment system is turned off. The lagoon sludges and soils are also a potential source of contamination to air in the vicinity of the site.

The volume of each lagoon subarea was estimated using data generated during Phase I and II RI activities. The volumes and surface area associated with each lagoon subarea are shown in Table 2. The volumes for the soils beneath the lagoons include material extending from the bottom of the sludge to the average water table depth. The soil volumes around each lagoon were also calculated using a depth of contamination of five feet in each area, except in the area between Lagoons 6, 8, and 9. In that area, the soil around the lagoons is assumed to be contaminated to the water table, because of the proximity of the lagoons to each other and possible overlapping of the lagoon boundaries. The assumption of contamination only in the top 5 feet for the rest of the soil around the lagoons is based on evaluation of the contaminant transport mechanisms by which the contamination migrated to these soils. These soils are estimated to be contaminated by surficial mechanisms such as trackout and airborne contamination. This assumption will need to be verified during the remedial design. The berm volumes were calculated by direct measurement off the site topographic map and only include material above grade. Volumes calculated for soils around the lagoons are based on limited information and should be considered as approximate values only.

Approximately 454,200 yd^3 of total contaminated media is estimated to be at this site. Approximately 22 percent (101,500 yd^3) represents contaminated sludge; 34 percent (156,200 yd^3) represents contaminated soil beneath the lagoons; 39 percent (178,500 yd^3) represents contaminated soil around the lagoons; and 4 percent (18,000 yd^3) represents contaminated berms around the lagoons. The volume of contaminated media may be further refined prior to remedial design.

TABLE 2

SOURCE AREA VOLUMES (yd^3)
BOFORS SITE
Muskegon, Michigan

Source Area	Sludge	Berms	Soil Beneath Lagoons	Soil Around Lagoons	Total Volume	Percent of Total Volume
1	3,400	300	9,300	7,700	20,700	4.6
3	7,600	0	10,700	3,900	22,200	4.9
5	8,000	0	14,400	6,300	28,700	6.3
6	3,400	2,300	5,400	17,900	29,000	6.4
7	7,000	0	26,400	12,600	46,000	10.1
8	28,400	5,500	28,400	14,400	76,700	16.9
9	9,600	0	30,500	33,100	73,200	16.1
10	34,100	9,900	31,100	82,600	157,700	34.7
Total	101,500	18,000	156,200	178,500	454,200	
Percent of Total Volume	22.3	4.0	34.4	39.3		

Note: Soil volume around the lagoons was calculated assuming only the top 5 feet of soil is contaminated.

RP/BFRSR[redacted]

Groundwater

Monitoring and purge wells were sampled and analyzed during the RI. The organic compounds detected in the groundwater are presented in Table 3. The extent of contamination in the groundwater appears to be bounded by the plant area to the north and the groundwater pumping and treatment system to the south. Contaminated groundwater at the site appears to be captured by the groundwater pumping and treatment system. At the present time, approximately 1 million gallons of groundwater per day is collected by the existing groundwater pumping and treatment system and is pumped to a PACT? treatment system owned by Lomac that also treats Lomac wastewater. The treatment effluent is discharged to the Muskegon County Wastewater Treatment Plant.

Based on historical data and groundwater modeling, if the groundwater pumping and treatment system is turned off, the contaminated groundwater will discharge into Big Black Creek, and the creek will become contaminated.

Potential Routes of Migration

Potential routes of migration and contaminant fate and transport were evaluated for the Bofors site. Based on this evaluation, the most significant pathways for release of contaminants at the Bofors site are through the air, surface water, and groundwater pathways. The Phase I baseline risk assessment indicated that the risks associated with ingestion of the sludge and soils was significantly less than the risks associated with the groundwater, surface water, and air pathways. Fate and transport mechanisms are summarized below for each of these three pathways.

Air Pathway

Contaminants can be released to the air in two ways, either by particulate or volatile emissions. Risks from particulate emissions were estimated for exposure by inhalation. These risks were estimated as approximately 100 times less than the risks from inhalation of volatile emissions. Therefore, volatilization appears to be the primary release mechanism to the air pathway from the lagoon area sludge and surficial soils surrounding the lagoons. Benzene, methylene chloride, and azobenzene are classified as highly volatile compounds and may readily volatilize from the sludge and contaminated surface soils. Aniline may also volatilize from the sludges, but to a lesser extent, and DCB and benzidine may volatilize to a limited extent. Even though these moderate and low volatility compounds may volatilize to a lesser degree, there may be significant mass loading to the atmosphere because of the large surface area and high concentrations of these compounds in the lagoons. Modeling of emission rates and contaminant transport via the air pathway have shown that the lagoon areas, due to their considerable surface area, present a

TABLE 3
SUMMARY OF DETECTED GROUNDWATER COMPOUNDS
Bofors Site
Muskegon, Michigan
June/July 1988
VOLATILE ORGANIC COMPOUNDS

Units: mg/kg (ppm)

	Background MW101*	Background [illegible]	Field Blanks	WC1*	WC2*	WC27*	LW1	LW3	LW4	PW31	PW33	PW39	PW41	MW07	MW18	MW41	MW50*	MW51*	MW52*
Halogenated Volatiles																			
Carbon Disulfide	--	--	--	--	--	--	--	1000	--	--	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--	--	920	--	240	--	--	--	--	--	--	--	--
1,2-Dichlorethane	--	--	--	--	--	--	--	--	--	--	110	--	55	--	--	--	--	--	--
1,2-Dichloroethylene	--	--	--	--	ND-1600J	--	--	1900	--	--	290	--	160	--	--	--	--	--	--
Methylene Chloride	--	--	ND-3J	--	ND-1400J	--	--	1200	--	2J	--	6	1100E	31J	--	--	--	--	--
Tetrachloroethylene	--	--	--	--	--	--	510J	18000	--	--	--	--	220	--	--	--	--	--	--
Trichloroethylene	--	--	--	--	--	--	--	--	--	--	--	--	43	--	--	--	--	--	--
Vinyl Chloride	--	--	--	--	--	--	--	--	----	--	1000	--	52	--	--	--	--	--	--
Nonhalogenated Compounds																			
Acetone	--	--	--	--	44000J-81000E	--	--	--	5100	--	--	--	--	31J	--	--	ND-7J	ND-8J	--
Benzene	--	--	ND-5	ND-3J	--	57000-65000	4000	--	--	--	--	--	--	120	--	92	--	--	--
Ethylbenzene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Toluene	ND-3J	--	ND-4J	ND-4J	31000J-110000E	260000-280000	23000	670	14000	2J	1100	--	--	2800E	680	--	ND-14	--	--
Xylene	ND-8	--	ND-7	ND-4J	--	--	--	--	--	--	--	5	100	--	--	--	ND-3J	ND-12	--
3,3,5-Trimethylcyclohexanone**	--	--	--	--	--	--	--	--	--	--	280J	--	55J	--	--	--	--	--	--
Unknowns	--	--	ND-25J	--	--	ND-8J	44J	--	3800J	33J	--	275	8J	--	5J	--	--	--	ND-10J

	MW84*	MW91*	MW102*	MW103*	MW104*	MW105*	MW106*	MW108*	MW110*
Halogenated Volatiles									
Carbon Disulfide	--	--	--	--	--	--	--	--	--
Chlorobenzene	--	--	--	--	--	--	--	--	--
1,2-Dichlorethane	--	--	--	--	--	--	--	--	--
1,2-Dichloroethylene	--	--	--	--	--	--	--	ND-3J	--
Methylene Chloride	--	--	ND-9	ND-3J	--	ND-3J	--	--	ND-3J
Tetrachloroethylene	--	--	ND-21J	--	--	--	--	--	--
Trichloroethylene	--	--	--	--	--	--	ND-4J	--	--
Vinyl Chloride	--	--	--	--	--	--	--	--	--
Nonhalogenated Compounds									
Acetone	--	--	ND-82	--	--	--	--	--	--
Benzene	3J-8	--	ND-750	--	--	--	ND-4000E	ND-310	ND-4J
Ethylbenzene	--	--	--	--	--	--	--	--	ND-3J
Toluene	ND-6	--	--	--	--	--	ND-200	--	--
Xylene	ND-3J	--	--	--	--	--	ND-4J	ND-4J	ND-4J
3,3,5-Trimethylcyclohexanone**	--	--	--	--	--	--	--	--	--
Unknowns	--	6J-30J	--	--	ND-12J	ND-15J	ND-13J	ND-6J	ND-5J

LEGEND:

, ND:	Not detected. ND used when ranges of concentrations were found.
J:	Value reported represents an estimate as value is above instrument detection limit but below contract required detection limit.
E	Exceeds calibration range.
*:	Well cluster
**:	Tentatively identified compound

TABLE 3
SUMMARY OF DETECTED GROUNDWATER COMPOUNDS
Bofors Site, Muskegon, Michigan
June/July, 1988
SEMIVOLATILE ORGANIC COMPOUNDS

Units: mg/kg (ppm)

	Field Blank	[redacted]	WC2*	WC27*	LW1	LW3	LW4	PW31	PW33	PW39	PW41	MW04*	MW05*	MW7
Halogenated Semivolatiles														
2-Chloroaniline	ND-85	ND-4J	ND-14J	6400-63000	7200	130	170J	13J	1300	54	3500	--	--	4J
4-Chloroaniline	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1,2-Dichlorobenzene	--	--	--	--	--	400	--	--	--	--	--	--	--	--
3,3'-Dichlorobenzidine	--	ND-16J	--	930J-1900	440	--	--	22J	80J	160	400	--	--	3J
1,2,4-Trichlorobenzene	--	--	--	ND-30J	58J	--	--	--	--	--	--	--	--	--
3,3'-Dichlorobenzidine isomer**	--	ND-72J	--	740J-890J	980J	--	--	24J	580J	880J	2600J	--	--	--
3,3'-Dichlorobenzidine isomer (cont'd) **	--	--	--	--	--	--	--	--	--	66J	160J	--	--	--
(3-Chlorophenyl) or (4-Chlorophenyl)Methanone**	--	--	--	ND-700J	--	--	--	--	--	--	--	--	--	--
Trichloro-1-propene isomer	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Nonhalogenated Semivolatiles														
Acenaphthene	--	--	--	--	--	20	--	--	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	21	--	--	--	--	--	--	--	--
Aniline	--	--	--	8900-10000	1500	--	--	--	64J	--	--	--	--	--
Anthracene	--	--	--	--	--	14J	--	--	--	--	--	--	--	--
Azobenzene	--	--	--	--	--	--	--	16J	--	--	20J	--	--	--
Benzidine	--	--	--	ND-110J	--	--	--	88	--	240	230	--	--	--
Benzo(a)Anthracene	--	--	--	--	--	19J	--	--	--	--	--	--	--	--
Benzo(a)Pyrene	--	--	--	--	--	230	--	--	--	--	--	--	--	--
Benzyl Alcohol	--	--	--	--	--	5J	--	--	--	--	--	--	--	--
Bis(2-Ethylhexyl)Phthalate	ND-1J	--	--	--	--	--	--	--	--	--	--	ND-188	1JB-2JB	4000J
Chrysene	--	--	--	--	--	18J	--	--	--	--	--	--	--	--
Dibenzofuran	--	--	--	--	--	18J	--	--	--	--	--	--	--	--
Dimethyl Phthalate	ND-4J	--	--	--	72J	4J	120J	--	--	--	--	--	--	--
Di-n-Butylphthalate	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Flouranthene	--	--	--	--	--	18J	--	--	--	--	--	--	--	--
Flourene	--	--	--	--	--	16J	--	--	--	--	--	--	--	--
Isophorone	--	--	54-170	--	--	450	1400	--	53J	--	280	--	--	--
2-Methylnaphthalene	--	--	ND-480	--	--	12J	--	--	--	--	--	--	--	8J
2-Methylphenol	--	--	13J-470	ND-82J	53J	17J	--	--	--	--	--	--	--	--
4-Methylphenol	--	--	ND-170	--	--	5J	--	--	--	--	--	--	--	--
Naphthalene	--	--	20J-650	--	--	22	--	--	--	--	--	--	--	13J
Nitrobenzene	--	--	--	ND-6600	450	--	--	--	--	--	--	--	--	--

TABLE 3
SUMMARY OF DETECTED GROUNDWATER COMPOUNDS
Bofors Site, Muskegon, Michigan
June/July, 1988
SEMIVOLATILE ORGANIC COMPOUNDS

Units: mg/kg (ppm)

	Field Blanks	WC1*	WC2*	WC27*	LW1	LW3	LW4	PW31	PW33	PW39	PW41	MW04*	MW05*	MW7
N-Nitroso-Di-n-Propylamine	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Phenanthrene	--	--	--	--	--	19J	--	--	--	--	--	--	--	--
Phenol	--	--	--	ND-68J	170J	--	--	--	--	--	--	--	--	--
Pyrene	--	--	--	--	--	27	--	--	--	--	--	--	--	--
1,1'-Diphenyl 2,2-Diamine**	--	--	--	--	--	--	--	--	--	--	970J	--	--	--
4-Methyl-3-penten-2-one	--	--	ND-170J	--	--	--	--	--	--	--	--	--	--	--
4-Hydroxy-4-methyl-2-pentanone**	--	--	ND-190J	--	--	--	--	--	--	--	--	--	--	--
3,3,5-Trimethylcyclohexanone**	--	--	340J-490J	--	--	430J	11000J	--	32000J	--	510J	--	--	--
Trimp Isomer(s)**	--	--	--	--	--	100J	550J	--	500J	--	88	--	--	--
Trimp Isomer(s) (cont'd)**	--	--	--	--	--	340J	2000J	--	1400J	--	340J	--	--	--
2,3-Dihydrodimethyl-1H-Indene**	--	--	ND-42J	--	--	--	--	--	--	--	--	--	--	--
Benzeneacetic Acid**	--	--	ND-140J	--	--	--	--	--	--	--	--	--	--	--
1-Methylmaphthalene**	--	--	ND-480J	--	--	--	--	--	--	--	--	--	--	--
N,N-Dimethylformamide**	--	--	ND-150J	--	--	--	--	--	450J	--	--	--	--	--
Dimethylbenzeneamine Isomer**	--	--	ND-120J	--	--	--	780J	--	--	--	--	--	--	--
1,2,3-Benzothiadiazole	--	--	--	870J-1300J	--	--	--	--	--	--	--	--	--	--
1-Methoxynitrobenzene Isomer**	--	--	--	ND-22000J	300J	--	--	--	--	--	--	--	--	--
Sulfur**	--	--	--	160J-1400J	1800J	--	--	--	--	--	--	--	--	--
1,2,4-Trithiolane**	--	--	--	ND-420J	--	--	--	--	--	--	--	--	--	--
1,3,5-Trithiane**	--	--	--	ND-100J	--	--	--	--	--	--	--	--	--	--
Methoxybenzeneamine Isomer**	--	--	--	--	21000J	--	--	--	--	--	--	--	--	--
2-Hydroxybenzonitrile**	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Dimethylmaphthalene**	--	--	ND-52J	--	--	--	--	--	--	--	--	--	--	--
Unknowns	--	ND-1610J	630J-22820J	27910J-100500	2850J-100500J	848J	5130J	--	2250J	--	388J	--	--	--

TABLE 3
SUMMARY OF DETECTED GROUNDWATER COMPOUNDS
Bofors Site, Muskegon, Michigan
June/July, 1988
SEMIVOLATILE ORGANIC COMPOUNDS

Units: mg/kg (ppm)

	MW7	MW8	MW41	MW51*	MW84*	MW91*	MW102*	MW103*	MW104*	MW105*	MW106*	MW108*	MW110
Halogenated Semivolatiles													
2-Chloroaniline	4J	--	780	--	--	--	130J-13000J	3J-100	--	--	410-1600	66-1600	12-6200
4-Chloroaniline	--	--	5J	--	--	--	ND-42J	--	--	--	ND-23	ND-14J	--
1,2-Dichlorobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--
3,3'-Dichlorobenzidine	3J	--	--	--	--	--	ND-200	--	--	--	ND-390	25-140	12J-260
1,2,4-Trichlorobenzene	--	--	--	--	--	--	ND-48J	--	--	--	--	--	--
3,3'-Dichlorobenzidine Isomer**	--	--	--	--	--	--	ND-320J	21J	--	--	ND-980J	ND-500J	ND-1000J
(3-Chlorophenyl) or (4-Chlorophenyl)Methanone**	--	--	--	--	--	--	ND-25J	--	--	--	--	--	--
Trichloro-1-propene Isomer	--	--	--	--	--	--	--	--	ND-25J	ND-36J	--	--	--
Nonhalogenated Semivolatiles													
Acenaphthene	--	--	--	--	--	--	--	--	--	--	--	--	--
Acenaphthylene	--	--	--	--	--	--	--	--	--	--	--	--	--
Aniline	--	--	--	--	--	--	--	--	--	--	ND-78	ND-23	--
Anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--
Azobenzene	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzidine	--	--	--	--	--	--	140-240J	ND-6J	--	--	35J-560	100-1300	71-890
Benzo(a)Anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzo(a)Pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzyl Alcohol	--	--	--	--	--	--	--	--	--	--	--	--	--
Bis(2-Ethylhexyl)Phthalate	4000J	--	--	ND-2J	ND-2J	ND-5J	ND-10J	--	1JB-2JB	--	ND-6JB	ND-3J	--
Chrysene	--	--	--	--	--	--	--	--	--	--	--	--	--
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	--	--	--
Dimethyl Phthalate	--	2JB	--	--	--	--	--	--	--	--	--	--	--
Di-n-Butylphthalate	--	--	--	ND-5J	--	--	--	--	--	ND-4JB	--	--	--
Flouranthene	--	--	--	--	--	--	--	--	--	--	--	--	--
Flourene	--	--	--	--	--	--	--	--	--	--	--	--	--
Isophorone	--	--	--	--	--	--	--	--	--	--	--	ND-3J	--
2-Methylnaphthalene	8J	--	--	--	--	--	--	--	--	--	--	--	--
2-Methylphenol	--	--	--	--	--	--	--	--	--	--	--	--	--
4-Methylphenol	--	--	--	--	--	--	--	--	--	--	--	--	--
Naphthalene	13J	--	--	--	--	--	--	--	--	--	--	--	--
Nitrobenzene	--	--	2J	--	--	--	--	--	--	--	--	--	--
N-Nitroso-Di-n-Propylamine	--	--	--	--	--	--	ND-6J	--	--	--	--	--	--

