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# REM III PROGRAM

## REMEDIAL PLANNING ACTIVITIES AT SELECTED UNCONTROLLED HAZARDOUS SUBSTANCE DISPOSAL SITES

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EPA CONTRACT 68-01-7250

EBASCO SERVICES INCORPORATED

EPA WORK ASSIGNMENT NUMBER: 37-2LB8
EPA CONTRACT NUMBER: 68-01-7250
EBASCO SERVICES INCORPORATED

# VINELAND CHEMICAL COMPANY SITE
# FINAL DRAFT
# FEASIBILITY STUDY REPORT
# RIVER AREAS
# VINELAND, NEW JERSEY

JUNE 1989

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Mr. M. Shaheer Alvi, PE
Dr. Ferdinand Cataneo, PhD, PE

SUBJECT: FINAL DRAFT FEASIBILITY STUDY REPORT
VINELAND CHEMICAL COMPANY SITE
RIVER AREAS
EPA WORK ASSIGNMENT NUMBER: 37-2LB8
EPA CONTRACT NUMBER: 68-01-7250

ACKNOWLEDGEMENT OF RECEIPT

Please acknowledge receipt of the Final Draft Feasibility Study Report by signing and returning the duplicate copy of this letter to the sender at the above address.

_____ _____
Signature Date

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EPA WORK ASSIGNMENT NUMBER: 37-2LB8
EPA CONTRACT NUMBER: 68-01-7250
EBASCO SERVICES INCORPORATED

# VINELAND CHEMICAL COMPANY SITE
# FINAL DRAFT
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# RIVER AREAS
# VINELAND, NEW JERSEY

JUNE 1989


Prepared by:

Raymond Nowak
Site Manager
Ebasco Services Incorporated

Approved by:

Dev R. Sachdev, PhD, PE