TABLE 3
SUMMARY OF DETECTED GROUNDWATER COMPOUNDS
Bofors Site, Muskegon, Michigan
June/July, 1988
SEMIVOLATILE ORGANIC COMPOUNDS

Units: mg/kg (ppm)

	MW7	MW13	MW41	MW51*	MW84*	MW91*	MW102*	MW103*	MW104*	MW105*	MW106*	MW108*	MW110
Phenanthrene	--	--	--	--	--	--	--	--	--	--	--	--	--
Phenol	--	--	--	--	--	--	--	--	--	--	ND-140	--	--
Pyrene	--	--	--	--	--	--	--	--	--	--	--	--	--
1,1'-Diphenyl 2,2-Diamine**	--	--	--	--	--	--	--	--	--	--	81J-3200J	140J-640J	ND-350J
4-Methyl-3-penten-2-one	--	--	--	--	--	--	--	--	--	--	--	--	--
4-Hydroxy-4-methyl-2-pentanone**	--	--	--	--	--	--	--	--	--	--	--	--	--
3,3,5-Trimethylcyclohexanone**	--	--	--	--	--	--	--	--	--	--	--	ND-31J	--
Trimp Isomer(s)**	--	--	--	--	--	--	--	--	--	--	--	ND-19J	--
Trimp Isomer(s) (cont'd)**	--	--	--	--	--	--	--	--	--	--	--	--	--
2,3-Dihydrodimethyl-1H-Indene**	--	--	--	--	--	--	--	--	--	--	--	--	--
Benzeneacetic Acid**	--	--	--	--	--	--	--	--	--	--	--	--	--
1-Methylnaphthalene**	--	--	--	--	--	--	--	--	--	--	--	--	--
N,N-Dimethylformamide**	--	--	--	--	--	--	--	--	--	--	ND-340J	--	--
Dimethylbenzeneamine Isomer**	--	--	--	--	--	--	--	--	--	--	--	--	--
1,2,3-Benzothiadiazole	--	--	--	--	--	--	--	--	--	--	--	--	--
1-Methoxynitrobenzene Isomer**	--	--	--	--	--	--	--	--	--	--	--	--	--
Sulfur**	--	--	--	--	--	--	--	--	--	--	--	--	--
1,2,4-Trithiolane**	--	--	--	--	--	--	--	--	--	--	--	--	--
1,3,5-Trithiane**	--	--	--	--	--	--	--	--	--	--	--	--	--
Methoxybenzeneamine Isomer**	--	--	--	--	--	--	--	--	--	--	--	--	--
2-Hydroxybenzonitrile**	--	--	--	--	--	--	ND-44J	--	--	--	--	--	--
Dimethylnaphthalene**	--	--	--	--	--	--	--	--	--	--	--	--	--
Unknowns	--	--	--	--	--	ND-30J	300J-6780J	--	16J-344J	136J-216J	ND-1100J	ND-25J	ND-39J

LEGEND:

B : Detected in lab and/or field blank.

--, ND : Not detected. ND used when ranges of concentrations were found.

J : Value reported represents an estimate as value is above instrument detection limit but below contract required detection limit.

* : Well cluster.

** : Tentatively identified compound.

Note: No semivolatiles were found in the background sample.

significant source of volatile contaminant transfer to the air. Even though air analysis indicated contamination only from the operating plant, sampling and analysis of this medium contains uncertainties.

Photolysis, or the breakdown of compounds through exposure to light, may also be a loss mechanism for benzidine, azobenzene, and DCB in the sludge and surficial soils. This mechanism may be partially responsible for the general absence of benzidine in the surficial soils. However, the breakdown products from photolysis of these compounds are hazardous. Oxidation may be a loss mechanism for benzene, benzidine, and aniline, especially in the lagoons with high iron content such as Lagoons 3 and 9.

Groundwater Pathway

Another contaminant migration route is through the groundwater pathway. Contaminant release to the groundwater has occurred from the lagoon sludge, soils beneath the lagoons, and contaminated soils around the lagoons due to infiltration of water through these media into the groundwater.

Sorption significantly decreases the mobility of azobenzene and DCB, especially in the sludge, because these compounds strongly sorb to organic material. This may be the reason these chemical are currently present in such large concentrations in the lagoon sludges. Methylene chloride and benzene sorb to the sludge but less strongly. Benzidine and aniline do not appear to strongly sorb to lagoon sludges. Sorption has a lesser effect in soils beneath the sludge due to the low organic content of these soils. However, even if soils have low organic content, sorption may be significant for DCB and azobenzene because of the high affinity of these compounds to even small amounts of soil organic material.

Dissolution and leaching of compounds from the sludge and soil appear to be the primary transport mechanism to the groundwater in the upper lacustrine aquifer. The contaminated groundwater in this aquifer does not appear to be a potential source of contaminants to the Marshall Sandstone drinking water aquifer due to the upward hydraulic gradient through the clay till that underlies the upper lacustrine aquifer. Furthermore, diffusion of contaminants through the till is expected to be extremely slow.

Surface Water Pathway

During the RI, no surface water runoff was observed. The primary route of contaminant release to the surface water appears to be groundwater discharge. As noted previously, contaminated groundwater is not presently being released to Big Black Creek since it is being intercepted by the groundwater pumping and treatment system. Therefore, groundwater discharge is not considered a

potential route for migration as long as the groundwater pumping and treatment system is in operation. However, past site conditions and computer modeling performed for the baseline risk assessment have shown that, if the groundwater pumping and treatment system is turned off, groundwater will be a major contamination migration route to the surface water.

Potential Receptors

Populations that could be affected, if exposed, include:

- Industrial workers (Lomac, Sun Chemical, Eagle, commercial facilities north of Evanston Road).
- Residents on Wolf Lake, Laketon, Carr, Evanston, Mill Iron, Summit, and Ravenna Roads within 1-1/4 miles of the site.
- Residents of the trailer park to the northwest of the site.
- Transient residents on the southern side of Big Black Creek.
- Residents using groundwater or surface water at the site at a future date.

Environmental areas that could be affected, if exposed, are primarily Big Black Creek, the wetlands around Big Black Creek in the immediate vicinity of the site, down-stream surface water bodies, and wildlife associated with these areas.

SUMMARY OF SITE RISKS

Human Health Risks

Contaminant Identification

The media of concern in this operable unit are the contaminated sludges and berms in the disposal lagoons and the contaminated soils around and under the sludge lagoons. As discussed previously, six contaminants of concern were identified in the baseline risk assessment from a list of 27 organic compounds detected in the RI. These compounds are:

- **Aniline**
- **Azobenzene**
- **Benzene**
- **Benzidine**
- **3,3'-Dichlorobenzidine (DCB)**
- **Methylene Chloride**

The concentrations of these compounds of concern that were used for the risk assessment are presented in Tables 4 (air), 5 (groundwater), and 6 (surface water). The maximum concentrations were used during the risk assessment to develop risks for this operable unit.

TABLE 4
ANNUAL AIR CONCENTRATION
(ug/m^3)
Bofors Site
Muskegon, Michigan
(Azimuth = 0)

Receptor: r = 402.34m
Azimuth = 0

Compound	Lagoon 1	Lagoon 3	Lagoon 5	Lagoon 6	Lagoon 7	Lagoon 8	Lagoon 9	Lagoon 10
SLUDGE ONLY								
Methylene Chloride	ND	ND	3.8E-03	3.7E-02	1.2E-02	1.3E-01	ND	ND
Benzene	ND	1.1E+00	3.8E-03	ND	ND	8.0E-02	8.4E-02	3.1E-03
3,3'-Dichlorobenzidine	2.6E-05	4.9E-05	3.3E-05	1.0E-05	4.4E-05	6.6E-05	1.6E-04	5.0E-05
Aniline	ND	ND	ND	ND	ND	6.6E-02	7.7E+00	5.0E-02
Azobenzene	ND	6.0E+00	5.4E-01	4.8E-01	2.4E-01	4.8E-01	1.3E+01	8.6E-01
Benzidine	ND	2.4E-03	ND	4.9E-04	ND	1.2E-03	5.2E-03	8.2E-04
Total	2.6E-05	7.1E+00	5.5E-01	5.1E-01	2.5E-01	7.6E-01	2.1E+01	9.2E-01
SOIL BENEATH LAGOONS								
Methylene Chloride	ND	ND	6.3E-03	ND	ND	ND	ND	ND
Benzene	ND	1.8E-02	ND	ND	ND	ND	ND	5.5E-03
3,3'-Dichlorobenzidine	ND	3.6E-05	2.1E-05	1.4E-05	3.1E-06	3.0E-05	2.9E-05	2.4E-05
Aniline	4.1E-02	2.2E-01	ND	ND	ND	ND	2.5E-01	1.1E-01
Azobenzene	2.1E-03	2.5E+00	1.4E-01	1.3E-01	ND	1.7E-01	8.1E-01	7.4E-01
Benzidine	ND	1.4E-03	4.2E-04	3.9E-04	ND	ND	7.4E-04	6.2E-04
Total	4.3E-02	2.7E+00	1.5E-01	1.3E-01	3.1E-06	1.7E-01	1.1E+00	8.6E-01
BERMS								
Methylene Chloride	ND	NP	NP	7.1E-02	NP	1.2E-01	NP	ND
Benzene	ND	NP	NP	ND	NP	1.0E-01	NP	2.4E-03
3,3'-Dichlorobenzidine	7.9E-06	NP	NP	1.3E-05	NP	6.2E-05	NP	2.6E-05
Aniline	ND	NP	NP	ND	NP	1.8E-01	NP	1.7E-02
Azobenzene	ND	NP	NP	8.1E-01	NP	2.6E-01	NP	6.4E-01
Benzidine	ND	NP	NP	5.5E-04	NP	ND	NP	ND
Total	7.9E-06	NP	NP	8.8E-01	NP	7.2E-01	NP	6.6E-01
SOIL AROUND LAGOONS								
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	1.1E+01	ND
3,3'-Dichlorobenzidine	1.0E-04	2.7E-05	5.2E-05	8.4E-05	8.5E-05	2.1E-05	6.1E-05	2.8E-04
Aniline	ND	1.4E-02	ND	ND	ND	8.4E-03	ND	9.0E-02
Azobenzene	ND	2.9E-01	1.5E-01	2.6E-01	1.4E-02	4.5E-02	6.9E-02	7.1E-01
Benzidine	ND	1.2E-04	ND	ND	ND	ND	6.1E-04	ND
Total	1.0E-04	3.1E-01	1.5E-01	2.6E-01	1.4E-02	5.3E-02	1.1E+01	8.0E-01

ND: Contaminant not detected in sample(s) from that lagoon.
NP: Media not present in specified lagoon area.

TABLE 5
GROUNDWATER CONCENTRATIONS OBTAINED FROM THE AT123D MODEL (PPM)
Bofors Site
Muskegon, Michigan

Units: ppm

Compound	Lagoon 1	Lagoon 3	Lagoon 5	Lagoon 6	Lagoon 7	Lagoon 8	Lagoon 9	Lagoon 10
SOIL AND SLUDGE								
Methylene Chloride	0.0E+00	0.0E+00	3.7E-06	2.3E-04	5.1E-06	1.9E-03	0.0E+00	0.0E+00
Benzene	0.0E+00	6.2E-01	3.4E-06	0.0E+00	0.0E+00	4.0E-03	4.5E-04	3.4E-06
3,3'-Dichlorobenzidine	5.8E-04	9.3E-03	1.1E-02	2.2E-03	8.3E-03	2.6E-02	1.0E+00	3.5E-02
Aniline	2.5E-03	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.1E+00	1.3E-02
Azobenzene	8.5E-04	7.5E-04	8.5E-04	1.8E-04	3.8E-04	2.2E-03	1.6E-03	2.9E-03
Benzidine	0.0E+00	1.0E+00	1.1E-03	1.6E-04	0.0E+00	0.0E+00	1.3E-01	3.9E-02
SLUDGE ONLY								
Methylene Chloride	0.0E+00	0.0E+00	1.5E-06	2.3E-04	5.1E-06	1.9E-03	0.0E+00	0.0E+00
Benzene	0.0E+00	2.6E-01	3.4E-06	0.0E+00	0.0E+00	4.0E-03	4.5E-04	2.0E-05
3,3'-Dichlorobenzidine	5.8E-04	1.2E-03	6.7E-04	2.8E-04	1.7E-03	3.4E-03	2.4E-03	4.7E-03
Aniline	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-03	2.1E+00	4.2E-03
Azobenzene	0.0E+00	1.2E-04	1.2E-04	3.1E-05	3.8E-04	3.8E-04	2.8E-04	5.3E-04
Benzidine	0.0E+00	6.7E-02	0.0E+00	6.1E-03	0.0E+00	2.1E-02	1.3E-01	4.1E-02
SOIL BENEATH LAGOONS								
Methylene Chloride	0.0E+00	0.0E+00	2.2E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	8.8E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-05
3,3'-Dichlorobenzidine	0.0E+00	1.3E-02	7.7E-03	3.1E-03	8.3E-03	3.6E-02	6.7E-02	4.8E-02
Aniline	2.5E-03	5.7E-02	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-02	5.7E-03
Azobenzene	8.5E-04	7.5E-04	8.5E-04	2.5E-04	0.0E+00	2.9E-03	2.1E-03	4.1E-03
Benzidine	0.0E+00	1.2E-01	6.8E-04	1.2E-03	0.0E+00	0.0E+00	7.2E-03	3.6E-03
BERMS								
Methylene Chloride	0.0E+00	NP	NP	3.0E-02	NP	7.8E-05	NP	0.0E+00
Benzene	0.0E+00	NP	NP	0.0E+00	NP	5.4E-04	NP	2.1E-05
3,3'-Dichlorobenzidine	4.3E-05	NP	NP	4.5E-04	NP	2.9E-03	NP	5.1E-03
Aniline	0.0E+00	NP	NP	0.0E+00	NP	1.6E-04	NP	4.6E-04
Azobenzene	0.0E+00	NP	NP	6.9E-05	NP	2.8E-04	NP	5.0E-04
Benzidine	0.0E+00	NP	NP	1.8E-04	NP	1.3E-03	NP	3.94E-03
SOIL AROUND LAGOONS								
Methylene Chloride	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.2E-01	0.0E+00
3,3'-Dichlorobenzidine	1.4E-02	1.4E-02	8.4E-03	1.5E-02	2.4E-02	8.6E-04	3.6E-02	1.8E-01
Aniline	0.0E+00	2.5E-04	0.0E+00	0.0E+00	0.0E+00	2.2E-03	0.0E+00	7.9E-04
Azobenzene	0.0E+00	6.9E-04	6.9E-04	1.2E-03	1.5E-04	8.5E-04	9.7E-04	1.3E-02
Benzidine	0.0E+00	1.8E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-03	0.0E+00

NP = Berms not present in these source areas.

TABLE 6
SURFACE WATER CONCENTRATIONS OBTAINED FROM THE AT123D MODEL (PPM)
Bofors Site
Muskegon, Michigan

Units: ppm

Compound	Lagoon 1	Lagoon 3	Lagoon 5	Lagoon 6	Lagoon 7	Lagoon 8	Lagoon 9	Lagoon 10
SOIL AND SLUDGE								
Methylene Chloride	0.0E+00	0.0E+00	3.7E-08	2.3E-06	5.1E-08	1.9E-05	0.0E+00	0.0E+00
Benzene	0.0E+00	6.2E-03	3.4E-08	0.0E+00	0.0E+00	4.0E-05	4.5E-06	3.4E-08
3,3'-Dichlorobenzidine	5.8E-06	9.3E-05	1.1E-04	2.2E-05	8.3E-05	2.6E-04	1.0E-02	3.5E-04
Aniline	2.5E-05	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.1E-02	1.3E-04
Azobenzene	8.5E-06	7.5E-06	8.5E-06	1.8E-06	3.8E-06	2.2E-05	1.6E-05	2.9E-05
Benzidine	0.0E+00	1.0E-02	1.1E-05	1.6E-04	0.0E+00	0.0E+00	1.3E-03	3.9E-04
SLUDGE ONLY								
Methylene Chloride	0.0E+00	0.0E+00	1.5E-08	2.3E-06	5.1E-08	1.9E-05	0.0E+00	0.0E+00
Benzene	0.0E+00	2.6E-03	3.4E-08	0.0E+00	0.0E+00	4.0E-05	4.5E-06	2.0E-07
3,3'-Dichlorobenzidine	5.8E-06	1.2E-05	6.7E-06	2.8E-06	1.7E-05	3.4E-05	2.4E-05	4.7E-05
Aniline	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-05	2.1E-02	4.2E-05
Azobenzene	0.0E+00	1.2E-06	1.2E-06	3.1E-07	3.8E-06	3.8E-06	2.8E-06	5.3E-06
Benzidine	0.0E+00	6.7E-04	0.0E+00	6.1E-05	0.0E+00	2.1E-04	1.3E-03	4.1E-04
SOIL BENEATH LAGOONS								
Methylene Chloride	0.0E+00	0.0E+00	2.2E-08	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	8.8E-07	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.3E-07
3,3'-Dichlorobenzidine	0.0E+00	1.3E-04	7.7E-05	3.1E-05	8.3E-05	3.6E-04	6.7E-04	4.8E-04
Aniline	2.5E-05	5.7E-04	0.0E+00	0.0E+00	0.0E+00	0.0E+00	1.3E-04	5.7E-05
Azobenzene	8.5E-06	7.5E-06	8.5E-06	2.5E-06	0.0E+00	2.9E-05	2.1E-05	4.1E-05
Benzidine	0.0E+00	1.2E-03	6.8E-06	1.2E-05	0.0E+00	0.0E+00	7.2E-05	3.6E-05
BERMS								
Methylene Chloride	0.0E+00	NP	NP	3.0E-04	NP	7.8E-07	NP	0.0E+00
Benzene	0.0E+00	NP	NP	0.0E+00	NP	5.4E-06	NP	2.1E-07
3,3'-Dichlorobenzidine	4.3E-07	NP	NP	4.5E-06	NP	2.9E-05	NP	5.1E-05
Aniline	0.0E+00	NP	NP	0.0E+00	NP	1.6E-06	NP	4.6E-06
Azobenzene	0.0E+00	NP	NP	6.9E-07	NP	2.8E-06	NP	5.0E-06
Benzidine	0.0E+00	NP	NP	1.8E-04	NP	1.3E-03	NP	3.94E-03
SOIL AROUND LAGOONS								
Methylene Chloride	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00
Benzene	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	0.0E+00	4.2E-03	0.0E+00
3,3'-Dichlorobenzidine	1.4E-04	1.4E-04	8.4E-05	1.5E-04	2.4E-04	8.6E-06	3.6E-04	1.8E-03
Aniline	0.0E+00	2.5E-06	0.0E+00	0.0E+00	0.0E+00	2.2E-05	0.0E+00	7.9E-06
Azobenzene	0.0E+00	6.9E-06	6.9E-06	1.2E-05	1.5E-06	8.5E-06	9.7E-06	1.3E-04
Benzidine	0.0E+00	1.8E-06	0.0E+00	0.0E+00	0.0E+00	0.0E+00	2.0E-05	0.0E+00

NP = Berms not present in these source areas.

The main health effects of these six compounds are as follows:

- Aniline: Attacks the blood, liver, kidneys, and cardiovascular system. May cause anoxemia, central nervous system depression, or cyanosis. Headaches, irritability, dyspnea, unconsciousness, and even death may result from cyanosis. Aniline is considered a potential human carcinogen.

- Azobenzene: Can irritate the eyes, skin, and respiratory tract. Azobenzene may also cause blood disorders. Azobenzene is considered a potential human carcinogen.

- Benzene: Acute exposures produce primarily central nervous system effects such as dizziness, nausea, headaches, loss of balance, narcosis, coma, and death. Benzene is also a known human carcinogen and causes several forms of leukemia.

- Benzidine: Direct contact may cause contact dermatitis and primary irritation or sensitization. Benzidine is also a known urinary tract carcinogen with an average latency period of 16 years.

- 3,3'-Dichlorobenzidine (DCB): Direct contact may cause allergic skin reactions. DCB may contribute to bladder cancer and is considered a potential carcinogen.

- Methylene Chloride: Repeated contact may cause dermatitis and eye and upper respiratory irritation. Methylene chloride is also a mild narcotic; effects include: headache, giddiness, stupor, irritability, and numbness. Exposure may cause elevated carboxyhemoglobin levels. Methylene chloride is considered a potential human carcinogen.

Exposure Assessment

Based on the baseline risk assessment, several exposure pathways were evaluated, including:

- air, as a result of volatilization of organic compounds from the surface of the lagoons;
- wetland sediments through resolubilization of contaminants and transport downstream in Big Black Creek;
- groundwater through direct use of the groundwater,
- surface water, through potential contamination of Big Black Creek by contaminated groundwater;
- direct contact with waste, and
- ingestion of waste.

Three of these pathways presented the most significant risks to potentially exposed populations:

- ingestion of contaminated groundwater from infiltration of contaminated precipitation from the lagoon area;
- ingestion of contaminated surface water;
- inhalation of contaminated air from volatilization of organic compounds from the lagoon area surface.

Potentially exposed populations used in the baseline risk assessment included adults living on- and off-site. Groundwater, air, and unsaturated-zone transport modeling was performed for the compounds of concern to characterize exposure point concentrations. Modeling procedures were developed to evaluate receptor exposure to the chemicals of concern for the lagoon sludge, berms, soil beneath the sludge, and soil around the lagoons for each lagoon area. The emission rates into the air or water from the sludge, soils and berms were first calculated, then the transport through the air and groundwater was evaluated.

A computer program was developed to calculate volatile air emission rates from each lagoon source area. A 70-year average emission rate was determined for each source area. Air risks were determined from the downwind concentrations at receptor locations.

Risks from dust emissions were estimated for exposure by inhalation. These risks were estimated as approximately 100 times less than the risks from inhalation of volatile emissions. Risks from inhalation of metals within the dust are expected to be less than risks from inhalation of organic compounds adsorbed to dust particles, because metals have higher settling velocities and are not transported as easily.

Chemical emissions from the unsaturated zone to the groundwater were also estimated. Simulations were run for each lagoon source area to determine the contaminant mass input to the groundwater from the sludge and soil beneath the lagoons, the sludge only, the soil beneath the lagoons only, the berms, and the soils around the lagoons. The 70-year average mass inputs were then calculated and the results were used as input to a groundwater model. The groundwater risks were then calculated using the maximum groundwater concentrations determined with the groundwater model.

Surface water risks were evaluated using average contaminant concentrations in groundwater expected to enter Big Black Creek, accounting for dilution by clean upstream water and groundwater on the opposite side of Big Black Creek. The dilution rate was estimated to be approximately 100, therefore, the surface water concentrations are 100 times lower than the corresponding groundwater concentration.

The major assumptions used in these models were:

- o The contamination is uniformly distributed within the soil or sludge matrix.
- o The contaminant of interest is assumed to be bound to either the soil or the sludge.
- o The waste does not flow within the carrier matrix.
- o The adsorption isotherm of the constituent of interest is linear within the depth of the waste and does not change with time.
- o No flow of gas is induced within the waste matrix.
- o The diffusion coefficient does not vary with either concentration or time.
- o The concentration of the constituent of interest in the gas phase at the surface of the lagoon is much lower than the concentration of the constituent of interest in the gas phase within the waste matrix.
- o No diffusion of the contaminant into depths below the waste layer is assumed.
- o Contaminant vapor, waste, solid, and water equilibrium is established at all times within the waste matrix.
- o Hydrolysis, biodegradation, and ligand formation were assumed to be insignificant mechanisms at this site.
- o The aquifer is infinitely wide.

The assumptions made for the risk assessment include:

- o People would be exposed to areas where the highest levels of contamination were found, i.e., maximum concentrations were used during the risk assessment to generate risks.

- o 70-kg adult resident is exposed daily over a 70-year lifetime.

- o Daily intake is 2 liters per day of groundwater or surface water and 20 cubic meters per day of air.

- o 100 percent absorption is assumed.

- o The groundwater pumping and treatment system is turned off.

These conservative assumptions allow the risk assessment to emphasize health protection.

Toxicity Assessment

All of the six compounds of concern are known or potential human carcinogens. Cancer potency factors (CPFs) have been developed by U.S. EPA's Carcinogenic Assessment Group for estimating excess lifetime cancer risks associated with exposure to potentially carcinogenic chemicals. CPFs, which are expressed in units of $(mg/kg\text{-}day)^{-1}$, are multiplied by the estimated intake of a poten-

tial carcinogen, in mg/kg-day, to provide an upper-bound estimate of the excess lifetime cancer risk associated with exposure at that intake level. The term "upper bound" reflects the conservative estimate of the risks calculated from the CPF. Use of this approach makes underestimation of the actual cancer risk highly unlikely. Cancer potency factors are derived from the results of human epidemiological studies or chronic animal bioassays to which animal-to-human extrapolation and uncertainty factors have been applied. The cancer potency factors for these compounds are presented in Table 7. RFDs were not used because the carcinogenic toxic effects of the compounds of concern far exceeded the non-carcinogenic toxic effects.

This table also presents information on whether the compound is a known or potential carcinogen. As shown in the table, benzene and benzidine are known human carcinogens (A); the other compounds of concern are potential human carcinogens (B_2). Benzidine is the most carcinogenic compound and DCB is the second most carcinogenic compound of the compounds of concern. Benzidine and DCB are several orders of magnitude more carcinogenic than the other compounds. These two compounds, and particularly benzidine, therefore, provide the highest risks at the site and drive the level of remediation required.

RISK CHARACTERIZATION

Excess lifetime cancer risks are determined by multiplying the intake level with the cancer potency factor. These risks are probabilities that are generally expressed in scientific notation (e.g., 1×10^{-6}). An excess lifetime cancer risk of 1×10^{-6} indicates that, as a plausible upper bound, an individual has a one in one million chance of developing cancer as a result of site-related exposure to a carcinogen over a 70-year lifetime under the specific exposure conditions at a site. Only potential future land use was evaluated since there is no current land use.

Potential Future Conditions - Residential Exposure Scenario

As discussed previously, the site was divided into eight source areas and their subareas. The carcinogenic risks were developed for each of the contaminants of concern for each of these subareas for each of the three exposure pathways. A discussion of the risks associated with the future use- residential exposure scenario for each of these pathways are presented below.

Air Inhalation Risks

Air inhalation risks are presented in Table 8. As shown in the table, these risks range from 1.2×10^{-3} to 7.9×10^{-9}, with the lagoon sludge posing the highest risks and berms posing the lowest risks.

TABLE 7
COMPOUNDS OF CONCERN AND CARCINOGENICITY
Bofors Site
Muskegon, Michigan

Compound	Potency Slope (mg/kg/day)	EPA Classification
Aniline	0.0057	B_2
Azobenzene	0.17	B_2
Benzene	0.029	A
Benzidine	230.0	A
3,3'-Dichlorobenzidine (DCB)	3.5	B_2
Methylene Chloride	0.0075	B_2

A: Known human carcinogen.

B_2: Known animal carcinogen; Probable human carcinogen (from Risk Assessment Guidance for Superfund, 1989)

TABLE 8
AIR RISKS
Bofors Site
Muskegon, Michigan
(Azimuth = 0)

Receptor: r = 402.34
Azimuth = 0

Compound	Lagoon 1	Lagoon 3	Lagoon 5	Lagoon 6	Lagoon 7	Lagoon 8	Lagoon 9	Lagoon 10
SLUDGE ONLY								
Methylene Chloride	ND	ND	1.5E-08	1.5E-07	4.9E-08	5.1E-07	ND	ND
Benzene	ND	9.2E-06	3.2E-08	ND	ND	6.6E-07	6.9E-07	2.6E-08
3,3'-Dichlorobenzidine	2.6E-08	4.9E-08	3.3E-08	1.0E-08	4.4E-08	6.6E-08	1.6E-07	5.0E-08
Aniline	ND	ND	ND	ND	ND	5.6E-07	6.6E-05	4.3E-07
Azobenzene	ND	1.9E-04	1.7E-05	1.5E-05	7.5E-06	1.5E-05	4.0E-04	2.7E-05
Benzidine	ND	1.6E-04	ND	3.2E-05	ND	7.7E-05	3.4E-04	5.4E-05
Total	2.6E-08	3.6E-04	1.7E-05	4.7E-05	7.6E-06	9.4E-05	8.1E-04	8.1E-05
SOIL BENEATH LAGOONS								
Methylene Chloride	ND	ND	2.5E-08	ND	ND	ND	ND	ND
Benzene	ND	1.5E-07	ND	ND	ND	ND	ND	4.6E-08
3,3'-Dichlorobenzidine	ND	3.6E-08	2.1E-08	1.4E-08	3.1E-09	3.0E-08	2.9E-08	2.4E-08
Aniline	3.5E-07	1.9E-06	ND	ND	ND	ND	2.1E-06	9.7E-07
Azobenzene	6.7E-08	7.7E-05	4.4E-06	4.0E-06	ND	5.4E-06	2.5E-05	2.3E-05
Benzidine	ND	9.4E-05	2.8E-05	2.6E-05	ND	ND	4.9E-05	4.1E-05
Total	4.2E-07	1.7E-04	3.2E-05	3.0E-05	3.1E-09	5.5E-06	7.6E-05	6.5E-05
BERMS								
Methylene Chloride	ND	NP	NP	2.9E-07	NP	6.4E-07	NP	ND
Benzene	ND	NP	NP	ND	NP	8.5E-07	NP	2.0E-08
3,3'-Dichlorobenzidine	7.9E-09	NP	NP	1.3E-08	NP	6.2E-08	NP	2.6E-08
Aniline	ND	NP	NP	ND	NP	1.6E-06	NP	1.4E-07
Azobenzene	ND	NP	NP	2.6E-05	NP	8.1E-06	NP	2.0E-05
Benzidine	ND	NP	NP	3.6E-05	NP	ND	NP	ND
Total	7.9E-09	NP	NP	6.2E-05	NP	1.1E-05	NP	2.0E-05
SOIL AROUND LAGOONS								
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	9.1E-05	ND
3,3'-Dichlorobenzidine	1.0E-07	2.7E-08	5.2E-08	8.4E-08	8.5E-08	2.1E-08	6.1E-08	2.8E-07
Aniline	ND	1.2E-07	ND	ND	ND	7.2E-08	ND	7.7E-07
Azobenzene	ND	9.2E-06	4.7E-06	8.0E-06	4.3E-07	1.4E-06	2.2E-06	2.2E-05
Benzidine	ND	7.8E-06	ND	ND	ND	ND	4.0E-05	ND
Total	1.0E-07	1.7E-05	4.8E-06	8.1E-06	5.1E-07	1.5E-06	1.3E-04	2.3E-05

ND: Contaminant not detected in sample(s) from that lagoon.
NP: Media not present in specified lagoon area.

Groundwater Ingestion Risks

Groundwater ingestion risks are presented in Table 9. These risks range from 9.9×10^{-1} to 3.4×10^{-5}. Overall, the sludge presents a total risk of 9.9×10^{-1}, the soil beneath the lagoons has a total risk of 6.6×10^{-1}, and the soil around the lagoons presents a total risk of 1.7×10^{-2} and the berms present a total risk of 1.2×10^{-2}. The sludge and soil beneath the sludge pose the greatest overall risk for groundwater ingestion. Total groundwater ingestion risks resulting from sludge, soil beneath lagoons, soil around lagoons, or berms are all above acceptable limits. The highest magnitude of risk is associated with benzidine. DCB poses the next highest risk.

Surface Water Ingestion Risks

Surface water ingestion risks are presented in Table 10. These risks assume that the groundwater pumping and treatment system is turned off. The calculated risks range from 1×10^{-2} to 3.4×10^{-7}. Benzidine is the chemical which drives the overall risk for surface water. Benzidine's combined risk for all source areas exceeds 2.5×10^{-2}. Thus, even though the surface water poses risks substantially lower than the groundwater, the risks from surface water ingestion are above the acceptable range by at least four orders of magnitude.

Combined Risks

The highest excess cancer risks developed were associated with the groundwater exposure pathway. The combined carcinogenic risks reflecting all the contaminants of concern and all exposure pathways of concern are estimated to be approximately 10^{-1} excess cancer risk. Non-carcinogenic effects are estimated to be insignificant in this operable unit, since the metals in the sludges and soils do not appear to exhibit significant mobility. If mobile, the non-carcinogenic effects would become significant. Therefore, non-carcinogenic effects were not used to estimate the level of remediation required.

Risks and risk-based cleanup criteria should be considered approximations due to the limitations and uncertainties of the manner in which these concentrations are computed. When modeling contaminant transport, when estimation was necessary, a value was chosen to provide the most conservative realistic risk estimate. Tests with the model have shown that contaminant concentrations within the soil and sludge have the greatest effect on overall risks. Other parameters, such as permeability, organic carbon content, surface area, and volumes may have significant effects on calculated risks.

TABLE 9
EXCESS CANCER RISKS FROM GROUNDWATER INGESTION
Bofors Site
Muskegon, Michigan

Compound	Lagoon 1	Lagoon 3	Lagoon 5	Lagoon 6	Lagoon 7	Lagoon 8	Lagoon 9	Lagoon 10
SOIL AND SLUDGE								
Methylene Chloride	ND	ND	1.6E-09	4.9E-08	1.1E-09	4.1E-07	ND	ND
Benzene	ND	5.2E-04	2.9E-09	ND	ND	3.4E-06	3.8E-07	2.9E-09
3,3-Dichlorobenzidine	5.9E-05	9.4E-04	1.1E-03	2.2E-04	8.4E-04	2.6E-03	1.0E-01	3.5E-03
Aniline	4.1E-07	ND	ND	ND	ND	ND	3.4E-04	2.1E-06
Azobenzene	2.7E-06	2.4E-06	2.7E-06	5.7E-07	1.2E-06	6.9E-06	5.0E-06	9.4E-06
Benzidine	ND	1.0E+00	7.2E-03	1.0E-01	ND	ND	5.7E-01	2.3E-01
Total	6.2E-05	1.0E+00	8.3E-03	1.0E-01	8.4E-04	2.6E-03	6.7E-01	2.3E-01
SLUDGE ONLY								
Methylene Chloride	ND	ND	7.0E-10	4.9E-08	1.1E-09	4.1E-07	ND	ND
Benzene	ND	2.2E-04	2.9E-09	ND	ND	3.4E-06	3.8E-07	1.7E-08
3,3-Dichlorobenzidine	5.9E-05	1.2E-04	6.8E-05	2.8E-05	1.7E-04	3.4E-04	2.4E-04	4.8E-04
Aniline	ND	ND	ND	ND	ND	3.8E-07	3.4E-04	6.9E-07
Azobenzene	ND	3.8E-07	3.8E-07	1.0E-07	1.2E-06	1.2E-06	8.9E-07	1.7E-06
Benzidine	ND	3.6E-01	ND	4.0E-02	ND	1.3E-01	5.9E-01	2.4E-01
Total	5.9E-05	3.6E-01	6.8E-05	4.0E-02	1.7E-04	1.3E-01	5.9E-01	2.4E-01
SOIL BENEATH LAGOONS								
Methylene Chloride	ND	ND	9.0E-10	ND	ND	ND	ND	ND
Benzene	ND	7.4E-08	ND	ND	ND	ND	ND	1.9E-08
3,3-Dichlorobenzidine	ND	1.3E-03	7.8E-04	3.1E-04	8.4E-04	3.6E-03	6.8E-03	4.9E-03
Aniline	4.1E-07	9.5E-06	ND	ND	ND	ND	2.2E-06	9.4E-07
Azobenzene	2.7E-06	2.4E-06	2.7E-06	8.0E-07	ND	9.4E-06	6.6E-06	1.3E-05
Benzidine	ND	5.4E-01	4.5E-03	8.1E-03	ND	ND	4.7E-02	2.4E-02
Total	3.1E-06	5.4E-01	5.3E-03	8.4E-03	8.4E-04	3.6E-03	5.4E-02	2.9E-02
BERMS								
Methylene Chloride	ND	NP	NP	6.6E-06	NP	3.3E-08	NP	ND
Benzene	ND	NP	NP	ND	NP	4.7E-07	NP	1.8E-08
3,3-Dichlorobenzidine	4.4E-06	NP	NP	4.6E-05	NP	2.9E-04	NP	5.2E-04
Aniline	ND	NP	NP	ND	NP	2.6E-08	NP	7.5E-08
Azobenzene	ND	NP	NP	2.2E-07	NP	8.9E-07	NP	1.6E-06
Benzidine	ND	NP	NP	1.2E-02	NP	8.6E-03	NP	2.5E-02
Total	4.4E-06	NP	NP	1.2E-02	NP	8.9E-03	NP	2.5E-02
SOIL AROUND LAGOONS								
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	3.5E-04	ND
3,3-Dichlorobenzidine	1.4E-03	1.4E-03	8.5E-04	1.5E-03	2.4E-03	8.7E-05	3.6E-03	1.8E-02
Aniline	ND	4.1E-08	ND	ND	ND	3.6E-07	ND	1.3E-07
Azobenzene	ND	2.2E-06	2.2E-06	3.9E-06	4.9E-07	2.7E-06	3.1E-06	4.3E-05
Benzidine	ND	1.2E-03	ND	ND	ND	ND	1.3E-02	ND
Total	1.4E-03	2.6E-03	8.5E-04	1.5E-03	2.4E-03	9.0E-05	1.7E-02	1.8E-02

ND: Contaminant not detected in sample(s) from that lagoon.
NP: Media not present in specified lagoon area.

TABLE 10
EXCESS CANCER RISKS FROM SURFACE WATER INGESTION
Bofors Site
Muskegon, Michigan

Compound	Lagoon 1	Lagoon 3	Lagoon 5	Lagoon 6	Lagoon 7	Lagoon 8	Lagoon 9	Lagoon 10
SOIL AND SLUDGE								
Methylene Chloride	ND	ND	3.0E-10	4.9E-10	1.1E-11	4.1E-09	ND	ND
Benzene	ND	5.2E-06	2.9E-11	ND	ND	3.4E-08	3.8E-09	2.9E-11
3,3-Dichlorobenzidine	5.9E-07	9.4E-06	1.1E-05	2.2E-06	8.4E-06	2.6E-05	1.0E-03	3.5E-05
Aniline	4.1E-09	ND	ND	ND	ND	ND	3.4E-06	2.1E-08
Azobenzene	2.7E-08	2.4E-08	2.7E-08	5.7E-09	1.2E-08	6.9E-08	5.0E-08	9.4E-08
Benzidine	ND	1.0E-02	7.2E-05	1.0E-03	ND	ND	5.7E-03	2.3E-03
Total	6.2E-07	1.0E-02	8.3E-05	1.0E-03	8.4E-06	2.6E-05	6.7E-03	2.3E-03
SLUDGE ONLY								
Methylene Chloride	ND	ND	1.0E-10	4.9E-10	1.1E-11	4.1E-09	ND	ND
Benzene	ND	2.2E-06	2.9E-11	ND	ND	3.4E-08	3.8E-09	1.7E-10
3,3-Dichlorobenzidine	5.9E-07	1.2E-06	6.8E-07	2.8E-07	1.7E-06	3.4E-06	2.4E-06	4.8E-06
Aniline	ND	ND	ND	ND	ND	3.8E-09	3.4E-06	6.9E-09
Azobenzene	ND	3.8E-09	3.8E-09	1.0E-09	1.2E-08	1.2E-08	8.9E-09	1.7E-08
Benzidine	ND	3.6E-03	ND	4.0E-04	ND	1.3E-03	5.9E-03	2.4E-03
Total	5.9E-07	3.6E-03	6.8E-07	4.0E-04	1.7E-06	1.3E-03	5.9E-03	2.4E-03
SOIL BENEATH LAGOONS								
Methylene Chloride	ND	ND	2.0E-10	ND	ND	ND	ND	ND
Benzene	ND	7.4E-10	ND	ND	ND	ND	ND	1.9E-10
3,3-Dichlorobenzidine	ND	1.3E-05	7.8E-06	3.1E-06	8.4E-06	3.6E-05	6.8E-05	4.9E-05
Aniline	4.1E-09	9.5E-08	ND	ND	ND	ND	2.2E-08	9.4E-09
Azobenzene	2.7E-08	2.4E-08	2.7E-08	8.0E-09	ND	9.4E-08	6.6E-08	1.3E-07
Benzidine	ND	5.4E-03	4.5E-05	8.1E-05	ND	ND	4.7E-04	2.4E-04
Total	3.1E-08	5.4E-03	5.3E-05	8.4E-05	8.4E-06	3.6E-05	5.4E-04	2.9E-04
BERMS								
Methylene Chloride	ND	NP	NP	6.6E-08	NP	3.3E-10	NP	ND
Benzene	ND	NP	NP	ND	NP	4.7E-09	NP	1.8E-10
3,3-Dichlorobenzidine	4.4E-08	NP	NP	4.6E-07	NP	2.9E-06	NP	5.2E-06
Aniline	ND	NP	NP	ND	NP	2.6E-10	NP	7.0E-10
Azobenzene	ND	NP	NP	2.2E-09	NP	8.9E-09	NP	1.6E-08
Benzidine	ND	NP	NP	1.2E-04	NP	8.6E-05	NP	2.4E-03
Total	4.4E-08	NP	NP	1.2E-04	NP	8.9E-05	NP	2.4E-03
SOIL AROUND LAGOONS								
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	ND	ND	3.5E-06	ND
3,3-Dichlorobenzidine	1.4E-05	1.4E-05	8.5E-06	1.5E-05	2.4E-05	8.7E-07	3.6E-05	1.8E-04
Aniline	ND	4.1E-10	ND	ND	ND	3.6E-09	ND	1.3E-09
Azobenzene	ND	2.2E-08	2.2E-08	3.9E-08	4.9E-09	2.7E-08	3.1E-08	4.3E-07
Benzidine	ND	1.2E-05	ND	ND	ND	ND	1.3E-04	ND
Total	1.4E-05	2.6E-05	8.5E-06	1.5E-05	2.4E-05	9.0E-07	1.7E-04	1.8E-04

ND: Contaminant not detected in sample(s) from that lagoon.
NP: Media not present in specified lagoon area.

Environmental Risks

Based on the preliminary evaluation performed for the preliminary risk assessment, site contamination does not appear to have affected critical habitats or endangered species. The State completed a qualitative evaluation of the likelihood and magnitude of each identified exposure pathway on endangered species. No adverse affects on wildlife were identified in this preliminary assessment.

The wetlands on this site are located in the floodplain on both sides of Big Black Creek. A portion of these wetlands are located within the L.O.U., as shown in Figure 2. These wetlands consist of a variety of plant communities with good species diversity. The entire valley area is composed of a complex mosaic of different wetlands, ranging from forested wetlands to small ponds. There are mature communities as well as recently developed wetlands, and wetland formation is still occurring within this active floodplain area. These wetlands appear to be relatively undisturbed by site contamination. However, U.S. EPA believes that, if the extraction system were turned off, impact to wetlands might occur from discharge of contaminated groundwater.

Although an animal study was not conducted on the site, past experience indicates that these types of wetlands would support good populations of various animal species. The relatively isolated and undisturbed nature of these wetlands, their proximity to upland woods, and the continuous band they form along Big Black Creek indicate potential for supporting good populations of deer, fur bearers, songbirds, migratory water fowl, herons, egrets, reptiles, amphibians, and a variety of invertebrates. Most likely, this wetland band also serves as a pathway for local movement of animals.

None of the wetland types or species encountered on the project site are unique or rare in the Upper Midwest. It is possible, however, that individual plant or animal species occurring in these wetlands may be federally protected or state protected species.

Summary

Actual or threatened releases of hazardous substances from this site, if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment.

FEASIBILITY STUDY ISSUES

Remedial Action Objectives

To evaluate the effectiveness of the technologies assessed in the treatability study, the groundwater ingestion risks were used to estimate the post-treatment chemical concentrations necessary to meet specified risk levels. As described previously, the groundwater ingestion route of exposure poses the greatest risks to human health and the environment.

The cleanup criteria developed are presented in Tables 11 (10^{-6} Risk) and 12 (10^{-4} Risk). These are the concentrations to which the sludge, berms, or soil must be treated to achieve the indicated risk level. In these tables, when the U.S. EPA Contract Laboratory Program (CLP) contract-required quantitation limit (CRQL) for the compound is higher than the risk-based cleanup criterion, the CRQL is used as the cleanup criterion. Each chemical and subarea where the cleanup concentration exceeded the concentration found in the original samples is designated by NA (not appropriate). These areas do not exceed the specified risk level and do not require treatment.

The distribution of the contaminants within each subarea was used in conjunction with the risk-based cleanup criteria to determine the technology combinations presented in the following alternatives.

The mass of each contaminant in each lagoon subarea was calculated from the RI data and the distribution of each compound in each of the four types of subareas were calculated, as presented in Table 13. As shown in this table, the sludge and berms account for 64 percent of the contamination by the compounds of concern. The soils under and around the sludge account for 36 percent of the contamination by the compounds of concern. Benzidine drives the remediation because of its extremely high toxicity. Of the total benzidine distribution at the site, 83 percent is present in the sludges and berms. These figures clearly indicate that the majority of the contamination is present in the sludges and berms and that the soils beneath and around the sludge are significantly less contaminated than the sludges and berms.

Applicable or Relevant and Appropriate Requirements

Section 121(d) of SARA mandates that, for all remedial actions conducted under the CERCLA, cleanup activities must be conducted in a manner that complies with applicable or relevant and appropriate requirements (ARARs). The NCP and SARA have defined both applicable requirements and relevant and appropriate requirements as follows:

Units: ppb

TABLE 11
SOURCE CONTROL CLEANUP CRITERIA TO ACHIEVE 10^{-6} RISKS
Bofors Site
Muskegon, Michigan

GROUNDWATER INGESTION

Compound	Lagoon 1					Lagoon 3					Lagoon 5					Lagoon 6				
	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B
Methylene Chloride	ND	ND	ND		ND	ND	ND	ND	ND	---	NA	NA	NA	ND	---	NA	ND	NA	ND	170
Benzene	ND	ND	ND		ND	4500	NA	790	ND	---	NA	ND	NA	ND	---	ND	ND	ND	ND	ND
3,3'-Dichlorobenzidine	39600 (Q)	ND	660 (Q)		1100	39600 (Q)	39600 (Q)	39600 (Q)	39600 (Q)	---	39600 (Q)	39600 (Q)	39600 (Q)	66000 (Q)	---	39600 (Q)	39600 (Q)	39600 (Q)	39600 (Q)	39600 (Q)
Aniline	ND	NA	NA	NA	ND	ND	970	580	NA	---	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
Azobenzene	ND	1000 (Q)	1000 (Q)	ND	ND	NA	420000	2.3×10^{6}	45000	---	NA	2000	24000	1700	---	NA	NA	NA	1000 (Q)	NA
Benzidine	ND	ND	ND	ND	ND	60000 (Q)	60000 (Q)	60000 (Q)	1000 (Q)	---	ND	1000 (Q)	1000 (Q)	ND	---	60000 (Q)	1000 (Q)	1000 (Q)	ND	1000 (Q)

GROUNDWATER INGESTION

Compound	Lagoon 7					Lagoon 8					Lagoon 9					Lagoon 10				
	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B
Methylene Chloride	NA	ND	NA	ND	---	NA	ND	NA	ND	91	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	---	820	ND	410	ND	NA	NA	ND	NA	625 (Q)	---	NA	NA	NA	ND	NA
3,3'-Dichlorobenzidine	39600 (Q)	39600 (Q)	39600 (Q)	39600 (Q)	---	39600 (Q)	39600 (Q)	39600 (Q)	7800	39600 (Q)	46000	39600 (Q)	39600 (Q)	39600 (Q)	---	39600 (Q)	660 (Q)	660 (Q)	660 (Q)	39600 (Q)
Aniline	ND	ND	ND	ND	---	NA	ND	NA	NA	NA	30000 (Q)	4500	2800	ND	---	2500	NA	1200	NA	NA
Azobenzene	18000	ND	3600	NA	---	28000	1000 (Q)	2700	1300	NA	NA	11000	400000	1000 (Q)	---	NA	3600	15000	1000 (Q)	75000
Benzidine	ND	ND	ND	ND	---	60000 (Q)	ND	1000 (Q)	ND	1000 (Q)	60000 (Q)	1000 (Q)	1000 (Q)	1000 (Q)	---	60000 (Q)	1000 (Q)	1000 (Q)	ND	1000 (Q)

Legend:

NA : Not applicable; cleanup concentrations higher than concentrations detected in sample.

ND : Not detected in original sample.

SL : Sludge.

SB : Soil beneath lagoon.

SL & SB : Sludge and soil beneath lagoon combined.

SA : Soil around lagoon.

B : Berm.

[ ] : Indicates exposure route, compound, and cleanup standard which drive remediation, based on risks.

Q: Cleanup criteria is analytical quantitation limit for the compound.

Units: ppb

TABLE 12
SOURCE CONTROL CLEANUP CRITERIA TO ACHIEVE 10^{-4} RISKS
Bofors Site
Muskegon, Michigan

GROUNDWATER INGESTION

Compound	Lagoon 1					Lagoon 3					Lagoon 5					Lagoon 6				
	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B
Methylene Chloride	ND	ND	ND	ND	ND	ND	ND	ND	ND	---	NA	NA	NA	ND	---	NA	ND	NA	ND	NA
Benzene	ND	ND	ND	ND	ND	450000	NA	79000	ND	---	NA	ND	NA	ND	---	ND	ND	ND	ND	ND
3,3'-Dichlorobenzidine	NA	ND	NA	1000	NA	690000	85000	100000	190000	---	NA	39800 (Q)	39800 (Q)	39800 (Q)	---	NA	130000	110000	39800 (Q)	NA
Aniline	ND	NA	NA	NA	ND	ND	NA	NA	NA	---	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
Azobenzene	ND	3400	2800	ND	ND	NA	NA	NA	NA	---	NA	NA	NA	NA	---	NA	NA	NA	NA	NA
Benzidine	ND	ND	ND	ND	ND	60000 (Q)	60000 (Q)	60000 (Q)	1000 (Q)	---	ND	1000 (Q)	1000 (Q)	ND	---	60000 (Q)	1000 (Q)	1000 (Q)	ND	1000 (Q)

GROUNDWATER INGESTION

Compound	Lagoon 7					Lagoon 8					Lagoon 9					Lagoon 10				
	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B	SL	SB	SL & SB	SA	B
Methylene Chloride	NA	ND	NA	ND	---	NA	ND	NA	ND	9100	ND	ND	ND	ND	---	ND	ND	ND	ND	ND
Benzene	ND	ND	ND	ND	---	NA	ND	NA	ND	NA	NA	ND	NA	34000	---	NA	NA	NA	ND	NA
3,3'-Dichlorobenzidine	150000	39800 (Q)	39800 (Q)	39800 (Q)	---	440000	39800 (Q)	39800 (Q)	NA	260000	$4.6x10^6$	39800 (Q)	39800 (Q)	39800 (Q)	---	800000	880 (Q)	43000	39800 (Q)	260000
Aniline	ND	ND	ND	ND	---	NA	ND	NA	NA	NA	$1.1X10^6$	NA	260000	ND	---	NA	NA	NA	NA	NA
Azobenzene	NA	ND	NA	NA	---	NA	46000	NA	NA	NA	NA	NA	NA	NA	---	NA	NA	NA	NA	NA
Benzidine	ND	ND	ND	ND	---	60000(Q)	ND	1000 (Q)	ND	1000 (Q)	60000 (Q)	1000 (Q)	1000 (Q)	1000 (Q)	---	60000 (Q)	1000 (Q)	1000 (Q)	ND	1000 (Q)

Legend:

NA : Not applicable; cleanup concentrations higher than concentrations detected in sample.

ND : Not detected in original sample.

SL : Sludge.

SB : Soil beneath lagoon.

SL & SB : Sludge and soil beneath lagoon combined.

SA : Soil around lagoon.

B : Berm.

[ ] : Indicates exposure route, compound, and cleanup standards which drive remediation.

Q: Cleanup criteria is the analytical quantitation limit for the compound.

TABLE 13
CONTAMINANT MASS DISTRIBUTION BY SUBAREA
Bofors Site
Muskegon, Michigan

Units: mg/kg (ppm)

	Total Mass				Percent Mass			
	SL	SB	B	SA	SL	SB	B	SA
Methylene Chloride	43.0	0.1	3.7	--	92.0 %	0.2	8.0	0.0
Benzene	7782.3	2.0	--	10209.8	43.0 %	~0.0	0.0	57.0
DCB	2712333.0	24171.0	20905.0	253513.0	48.0 %	4.0	4.0	44.0
Aniline	38770.8	626.6	14.8	132.0	98.0 %	1.6	~0.0	0.3
Azobenzene	188478.8	18193.4	2264.8	4250.3	88.4 %	8.5	1.1	2.0
Benzidine	40654.5	8122.6	203.2	121.1	82.8 %	16.5	0.4	0.2
Percent of Total Mass	61.5 %	5.7 %	2.6 %	30.1 %				

LEGEND:

SL: Sludge.

SB: Soil beneath lagoon.

B: Berm.

SA: Soil around lagoon.

- Applicable Requirements are those federal and state requirements that would be legally applicable, either directly or as incorporated by a federally authorized state program, if the response action was not undertaken pursuant to Section 104 or 106 under CERCLA.

- Relevant and Appropriate Requirements are those federal and state requirements that, while not legally "applicable", are designed to apply to problems sufficiently similar to those encountered at CERCLA sites that their application is appropriate. Requirements may be relevant and appropriate if they would otherwise be "applicable" but for jurisdictional restrictions associated with the requirement.

- Other Requirements to be Considered are federal and state non-regulatory requirements, such as guidance documents or criteria. Advisories or guidance documents do not have the status of potential ARARs. However, where there are no specific ARARs for a chemical or situation, or where such ARARs are not sufficient to be protective, guidance or advisories should be identified and used to ensure that a remedy is protective.

The pertinent ARARs are summarized in the description of each alternative and addressed in detail in the section on Comparative Analysis of Alternatives.

Resource Conservation and Recovery Act Issues

The applicability of the Resource Conservation and Recovery Act (RCRA) hazardous waste regulations to the treatment, storage, and disposal of contaminated sludge, soil, and berms at this site was reviewed. Several sludge/soil samples were tested for ignitability, corrosivity, reactivity, and toxicity to determine their classification as a RCRA characteristic hazardous waste. Only one sludge sample showed a RCRA hazardous characteristic (reactivity). All the samples tested for the other characteristics, including TCLP, showed negative results. Since only one sample tested positive as a RCRA characteristic hazardous waste, and only for one characteristic, it is not expected that the waste at this site is a RCRA characteristic hazardous waste. However, this should be confirmed during the design. If the waste is a RCRA characteristic waste, then treatment and disposal must comply with RCRA requirements.

After treatment, the resulting ash may exhibit the characteristic of toxicity through TCLP testing for metals, because the metals may be concentrated in the ash and their mobility increased. This should also be confirmed during the design phase.

RCRA U-listed hazardous wastes are discarded commercial chemical products, off-specification species, container residues, and spill residues that contain substances listed in 40 CFR 261.33(f). While the sludge and berms contain constituents included in the list of U wastes contained in 40 CFR 261.33(f), it is unlikely that the contaminated media in the L.O.U. were discarded commercial products, off-specification species, container residues, and spill residues. Rather, the sludge in the L.O.U. is production waste from the manufacture of DCB and benzidine.

Treatability Studies

Treatability testing has been performed to evaluate treatment of the groundwater. Ozone oxidation, UV/peroxide oxidation, and carbon adsorption were evaluated at the bench-scale. This testing indicated that ozone oxidation offers the best combination of cost-effectiveness and performance of the technologies tested at this site.

Treatability testing has also been performed to evaluate treatment of the sludges and soils in this operable unit. Soil washing, low temperature thermal desorption, and solidification/stabilization technologies were evaluated at the bench-scale. These tests indicated that soil washing has limited applicability to this site, that LTTD may be suitable as a remedial technology at this site, and that stabilization is not suitable for use at this site.

DESCRIPTION OF ALTERNATIVES

The remedial alternatives considered for this operable unit are:

- Alternative 1: No Action.
- Alternative 2: Capping; Institutional Controls on Groundwater Use and Site Access; Pump and Treat Groundwater Perpetually.
- Alternative 3: On-Site Incineration/Low-Temperature Thermal Desorption; Capping; Pump and Treat Groundwater for a Finite Period.
- Alternative 4: On-Site Incineration/Low-Temperature Thermal Desorption; On-Site Landfilling; Pump and Treat Groundwater for a Finite Period.

All the remedial alternatives contain the same following components:

- Maintaining a fence around the site. The existing fence would be maintained around the site to prevent trespassing on the site. The fence includes signs warning potential trespassers about contamination and threats to human health and the environment at the site.
- Monitoring groundwater and surface water. Samples from existing monitoring wells would be collected to assess the effectiveness of the remedial action, if applicable. Samples would be collected four times during the first year of monitoring and twice annually in subsequent years. To monitor surface water quality, samples from two locations would be collected in Big Black Creek. The surface water samples would be collected on four occasions during the first year of monitoring and twice annually in subsequent years.

Remedial Alternatives 2, 3, and 4 contain the following additional components:

- Constructing on-site roads. About 4,500 feet of roads would be constructed on the site, primarily near the sludge lagoons, to accommodate truck traffic on the site during the remedial action cleanup.

- Monitoring air. Air samples would be collected from the work zone and perimeter of this site during excavation of the contaminated material. Air samples would also be collected to measure the potential emissions from the treatment facilities. These samples would be collected from the facility stack and from the site perimeter. The frequency of sampling would be determined prior to construction.

- Groundwater pumping and treatment. The groundwater is currently being pumped using the existing groundwater extraction system. For this remediation, the pumping system would be upgraded and the distribution system would be relocated to accommodate excavation and treatment of the lagoons. A new treatment system would be built. Treatability studies indicated that ozone treatment will achieve effluent concentrations below detection limits. Therefore, the groundwater would be treated using an ozone oxidation treatment system or a system that achieves equivalent performance. The treated effluent would then be discharged to Big Black Creek. Although a National Pollutant Discharge Elimination System (NPDES) permit is not required because treatment and discharge of the effluent occurs on-site, the substantive requirements of the permit will be met. The proposed Best Available Technology (BAT) discharge standards for the indicator chemicals are as follows: Methylene Chloride, 5.0 ug/l; Benzene, 5.0 ug/l; DCB, .06 ug/l; Aniline, 4.0 ug/l; Benzidine, .04 ug/l; discharge standards for Azobenzene are in the process of being developed. The groundwater treatment

system will be operated to achieve these standards.

Alternative 1: No Action

The no action alternative involves leaving the L.O.U. contaminant source areas intact and terminating operation of the existing groundwater pumping and treatment system which currently controls groundwater migration off-site. Groundwater and surface water monitoring will be performed semiannually to evaluate impacts of terminating operations of the groundwater pumping and treatment system. Therefore, the potential for release of contamination to air, groundwater, and surface water pathways and for exposure to compounds above acceptable risk levels will continue to exist. This alternative will not meet target risk levels and no reduction of toxicity, mobility or volume of site contaminants will occur. Risk levels predicted for this alternative are 10^{-3} for the air inhalation pathway, 10^{-1} for the groundwater ingestion pathway, and 10^{-2} for the surface water ingestion pathway, for a total risk of 10^{-1}. This alternative is included as a NCP requirement and also to provide a baseline against which other alternatives may be compared.

Alternative 2: Cap, Institutional Controls, Pump and Treat Groundwater Perpetually

The components of this alternative are presented in Figure 3. The components presented in this figure are approximate and may be modified during design or construction.

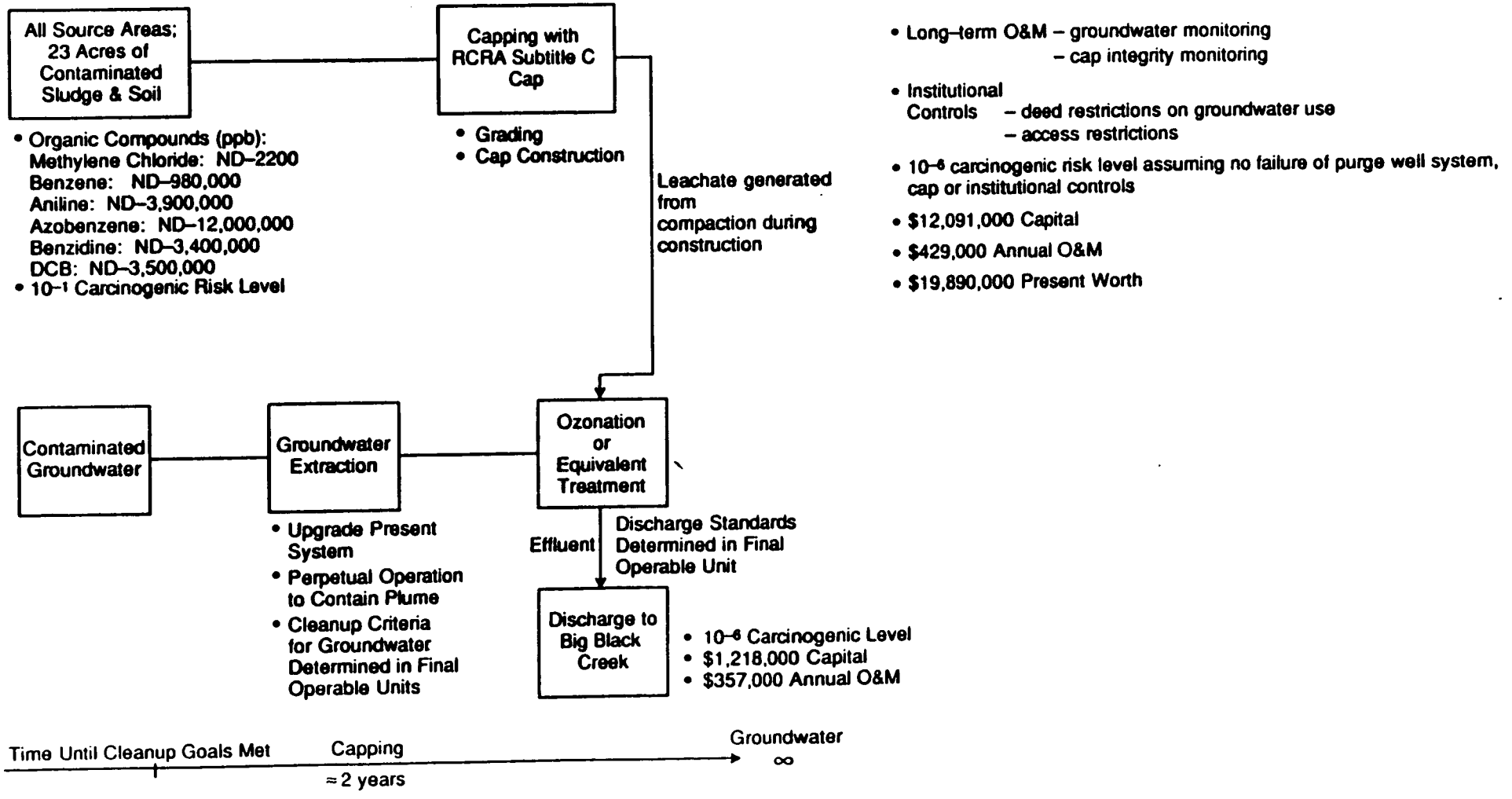
Treatment Components

There is no treatment of the sludges and soils in this alternative. Fluids generated from sludge compaction during the construction of the cap will be treated in the groundwater treatment system. This is estimated to be 3.1 million gallons over a two-year period. The groundwater will be pumped and treated perpetually using an ozone oxidation or equivalent treatment system. Treatment levels will be determined in the next operable unit.

Containment Components

All eight lagoon source areas (Lagoon Areas 1,3,5,6,7,8,9,10) will be capped (approximately 23 acres of contaminated sludges and soils). The cap, designed to meet the intent of RCRA Subtitle C, and constructed to meet U.S. EPA guidance provided in 40 CFR 264.310, will consist of an upper 2-foot vegetated soil layer underlain by filter fabric and a 12-inch sand layer over a low permeability layer. The low-permeability layer will be composed of a synthetic liner (minimum thickness of 20 mil) over a 2-foot compacted clay layer (i.e., soil liner) with a permeability less than or equal to 1×10^{-7} cm/sec.

Figure 3
Components of Alternative 2



To reduce water and wind-borne migration of contaminants off-site, erosion controls will be used. As needed, dust suppression techniques will be used to reduce airborne contaminant transport. After the initial grading of the site, the area to be capped will be further prepared. Initially, a foundation layer will be formed using local or imported material capable of structurally supporting the weight of the cap. This material will be spread and graded to form a smooth subgrade prior to cap placement. Final grading of the subgrade will be performed in accordance with the proposed cap grades to provide positive surface drainage off the cap. A drainage system will be constructed to collect consolidation leachate.

The minimum post-compaction slopes for the cap will be 5 percent where attainable; the maximum cap slope will be 25 percent. The final capped area will rise approximately four feet above existing grade. Stability of the soils on-site is not expected to be a problem for the cap design for most of the site. However, based on geotechnical testing, the sludges consist of low-strength, highly compressible materials. These construction concerns have been taken into account in the cap design and cost estimate. After final grading is complete, the cap will be fertilized, seeded, and mulched to promote vegetative growth. Drainage pathways will be established to divert surface water runoff away from the capped area on a permanent basis.

Groundwater Components

The groundwater is currently being pumped using an existing groundwater extraction system. For this remediation, the pumping system would be upgraded to increase performance efficiency and the distribution system would be relocated to accommodate excavation and treatment of the lagoons. As previously mentioned, a new treatment system would be built, using an ozone oxidation treatment system or equivalent system to treat the groundwater. The treated effluent would then be discharged to Big Black Creek. In this alternative, the groundwater will be pumped and treated perpetually to contain the groundwater plume.

General Components

This alternative addresses all of the contaminated soils and sludges in this operable unit through containment using capping and groundwater extraction. Capping the eight source areas will reduce air emissions and reduce infiltration of precipitation and contaminants into the groundwater. However, the reduction in infiltration will not be sufficient to achieve 10^{-6} risks for groundwater or surface water ingestion. Therefore, the existing pump and treat system will be operated perpetually and will contain the groundwater contaminant plume to prevent groundwater migration off-site and subsequent surface water contamination. Institutional controls limiting on-site access and groundwater

use will also be incorporated to prevent future development, site access, and use of the contaminated groundwater. Placement of the cap will involve alterations to the wetlands in source area 10.

This alternative is estimated to achieve a risk of 10^{-6}, assuming the cap, groundwater extraction and treatment system, and institutional controls are successfully maintained. This represents a five order-of-magnitude reduction in risk from the 10^{-1} initial risk.

The cap will require periodic inspection and repair. Periodic sampling, inspection, and maintenance of groundwater monitoring wells and the groundwater extraction system will be required. As noted previously, the cap will be constructed to meet the intent of RCRA Subtitle C. Although RCRA is not applicable or relevant and appropriate for this operable unit, the level of technology required by RCRA is proposed to be used to provide an increased level of protection.

Institutional controls on groundwater use and site access may be difficult to enforce over an extended time period. There is significant uncertainty over the likelihood that the institutional controls, the cap, and the groundwater extraction and treatment system will be operated, maintained, and enforced forever.

The costs and estimated implementation time frame for Alternative 2 are:

Capital:	$12 million
Annual O&M:	$429,000
Present Worth:	$20 million
Estimated Implementation Time:	2 years

ARARs

Alternative 2 will comply with the substantive requirements of an NPDES permit (Clean Water Act), which is an applicable ARAR. Since wetlands on the north side of Big Black Creek will be impacted during the construction of this alternative, the substantive requirements of a 404 permit will need to be satisfied, as well as the requirements of the State Wetland Protection Act, also applicable ARARs. The State Soil and Erosion Act is relevant and appropriate to this alternative, which is expected to comply with the requirements of this ARAR. The Clean Air Act and State Air Pollution Control Act are applicable to this alternative during construction of the cap. This alternative is expected to comply with the requirements of these ARARs. The Safe Drinking Water Act is a relevant and appropriate ARAR and the State Water Resources Commission Act is an applicable ARAR to this alternative because of discharge of treated groundwater to

Big Black Creek. The requirements of these ARARs are anticipated to be met by this alternative. According to the State of Michigan, the Michigan Act 307 requirements may not be met.

Alternative 3: On-Site Incineration/Low Temperature Thermal Desorption, Cap, Pump and Treat Groundwater

Alternative 3 consists of combined treatment and containment technologies directed toward removal and treatment of the most contaminated sludges, and capping of less contaminated sludges and soils. The components of this alternative are presented in Figure 4. The components presented in this figure are approximate and may be modified during design or construction.

Treatment Components

Source Areas 3 and 9: Sludge, berms, and soils under the sludge will be excavated and incinerated on-site. Low-temperature thermal desorption (LTTD) may be used on either or both of these source areas or subareas if pilot-scale testing indicates acceptable performance by achieving the cleanup criteria. LTTD is a volume reduction technology that removes contaminants from the sludge or soil by volatilization and concentrates the contaminants in an aqueous phase which is then treated. This technology can provide a less-expensive alternative to incineration when there is sufficient performance to achieve cleanup criteria.

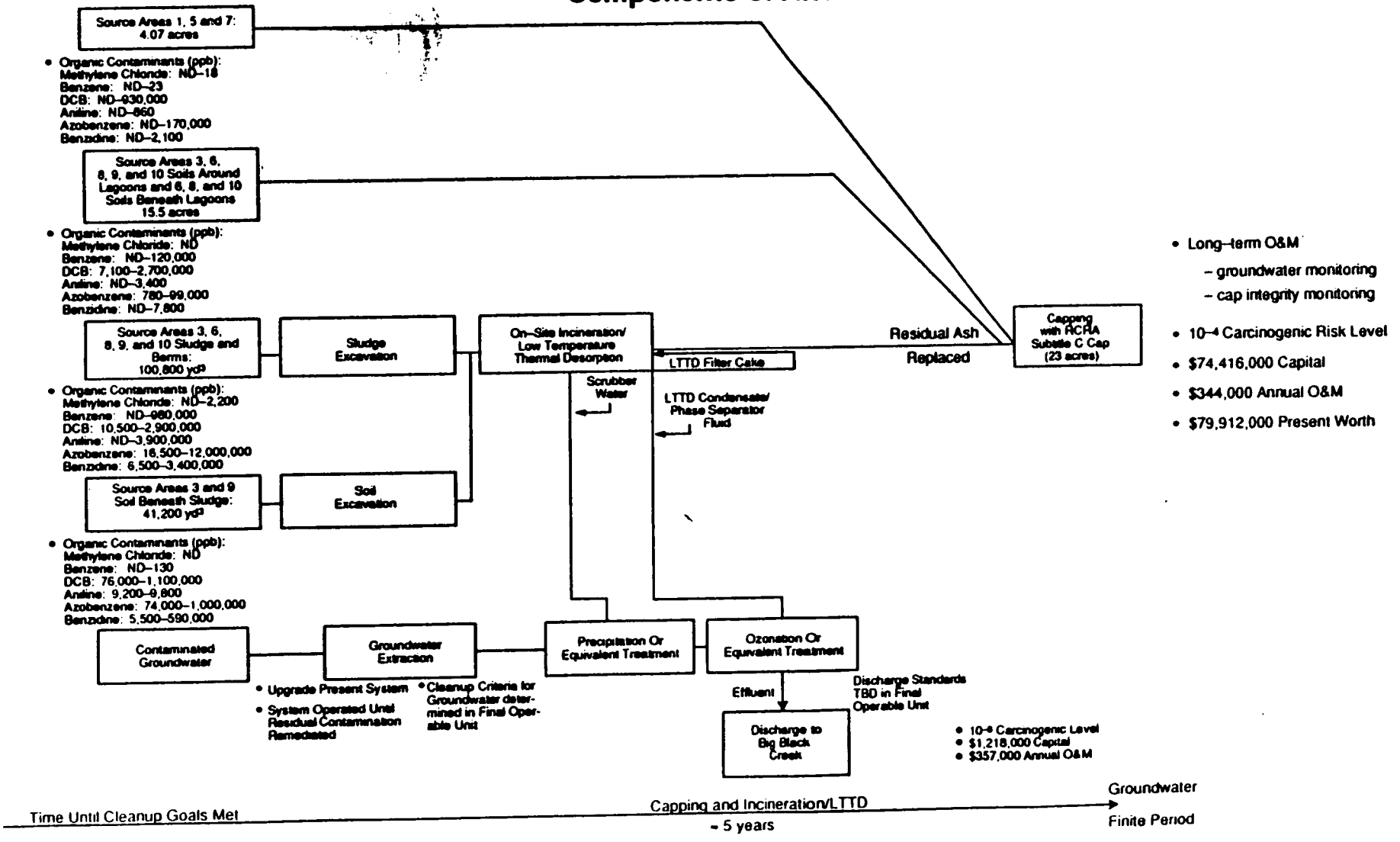
Source Areas 6 and 8: Sludge and berms will be excavated and incinerated. On-site LTTD may also be used on either or both of these source areas or subareas if pilot scale testing indicates acceptable performance.

Source Area 10: Sludge and berms will be excavated and treated on-site using LTTD.

Fluids generated during the construction of the cap from sludge compaction in Source Areas 1, 5, and 7 will be treated in the groundwater treatment system.

Fluids generated during LTTD will be treated on-site using the groundwater treatment system. Scrubber water from the incinerator will be treated by precipitation or equivalent treatment. Filter cake from filtering the LTTD wastewater will be incinerated in the on-site incinerator. The groundwater beneath the site will be collected and treated using ozone or equivalent treatment.

Figure 4
Components of Alternative 3



Containment Components

All material will be capped in Source Areas 1, 5, and 7. For the other source areas, after incineration of the sludges and soils, the ash will be replaced, then each source area will be capped. The cap used in this alternative is the same as the cap in Alternative 2.

Groundwater Components

The groundwater component for this alternative is the same as the component described in Alternative 2, except the groundwater will be pumped and treated for a finite period. The cleanup criteria for the groundwater will be determined in the final operable unit.

General Components

This alternative addresses all the contaminated soils and sludges in this operable unit through a combination of treatment and containment.

This alternative is expected to achieve a risk of 10^{-4} in the groundwater, because the capping component can achieve only this risk level since the reduction in precipitation migration through the cap is not sufficient to achieve 10^{-6} risks. The 10^{-4} risk represents a three order-of-magnitude reduction in risk from the 10^{-1} initial risk.

Source Areas 1, 5, and 7 will be capped, and the remaining Source Areas (3, 6, 8, 9, and 10) which contain the most contaminated materials in the L.O.U. will be treated. Capping after treatment of the sludges and replacement of the ash will reduce infiltration through the soils underneath the sludge. Placement of the cap will involve alterations of the wetlands in source area 10. This alternative involves capping approximately 23 acres of contaminated sludges and soils and excavating and incinerating or LTTD of approximately 56,800 yd^3 of sludge and berms (Source Areas 3, 6, 8, 9) and 41,200 yd^3 of contaminated soil beneath the lagoons (Source Areas 3, 9) and LTTD approximately 44,000 yd^3 of sludge and berms (Source Area 10). LTTD is proposed to be used in addition to incineration to reduce treatment costs. As indicated previously, LTTD may be used on other source area media, if pilot-scale testing indicates acceptable performance.

Pilot-scale treatability testing will be needed to determine the applicability of LTTD and treatability testing will most likely also be needed for incineration.

The costs and estimated implementation time frame for Alternative 3 are:

Capital:	$74 million
Annual O&M:	$344,000
Present Worth:	$80 million
Estimated Implementation Time:	5 years

ARARs

The ARARs presented for Alternative 2 also are pertinent to this alternative. In addition, air emissions requirements concerning construction of equipment that may be a source of air emissions in the Clean Air Act and Michigan Air Pollution Control Act are applicable to this alternative. RCRA is a potential ARAR for this alternative if the ash tests positive as a RCRA characteristic waste. According to the State of Michigan, this alternative does not satisfy Michigan Act 307 requirements.

Alternative 4: On-Site Incineration/Low Temperature Thermal Desorption, On-Site Landfill, Pump and Treat Groundwater

Alternative 4 also consists of combined treatment and containment technologies directed to treatment of the most contaminated sludges and landfilling of less contaminated sludges and soils. The components of Alternative 4 are presented in Figure 5. The components presented in this figure are approximate and may be modified during design or construction.

Treatment Components

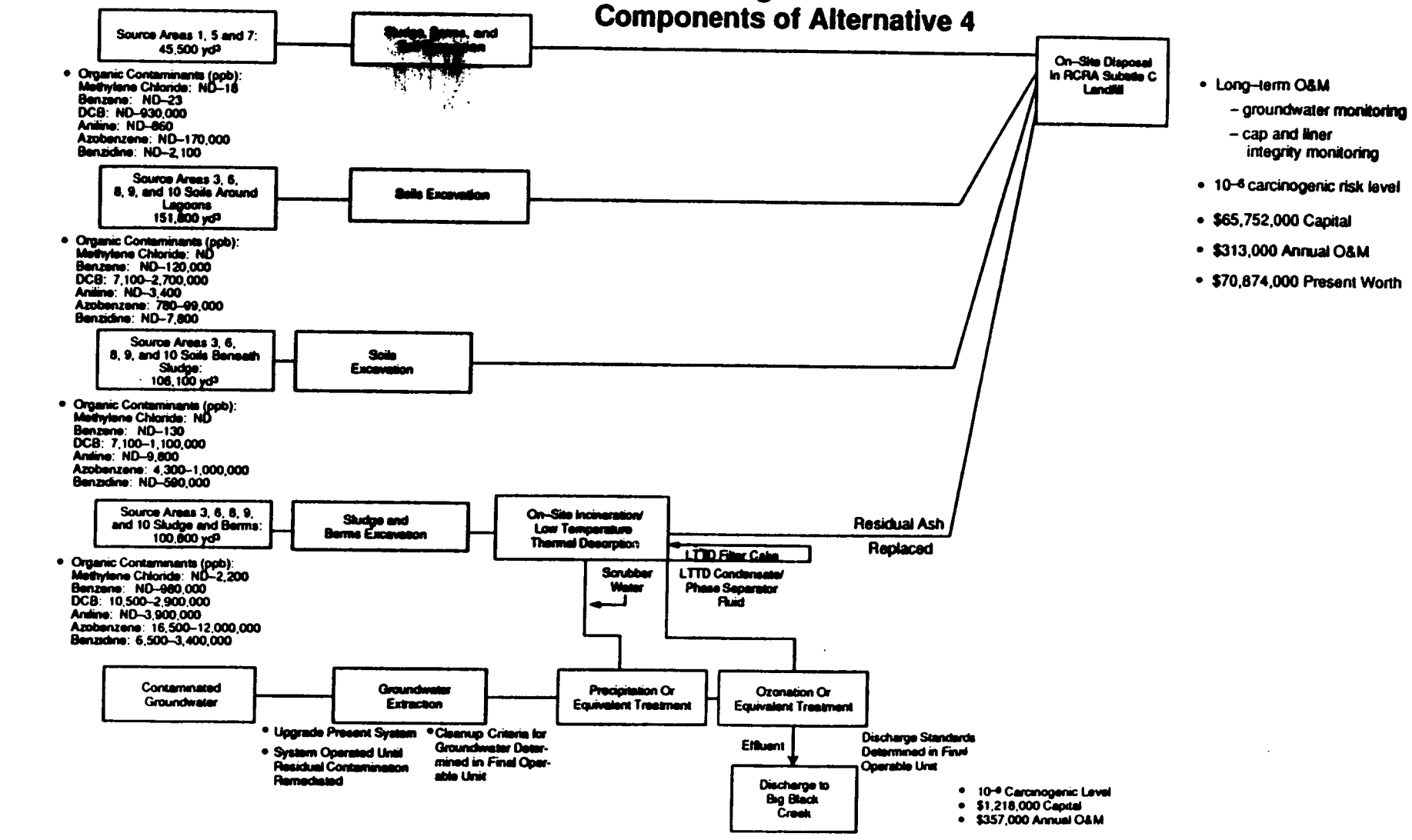
Source Areas 3, 6, 8, and 9: Sludge and berms will be excavated and incinerated on-site. LTTD may be used on these source areas if pilot-scale testing indicates acceptable performance.

Source Area 10: Sludge and berms will be excavated and treated on-site using LTTD.

Fluids generated during LTTD will be treated on-site using the groundwater treatment system. Filter cake generated during LTTD will be incinerated on-site. Scrubber water from the incinerator will be treated by precipitation or equivalent treatment. Landfill leachate will be treated in the groundwater treatment system.

The groundwater from beneath the site will be pumped and treated using ozone or equivalent treatment.

Figure 5
Components of Alternative 4



Containment Components

All material in Source Areas 1, 5, and 7, including sludge, berms, and soils, will be excavated and placed in an on-site RCRA-type landfill. The ash from incineration and LTTD (Source Areas 3, 6, 8, 9, and 10) will be placed in the on-site RCRA landfill. Soils beneath and around the lagoons in these source areas will be excavated and also placed in the landfill. The approximate location of the landfill is presented in Figure 6.

Groundwater Components

The groundwater component for this alternative is the same as described in Alternative 3.

General Components

This alternative also addresses all the contaminated sludges and soils in this operable unit through a combination of treatment and containment. The risks remaining after remediation using this alternative are estimated to be 10^{-6}. This alternative will require the excavation and treatment of approximately 100,800 yd^3 of sludge and berms and landfilling of approximately 18,700 yd^3 of sludge. The approximate volume of soil to be landfilled is 334,700 yd^3. The volume of ash from incineration and LTTD that will be landfilled is 73,100 yd^3. The total volume of material that will be landfilled is approximately 426,506 yd^3. The landfill will occupy approximately 8 acres. A minimum of 12-feet separation between the landfill base and the water table will be provided. Landfilling of soils in source area 10 will impact the existing wetlands.

The costs and estimated implementation time frame for Alternative 4 are:

Capital:	$65,752,000
Annual O&M:	$313,000
Present Worth:	$70,874,000
Estimated Implementation Time:	5 years

ARARs

The ARARs presented for Alternative 3 also are pertinent to this alternative except Michigan Act 307 requirements would be met.

SUMMARY OF COMPARATIVE ANALYSIS OF ALTERNATIVES

The following nine criteria were used to evaluate the four alternatives:

1. **Overall protection of human health and the environment:** addresses whether a remedy provides adequate protection and

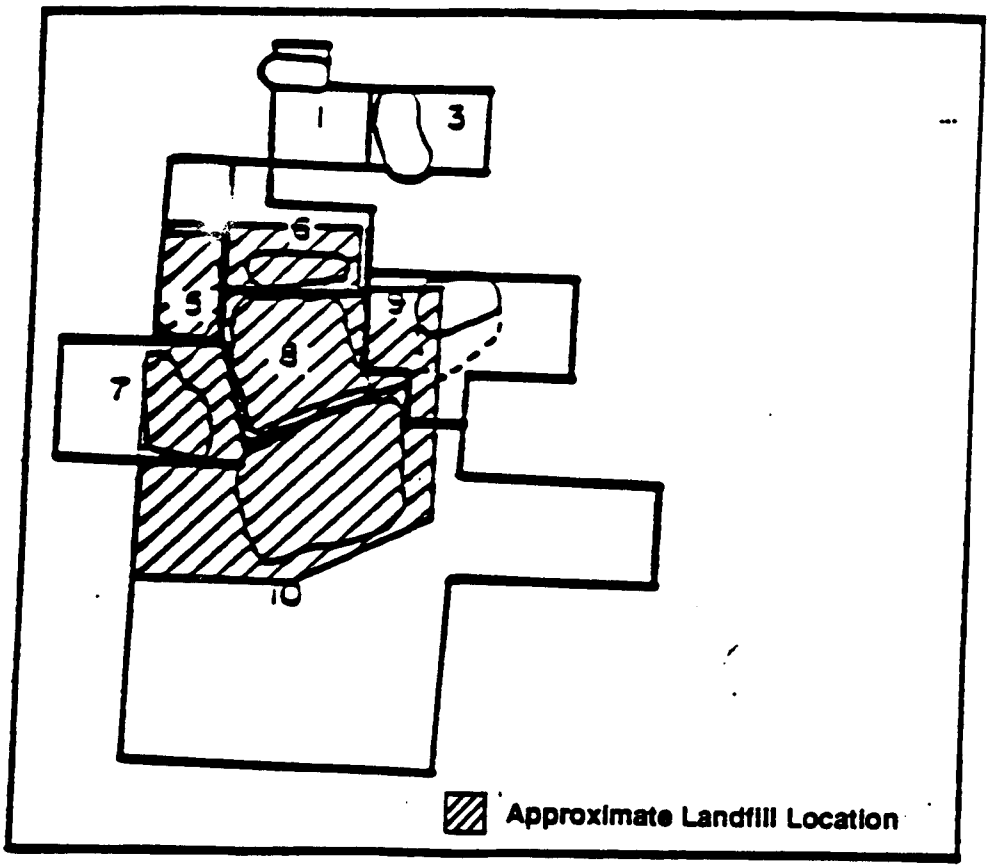


Figure 6 Location of RCRA Landfill

describes how risks posed through each pathway are eliminated, reduced, or controlled through treatment, engineering controls, or institutional controls.

2. **Compliance with applicable or relevant and appropriate requirements (ARARs):** addresses whether a remedy will meet all of the ARARs of other Federal and State environmental laws and/or justifies a waiver.

3. **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 clean-up goals have been met.

4. **Reduction of toxicity, mobility, or volume through treatment:** is the anticipated performance of the treatment technologies a remedy may employ.

5. **Short-term effectiveness:** addresses the period of time needed to achieve protection and any adverse impacts on human health and the environment that may be posed during the construction and implementation period, until clean-up goals are achieved.

6. **Implementability:** is the technical and administrative feasibility of a remedy, including the availability of materials and services needed to implement a particular option.

7. **Cost:** includes estimated capital and O&M costs, as well as present-worth costs.

8. **State Acceptance:** is used to indicate the state's comments.

9. **Community Acceptance:** summarizes the public's general response to the alternatives described in the Proposed Plan and RI/FS Report. The specific responses to public comments are addressed in the Responsiveness Summary section of the ROD.

Threshold Criteria

Overall Protection of Human Health and the Environment

Alternative 1 provides no protection, since no action is taken. Alternative 2, even though it attains a 10^{-6} risk, is the next least protective because no treatment of the principal threat is included in the alternative. If failure of the cap, institutional controls, or pump and treat system occurs because the original source is still present, the site could return to current risk levels. In addition, in this alternative, achieving the 10^{-6} risk estimate assumes that institutional controls and groundwater pumping and treatment will be maintained forever, an

unlikely event. Alternative 3 is more protective than Alternative 2 because of the treatment of sludge, berms, and soils, and the finite groundwater pumping and treatment period. However, Alternative 3 presents a 10^{-4} risk, two orders of magnitude greater excess cancer risk than Alternatives 2 and 4. This greater residual risk is due to the use of capping only as a containment technology, rather than in combination with perpetual groundwater pumping and treatment. Alternative 4 is the most protective because it provides treatment of highly contaminated materials, high degree of containment of less contaminated materials through landfilling rather than capping, and does not require perpetual pumping and treatment of groundwater.

Compliance with ARARs

The substantive provisions of the following have been identified as ARARs for this operable unit:

Federal:

- Clean Water Act (33 U.S.C. 1251)
- Clean Air Act (42 U.S.C. 7401)
- Flood Plain Management and Protection of Wetlands (42 U.S.C. 4321)

State:

- Water Resources Commission Act (ACT 245)
- Goemaere-Anderson Wetland Protection Act (ACT 203)
- Michigan Environmental Response Act (ACT 307)
- Soil Erosion and Sedimentation Act (ACT 347)
- Air Pollution Act (ACT 348)

The following have been identified as potential ARARS for this operable unit:

- Resource Conservation and Recovery Act (42 U.S.C.6901)
- Safe Drinking Water Act (42 U.S.C. 300(f)

Federal

The Clean Water Act (CWA) regulates the chemical, physical, and biological integrity of surface waters. Under Title III and IV of this act, effluent standards and permits are required to be established and applied to discharges to surface waters. Section 404 of Title IV specifically regulates the discharge of dredged or fill material into surface waters, including adjacent wetlands. Title 40, Part 129 of the Code of Federal Regulations (40 CFR 129) establishes effluent standards and ambient water criteria for certain toxic pollutants, including benzidine.

Alternative 1, the no action alternative, will affect the water quality of Big Black Creek, a recreational-use stream, since this alternative involves the discontinuation of the groundwater pumping and treatment system. Alternatives 2, 3, and 4 include pumping, treating, and discharging groundwater on-site to the Big Black Creek. Therefore, this regulation is applicable to all the alternatives for the L.O.U. 40 CFR 122, 125 and 136 establish guidelines and procedures for the National Pollutant Discharge Elimination System (NPDES). The NPDES program is a national program for issuing, monitoring, and enforcing permits for direct discharges. The substantive requirements of these regulations must be met for on-site discharges. Therefore, the substantive requirements of these regulations are applicable to Alternatives 2, 3, and 4.

40 CFR 230 regulates the disposal of dredged or fill material in surface water and wetland areas. Alternatives 2, 3, and 4 involve excavation and other remedial activities in the wetland area. Therefore, the substantive requirements of this regulation are applicable to these alternatives. The MDNR has assumed administration over the wetlands in the State of Michigan because of Act 203 and several other environmental statutes which incorporate these Federal requirements. However, the Federal government retains the authority to review and comment. Section 10 of the Federal River and Harbor Act, as amended, regulates the obstruction or alteration of any navigable water in the United States. The jurisdiction of navigable waters includes connected wetlands. Alternatives 2 and 3 include activities which will cause alterations in the wetland area of the Big Black Creek by capping the wetlands in Source Area 10. Alternative 4 includes activities which will cause alterations in the wetlands by excavating the wetlands in Source Area 10. Therefore, the substantive requirements of 33 CFR 320 through 330 may be applicable to these alternatives.

The Safe Drinking Water Act (SDWA) of 1974, as amended, was enacted to assure high water quality in public water systems. The National Primary Drinking Water Regulations specify the maximum contaminant levels (MCLs) and the maximum contaminant level goals (MCLGs) for public water systems for inorganic and organic chemicals. The surface water in Big Black Creek is not currently distributed through the public water supply systems. Therefore, these regulations are not applicable to the site. However, the surface water is a potential source of drinking water. Therefore, these standards may be relevant and appropriate for Alternatives 1, 2, 3, and 4. Benzene is the only compound of the compounds of concern which has a MCL and MCLG. According to the final NCP, MCLGs which have values of zero are not relevant or appropriate at CERCLA sites (55 FR 8751). Since the MCLG for benzene is zero, this standard is not relevant or appropriate to the L.O.U. The MCL for benzene is 5 ppb, which is equivalent to an excess cancer risk of 10^{-6}.

Lagoon 3 soil and sludge and Lagoon 9 soil around the lagoon may result in an excess cancer risk of benzene in surface water at the same order of magnitude as the MCL. Based on this information, Alternative 1, the no action alternative, may not comply with MCLs. However, Alternatives 2, 3, and 4 are expected to comply with MCLs.

The Clean Air Act (CAA) was enacted to protect and enhance air quality. 40 CFR 6 requires that all Federal projects, licenses, permits, plans, and financial assistance activities conform to any State Air Quality Implementation Plan (SIP). This requirement is action specific and therefore, is applicable to Alternatives 2, 3, and 4. 40 CFR 50 establishes primary and secondary ambient air quality standards. Since these requirements regulate ambient air quality, these rules are applicable to all the alternatives. It is expected that all the alternatives, except Alternative 1, will be able to attain primary and secondary air quality standards. 40 CFR 60.50-54 specify emission standards for newly constructed incinerators. These rules are only applicable to Alternatives 3 and 4 which include incineration of soil and/or sludge and berms as part of the remedial alternative. These alternatives are expected to comply with 40 CFR 60.50-54 rules. 40 CFR 61 specifies national emission standard for hazardous air pollutants from stationary sources. The hazardous air pollutant at this site specified under these regulations is benzene. This regulation is applicable to Alternatives 3 and 4 which contain treatment systems for the groundwater, soil, and/or sludge and berms which may emit hazardous air pollutants.

U.S. EPA's policies and procedures for implementing Executive Orders 11988 (Floodplain Management) and 11990 (Wetlands Protection) and the Fish and Wildlife Coordination Act are provided in 40 CFR 6. The procedures provided in 40 CFR 6, Appendix A, substantively require that U.S. EPA conduct its activities to avoid long- and short-term adverse impacts associated with actions in the wetland or floodplain areas. Because Alternatives 2 and 3 involve capping in a portion of the wetland area and Alternative 4 involves excavation in a portion of the wetland area, compliance with the Wetland Act must be met for these alternatives and will require close interaction with the appropriate regulatory agencies.

The Resource Conservation and Recovery Act (RCRA) is a potential ARAR for Alternatives 3 and 4. After treatment in these alternatives, the resulting ash may exhibit the characteristic of toxicity for metals through TCLP testing, since metals may be concentrated in the ash and their mobility increased. This will be confirmed during the design phase. If the ash is a RCRA characteristic waste, then Alternatives 3 and 4 must comply with RCRA regulations concerning disposal.

State
The Water Resources Commission Act was established to protect the water quality of Michigan. Part 4 rules establish surface water quality standards and regulate discharge to surface water bodies. Since surface water quality would be affected by the no action alternative, Alternative 1 does not comply with these water quality requirements. Alternatives 2 through 4 include groundwater pumping and treatment followed by discharge to Big Black Creek, a recreational-use stream. Rule 323.1057 (Rule 57) of Part 4 establishes standards for toxic substances. Standards for toxic substances are established on a site-specific basis. NPDES permits are regulated by the State under the Part 4 Water Quality rules. Because all remedial activities occur on-site, permits are not required; however, the substantive requirements of the NPDES permit will be met.

Act 203, the Goemaere-Anderson Wetland Protection Act, applies to activities that result in discharge to the wetland area that drains to the Big Black Creek. In Michigan, the MDNR has jurisdiction over the wetlands. All the alternatives result in discharge to, excavation, or grading of a portion of the wetland area of the Big Black Creek south of Lagoon 10 in some form. The no action alternative may detrimentally affect the wetland area by natural discharge of contaminated groundwater into the wetlands. Therefore, this alternative may not comply with the Wetland Protection Act. Alternatives 2, 3, and 4 include remedial activities, i.e. excavation and/or filling in the wetland area. These activities must meet the substantive requirements of the Wetlands Protection Act. Compliance with the substantive standards of the Wetland Act must be met for Alternatives 2, 3, and 4 and will require close interaction with the appropriate regulatory agencies.

The substantive provisions of Parts 6 and 7 of the rules promulgated under the Michigan Environmental Response Act (Act 307) are considered an ARAR for the remedial action to be undertaken at this site. These rules provide, inter alia, that remedial action be protective of human health, safety and the environment, (Rule 299.5705 (1)). The rules specify that this standard is achieved by a degree of cleanup which conforms to one or more of three cleanup types (Rule 299.5705(2)). A type A cleanup generally achieves cleanup to background (Rule 299.5707); a type B cleanup meets specified risk-based levels in all media (Rule 299.5709); and a type C cleanup is based on a site-specific risk assessment which considers specified criteria. The selected remedy meets this ARAR.

The Soil Erosion and Sedimentation Act establishes general soil erosion and sedimentation control procedures and measures for specified activities which disturb one or more acres of land or is within 500 feet of a lake or stream. Because the activities

specified in Part 17 rules are not the activities which directly correspond to the remedial alternatives, these rules are not applicable to the alternatives for the L.O.U. However, Alternatives 2, 3, and 4 will disturb one or more acres of land and are within 500 feet of a stream. Therefore, the requirements of these rules are sufficiently similar to the site that they are relevant and appropriate. It is expected that Alternatives 2, 3, and 4 will comply with the requirements of Part 17 Soil Erosion and Sedimentation rules.

The Air Pollution Control Act was enacted to control air pollution in Michigan. Part 2 Air Use Approval rules establishes requirements for the installation or construction of equipment which may be a source of an air contaminant. Alternatives 2, 3, and 4 include ozonation for the groundwater. Alternatives 3 and 4 include LTTD and incineration of soil and/or sludges and berms. These treatment systems may be sources of air contaminants, therefore, Part 2 rules are applicable. Alternatives 2, 3, and 4 are expected to comply with the requirements of these rules. Part 3, Emissions Limitations and Prohibitions for Particulate Matter, establishes standards for the density of emissions and emission of particulate matter. Alternatives 2, 3, and 4 include activities which are sources of particulate matter, i.e. processing, using, storing, transporting and/or conveying bulk materials. Therefore, these rules are applicable to Alternatives 2, 3, and 4. It is expected that these alternatives will comply with the requirements of these rules. Part 7, Emission Limitations and Prohibitions for New Sources of Volatile Organic Compound Emissions provides general provisions for new sources of volatile organic compound emissions. Alternatives 2, 3, and 4 may provide VOC emissions. Therefore, these rules are applicable to these alternatives. It is expected that Alternatives 2, 3, and 4 will comply with requirements of Part 7 rules. Part 9 Emissions Limitations and Prohibitions prohibits the emission of an air contaminant or water vapor in a quantity that causes injurious effects to human health and the environment. From the risk assessment, the L.O.U. may provide an unacceptable risk to human health and the environment via the air route of exposure. Part 9 rules are applicable to the no action alternative, and this alternative does not comply with the requirements of these rules. With appropriate emissions controls, Alternatives 2, 3, and 4 are expected to comply with these rules. Part 10, Intermittent and Sampling rules give the commission the authority to require performance tests of any source of an air contaminant. Performance tests can be performed only on unit processes.

Therefore, these rules are applicable to Alternatives 2, 3, and 4 which include treatment systems. It is expected that these alternatives will comply with intermittent testing and sampling if and when the commission requires performance tests.

Primary Balancing Criteria

Long-Term Effectiveness and Permanence

The evaluation of alternatives under this criterion addresses the risk remaining at the site after response objectives have been met. The primary focus of this evaluation is the extent and effectiveness of the controls that may be required to manage the risk posed by treatment residuals and/or untreated wastes.

Alternative 1 provides no long-term effectiveness and would result in continuation of the evaluated 10^{-1} risk levels that exist at the Bofors site. Alternative 2 provides for institutional controls and permanent extraction and treatment of groundwater as a means of perpetually managing the site. The reliability of controls for this alternative for the most part depend on the successful implementation of institutional controls on the use of groundwater as a drinking water source and continuation of groundwater pumping and treatment forever. There will likely be difficulties in implementing and maintaining these institutional controls and perpetual groundwater remediation. Alternative 3 remediates the more contaminated areas of the Bofors Site. Alternative 3 requires a finite groundwater extraction and treatment period, but compromises the cleanup level attained in groundwater to 10^{-4} rather than 10^{-6} because of the use of capping. Therefore, the residual risk of Alternative 3 must be recognized as two orders of magnitude greater than Alternatives 2 and 4. Alternative 4 is the most comprehensive of the alternatives relative to long-term risks. This alternative is projected to be able to attain 10^{-6} risk levels. This alternative, like Alternative 3, minimizes long-term management because the purge well and treatment system will be turned off eventually. In addition, Alternative 4 uses a higher degree of containment (landfilling), than Alternative 3 (capping).

Reduction of Toxicity, Mobility, or Volume Through Treatment

This evaluation criterion addresses the statutory preference for selecting remedial actions that employ treatment technologies that permanently and significantly reduce toxicity, mobility, or volume of the untreated wastes. The preference is toward treatment processes which result in destruction of toxic contaminants, reduction of toxic contaminants total mass, irreversible reduction in contaminant mobility, or reduction of total volume of contaminated media.

All alternatives except Alternatives 1 and 2 provide, to varying degrees, permanent and irreversible reduction of contaminants. No significant destruction of toxic components or reduction in total volume is achievable in Alternative 2. Alternatives 3 and 4 employ both containment and treatment technologies with treatment of the principal threat.

Alternatives 3 and 4 include on-site treatment technologies (incineration and LTTD) capable of significantly and irreversibly reducing the toxicity and volume of the untreated source wastes. The landfill component of Alternative 4 provides only permanent containment, not destruction or reduction in volume. However, this containment is more protective than the capping in Alternative 3, because the landfill has a cap and a bottom liner system, providing a greater degree of containment.

Short-Term Effectiveness

This evaluation criterion addresses the effects of the alternative during the construction and implementation phases until remedial response objectives are attained. Under this criterion, alternatives are evaluated with respect to their effects on human health and the environment.

Short-term effectiveness is not applicable to Alternative 1 since there is no remediation in this alternative. Alternative 2 does not require excavation of contaminated material and therefore has a lower potential risk to the on-site workers and the nearby community. Some grading will be required that may generate some air-borne contamination that must be controlled. Alternatives 3 and 4 both require excavation of contaminated material which could generate air-borne contamination. Alternatives 3 and 4 also have the potential for air emissions from the incinerator and LTTD units. Air emissions controls will be implemented on these systems as needed and these alternatives would be subjected to community health and safety work plans for controlling fugitive dust and air emissions and potential exposures.

Considering the time required for protection and the time until the remedial action objectives are met, Alternative 2 requires perpetual groundwater extraction and treatment and is essentially a management alternative that requires the establishment of a permanent treatment facility, monitoring plan, site security, etc. In contrast, Alternatives 3 and 4 require a finite period of time for groundwater extraction and treatment. This can be more easily managed. Both Alternative 3 and 4 are expected to

require approximately the same remediation time period of 5 years (not including the time to pump and treat groundwater).

Implementability

This criterion addresses the technical and administrative feasibility of implementing an alternative and the availability of various services and materials required during its implementation.

Technically, all site alternatives are easily implemented and readily constructed of available materials. The technologies considered (which include incineration, LTTD, capping, and pumping and treatment of groundwater) are available from commercial vendors. Those alternatives which employ incineration and LTTD simultaneously present moderate site restrictions. As a result of space constraints, these processes must be separated, therefore construction will occur on opposite sides of the Bofors site, warranting careful coordination between these construction phases.

Groundwater treatment systems and long-term monitoring will be required for each remedial alternative and do not present constraints on implementation. However, approval of institutional controls placed on groundwater under Alternative 2 may be difficult to obtain, and the long-term reliability of these controls is questionable.

All remedial actions in Alternatives 2, 3, and 4 are proposed to take place on-site. Therefore, no actual permits are required; however, the substantive requirements of permits must be met. Coordination with the local community may be required to ensure the acceptability of incineration and LTTD in Alternatives 3 and 4 and the substantive requirements of the air permit will need to be met for air emissions from implementation of these two alternatives.

Cost

Capital, annual O&M, and present worth costs are summarized in Table 14. Alternative 4 is the least expensive alternative of the alternatives that provide treatment of the contaminated material. Alternative 2 is less expensive than Alternative 4 but contains no treatment of the principal threat and requires perpetual pumping and treatment of the groundwater for containment of the plume.

TABLE 14
ALTERNATIVE COST SUMMARY
Bofors Site
Muskegon, Michigan

Alternative	Alternative Descriptions	Capital Cost	O&M Cost	Total Present Worth Cost*	Risk Remaining After Remediation	Pathways Remediated
Alternative 1	No Action.	---	$27,000	$484,000	10^{-1}	None
Alternative 2	Capping, Groundwater Institutional Controls, Pump & Treat Groundwater Perpetually.	$12,091,000	$429,000	$19,890,000	10^{-6}	SW, A
Alternative 3	Capping, Incineration, LTTD, Pump and Treat Groundwater for Finite Period.	$74,416,000	$344,000	$79,912,000	10^{-4}	GW, SW, A
Alternative 4	Incineration, LTTD, Landfill, Pump and Treat Groundwater for Finite Period.	$65,752,000	$313,000	$70,874,000	10^{-6}	GW, SW, A

NOTES:

* [1] Present Worth based on perpetual pump and treat for Alternatives 2 and 4; 43 years of pump and treat for other alternatives; variable times for flushing options depending on time to effectively reduce contaminant concentrations; all present worth costs are calculated using an interest rate 5.5%. Cap and landfill options provide long-term O&M for periods equal to the pump and treat times. 43-year groundwater pump and treat period is approximate only and based on preliminary evaluations. This will be evaluated further in the Groundwater Operable Unit Feasibility Study.

[2] The present worth analysis is used to evaluate expenditures that occur over different time periods by discounting all future costs to a common base year. This allows the cost of remedial action alternatives to be compared on the basis of a single figure representing the amount of money that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial alternative over its planned life.

Alternative 1 costs represent long-term monitoring.

Costs assume sludge, berms, and soils beneath the lagoons are contaminated above 10^{-6} risk level to the water table. Soils around are assumed to be contaminated above 10^{-6} risk level only in the top 5 feet.

GW: Groun ter.

SW: Surface water.

A Air

Modifying Criteria

State Acceptance

The State of Michigan has indicated it's acceptance of Alternative 4 for remediation of the L.O.U. at the Bofors site and a letter of concurrence is forthcoming.

Community Acceptance

There were several comments received from the community during the public comment period. In summary, two who commented perceive that there is a high level of cancer mortality in the area and that more needs to be done to protect the community. The third expressed that money could be spent on "better priorities" than expanding wastewater facilities, and suggested the use of bacteria to "eat up" contaminants. Several commenters expressed objections to the use of incineration. However, U.S. EPA is confident that the remedy will be protective of human health and the environment. The complete comments are addressed in the attached Responsiveness Summary.

THE SELECTED REMEDY

Based upon consideration of the requirements of CERCLA, the detailed analysis of the alternatives, and public comments, both U.S. EPA and the State have determined that Alternative 4: Excavation, On-site Incineration/Low-Temperature Thermal Desorption, On-site Disposal, and Pumping and Treatment of Groundwater is the most appropriate remedy for the Bofors site in Muskegon, Michigan.

Approximately 100,800 cubic yards (yd^3) of most-contaminated sludge will be excavated from the lagoon area. The organic compounds in the sludge will be treated using incineration and low-temperature thermal desorption technologies. Approximately 64 percent of the organic compounds will be removed by this treatment process. The treated sludges will be landfilled in an RCRA landfill. It is estimated that 73,100 yd^3 of treated ash will be landfilled. Approximately 334,700 yd^3 of less-contaminated sludges and soils will also be excavated and placed in the RCRA landfill. This landfill will occupy approximately 8 acres in the lagoon area.

Remediation Goals

The purpose of this response action is to control risks posed by migration of organic compounds to groundwater and surface water and through air. Existing conditions at the site have been determined to pose an excess lifetime cancer risk of 10^{-1} from ingestion of contaminated groundwater. This risk relates to the organic compound concentrations (primarily benzidine and DCB) in

TABLE 15

COST SUMMARY FOR THE SELECTED REMEDY

CAPTIAL COSTS:	Cost
Site Work	
1. Site Preparation	$ 2,090,400
2. Soil Excavation	$ 4,731,000
3. Materials Transport	$ 2,752,400
4. Materials Processing/Size Reduction	$ 555,400
5. Site Monitoring	$ 7,241,000
Treatment Component	
1. On-site Incineration	$15,035,100
2. On-site LTTD	$11,347,000
3. Pumping and Treatment Systems	$ 1,218,200
Containment Component	
1. On-site Secure Landfill	$ 6,387,600
2. Indirect Capital Costs	$14,383,200
Subtotal	$65,752,000
OPERATION AND MAINTENANCE COST:	
1. Landfill O&M	
Leachate Pump & Treat: combined with groundwater pump & treat; 1.2 million gallons per year	$ 5,000/yr
Maintenance of Cap and Leachate System	$ 22,000/yr
Utilities	$ 10,000/yr
Environmental Monitoring	$ 10,000/yr
Subtotal	$ 47,000/yr
2. Pump and Treat O&M	$266,000/yr
Subtotal	$313,000/yr

Note: Detail cost breakdowns are in Appendix F of the Feasibility Study.

RP/BFRSROD/AA1

the sludges. Since no Federal or State chemical-specific ARARs exist for sludge and soil that specify concentrations, the action level for the organic compounds in sludge and soil was determined through a site-specific analysis. This analysis used fate and transport modeling to determine levels to which organic compounds in sludges and soils should be reduced in order to ensure no migration of contaminants to the primary pathways of groundwater, surface water, or air above 10^{-6} levels.
The excavated contaminated sludges and berms will be treated using incineration and low-temperature thermal desorption which will remove approximately 64 percent of the organic compounds from the sludge and berms. The ash from treated sludge and berms will be excavated and landfilled in a on-site landfill that will meet the intent of RCRA subtitle C requirements, along with the less contaminated soils beneath and around the sludge.

A breakdown of capital, annual O&M, and present-worth costs for the selected remedy are presented in Table 15.

THE STATUTORY DETERMINATIONS

Under its legal authorities, U.S. EPA's primary responsibility at Superfund sites is to undertake remedial actions that achieve adequate protection of human health and the environment. In addition, section 121 of CERCLA establishes several other statutory requirements and preferences. These specify that when complete, the selected remedial action for this site must comply with applicable or relevant and appropriate environmental standards established under Federal and State environmental laws unless a statutory waiver is justified. The selected remedy also must be cost-effective and utilize permanent solutions and alternative treatment technologies or resource recovery technologies to the maximum extent practicable. Finally, the statute includes a preference for remedies that employ treatment that permanently and significantly reduce the volume, toxicity, or mobility of hazardous wastes as their principal element. The following sections discuss how the selected remedy meets these statutory requirements.

Protection of Human Health and the Environment

The selected remedy protects human health and the environment through treatment and landfilling of organic compound contaminated sludge, and landfilling the soils in the lagoon area. The landfill will be constructed to meet the intent of RCRA Subtitle C landfill requirements to reduce the likelihood of contaminant migration.

Treatment of the most contaminated sludge also will reduce the risks to less than 1×10^{-6}. This level is within the range of acceptable exposure levels of between 10^{-4} and 10^{-6}. By land-

filling the contaminated soils, the risks of ingestion of groundwater contaminated from the soils will be further reduced. There may be short-term threats associated with the selected remedy during excavation; however, these can be controlled. No adverse cross-media impacts are expected from the remedy.

Compliance with ARARs

The selected remedy of excavation, on-site thermal treatment, and landfilling will comply with all chemical-, action-, and location-specific ARARs. The ARARs are presented below.

Action-Specific ARARs:

Clean Water Act (CWA) of 1977, as amended [33 U.C.S. 1251]

40CRF122 + 40CRF125 - The National Pollutant Discharge Elimination System (NPDES), which specifies the scope and details of the NPDES permit applications, including limitations, standards, and other permit conditions which are applicable to all permits including specified categories of NPDES permits. Also specifies schedules of compliance and requirements for recording and reporting monitoring results.

Act 348 of the Public Acts of 1965, as amended: Air Pollution Act

Part 2 - Air Use Approval, which specifies information required for a permit to install, construct, reconstruct, relocate, or alter any process, fuel burning or refuse burning equipment, or control equipment which may be a source of an air contaminant.

Chemical-Specific ARARs:

Clean Water Act (CWA) of 1977, as amended [33 U.C.S. 1251]

40CFR129 - Toxic Pollutant Effluent Standards, which establishes toxic pollutant effluent standards and prohibitions of specific compounds for specified facilities discharging into navigable waters. 40CFR129.104 sets the ambient water criterion for benzidine in navigable water as 0.1 ug/l.

Public Health Service Act: Title XIV, as amended by the Safe Drinking Water Act [42 U.S.C. 300(f)] (Potential ARARs)

40CFR141 - National Primary Drinking Water Regulations, which specify maximum chemical contaminant levels (MCLs) of public water systems for inorganic and organic chemicals, maximum contaminant level goals (MCLGs) of public water systems for organic chemicals, and establishes national revised primary drinking water regulations of MCLs for organic chemicals.

Clean Air Act of 1963, as amended [42 U.S.C. 7401]

40CFR50 - National Primary and Secondary Ambient Air Quality Standards, which establish national primary and secondary

ambient air quality standards. The appendices provide methods and procedures for measuring specific air pollutants.

40CFR60 - Standards of Performance for New Stationary Sources, which indicate applicability, sets particulate matter effluent standards, specifies monitoring requirements, and outlines test methods and procedures for incinerators.

40CFR61 - National Emission Standards for Hazardous Air Pollutants, which identifies substances that have been designated hazardous air pollutants, and for which a Federal Register notice has been published, and specifies prohibited activities, describes procedures for determining whether construction or modification is involved, prescribes methods of applying for approval, and covers manner in which start-up notification is to be provided.

Act 245 of the Public Acts of 1929, as amended: Water Resources Commission Act

Part 4, Rule 57 - Water Quality Standards (Surface Water Quality Standards), which establishes limits for all waters of the State for the following components: dissolved solids, pH, taste and odor producing substances, toxic substances, total phosphorous and other nutrients, and dissolved oxygen.

Act 348 of the Public Acts of 1965, as amended: Air Pollution Act

Part 3 - Emission Limitations and Prohibitions - Particulate Matter, which establishes standards for the density of emissions and emission of particulate matter.

Act 307, Michigan Environmental Remediation Act, sets requirements for remediation of hazardous waste sites in Michigan. There are three types of remediation specified by this act; Type A, B, and C.

<u>Location-Specific ARARs</u>:

Clean Water Act (CWA) of 1977, as amended [33 U.C.S. 1251]

33CFR322 - Permits for Structures or Work in or Affecting Navigable Waters of the United States, which provide procedures for the C.O.E. for reviewing permits to authorize structures or work affecting navigable water, including wetland areas.

Floodplain Management, and 11990, Protection of Wetlands [42 U.S.C. 7401]

40CFR6 - Procedures for Implementing Requirements of the Council on Environmental Quality on the National Environmental Policy Act, which provide policies and procedures for floodplain management and wetland protection.

Act 203 of the Public Acts of 1979: The Goemaere-Anderson Wetland Protection Act - These rules apply to activities that result in discharge to the wetland area that drains to the Big Black Creek. These rules include permitting requirements, wetland determination, and mitigation.

Act 347 of the Public Acts of 1972: Soil Erosion and Sedimentation Control Act

Part 17 - Soil Erosion and Sedimentation Control - Establishes general soil erosion and sedimentation control procedures and measures. Also, specifies earth change requirements and soil conservation district standards and specifications.

Other Criteria, Advisories or Guidance to be Considered (TBCs):

None.

Cost-Effectiveness

The selected remedy is cost-effective because it has been determined to provide overall effectiveness proportional to its costs, the net present worth value being $70,000,000. The estimated costs of the selected remedy are within an order of magnitude of the costs associated with treatment of sludge and on-site capping of the contaminated soils, and yet the selected remedy assures a lower residual risk after remediation is complete and higher degree of certainty that the remedy will be effective in the long-term since more complete containment (landfilling) is used.

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

U.S. EPA and the State of Michigan have determined that the selected remedy represents the maximum extent to which permanent solutions and treatment technologies can be utilized in a cost-effective manner for the lagoon area operable unit at the Bofors site. Of those alternatives that are protective of human healtl

and the environment and comply with ARARs, U.S. EPA and the State have determined that this selected remedy provides the best balance of tradeoffs in terms of long-term effectiveness and permanence, reduction in toxicity, mobility, or volume achieved through treatment, short-term effectiveness, implementability, cost, also considering the statutory preference for treatment as a principal element and considering State and community acceptance.

The selected remedy offers a high degree of long-term effectiveness and permanence since incineration is being used.

The selected remedy treats the principal threats posed by the sludges, achieving significant organic compound reductions (60 percent). The implementability of the selected remedy is comparable to the nontreatment alternatives. The selected remedy is also the least costly of the two alternatives.

The selection of treatment of the contaminated sludges is consistent with program expectations that indicate that highly toxic and mobile waste are a priority for treatment and often necessary to ensure the long-term effectiveness of a remedy. Since the selected remedy has the most complete containment, this remedy is anticipated to have the best long-term effectiveness and permanence and is therefore determined to be the most appropriate solution for the contaminated sludges and soils at the Bofors site.

Preference for Treatment as a Principal Element

By treating the contaminated sludges in a thermal destruction unit and landfilling the ash and contaminated soils, the selected remedy addresses one of the principal threats posed by the site through the use of treatment technologies. Therefore, the statutory preference for remedies that employ treatment as a principal element is satisfied.

RESPONSIVENESS SUMMARY

The Remedial Investigation/Feasibility Study (RI/FS) and the Proposed Plan for the Bofors-Nobel site were made available to the public in July, 1990. The notice of availability for these two documents was published in the Muskegon Press on July 23, 1990. A public comment period was held from July 23 through August 23 and a public meeting was held on August 1, 1990. At this meeting, representatives from U.S.EPA and the Michigan Department of Natural Resources (MDNR) answered questions about problems at the site and the remedial alternatives under consideration. Three comments were submitted at the public meeting and several comments were received in the mail prior to August 23, 1990, the last day of the public comment period. Following are all the comments received and U.S. EPA's response to each comment.

Comment
The first comment related to contamination in the air from the chemical company and the fact that several people in the community have died of cancer.

Response
There are several chemical companies and several Superfund sites in the area and the Michigan Department of Public Health is pursuing this issue.

Comment
The second commentor felt the proposed alternative is not protective enough, particularly concerning air exposure during remediation. She indicated more should be done.

Response
U.S. EPA is very sensitive to the concerns of the public and believes the selected remedy is the most protective and will alleviate any air emissions from the lagoon site as part of the remedy. Because of the highly toxic nature of the material on site, the alternative uses incineration to destroy the most hazardous waste. State of the Art technology will be used to eliminate hazardous air emissions. Extensive air monitoring will be performed to ensure control of air emissions during construction.

Comment
The third commenter questioned if bacteria could be used to eat up the contamination and suggested bioremediation was not selected due to costs.

Response
In fact, biological treatment methods were considered and screened out early because they will not work efficiently and are not cost effective. 3,3'-Dichlorobenzidine (DCB), which is one of the major contaminants at the site, is present at the site in a crystalline form. DCB requires the transfer from a crystalline form into an aqueous matrix which would require a soil washing pretreatment step. Soil washing treatability studies have indicated that this technology cannot adequately remove DCB from soil. In addition, heavy metals such as zinc, chromium, and lead which are present at the site, can be toxic to the microorganisms and additional treatment would probably be needed for metal contamination. In both cases the concentrations of contaminants are very high and the waste would be very difficult to bioremediate.

Comment
Several commentors objected to incineration based on information provided by the West Michigan Region Environmental network concerning uncertainties, hazards and health risks associated with incineration.

Response
As previously mentioned, U.S. EPA is very sensitive to the concerns of the community. The agency believes the selected remedy provides the best protection the U.S. EPA can provide. Contrary to the information the citizens were given, incineration will destroy the hazardous compounds and the incinerator will be operated in such way to insure total destruction. Extensive testing prior to start-up including treatability studies and trial burns will be performed to determine the correct operating procedures for the incinerator. This extensive testing is designed to overcome the uncertainties involved in treatment of hazardous waste. Extensive monitoring including air emissions and other operating parameters will be performed to evaluate incinerator performance and corrections will be made as necessary.

Comment
Several commentors expressed concern over the fact the groundwater will not be addressed until much later.

Response
In fact, the contaminated groundwater is currently being controlled by a pump and treat system which will be upgraded during this remedy. In addition, the groundwater Remedial Investigation/Feasibility Study (RI/FS) is currently underway.

Comment
A few citizens were concerned that the pollutants will drift into populated areas, especially the Carr Elementary School.

Response
The response to the comment regarding objection to incineration applies to this comment.

Comment
One commentor stated that all landfills leak and does not want the material landfilled on site. This commentor suggested we excavate and transport the hazardous material to an offsite (emphasis added) landfill.

Response
Because it is known that landfills may leak, the U.S. EPA has selected technology that provides the most protective type of landfill. The landfill design that will be used in this remedy will consist of a double lined containment system with a leachate collection system between the two liners to prevent migration of any leachate that might be generated. In addition the landfill cap will be constructed to prevent infiltration of any precipitation so that leachate generation is minimized. Furthermore, there will be a detection system below the bottom liner to provide backup monitoring for the system. In addition, the majority of contamination will be destroyed through the incinerator and the less contaminated material will be landfilled.

The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) states in section 121(b)(1) that remedial actions in which treatment which permanently and significantly reduces the volume, toxicity or mobility of the hazardous substances, pollutants, and contaminants, are to be preferred over remedial actions not involving such treatment. The offsite transport and disposal of hazardous substances or contaminated materials without such treatment should be the least favored alternative remedial action where practicable treatment technologies are available. U.S. EPA does not recommend offsite landfilling of the hazardous material because it would not comply with the law as incineration is a proven technology.

Comment
One person indicated it is a disgrace that the Responsible Parties wriggle out of cleaning up the site.

Response
It has not been established that liable parties exist for this site. U.S. EPA will continue to explore the possibility of naming potentially Responsible Parties in the future.

Comment
Several commentors requested an extension on the second to the last day of the comment period.

Response
The National Contingency Plan (NCP) allows for a 30 day extension to a public comment period if requested in a timely manner. The NCP defines a "timely" request as generally being within 2 weeks after the initiation of the public comment period. U.S. EPA does not believe a delay in this project will benefit the community. The protection of public health and the environment will better be served by moving ahead with the design and clean-up of this site.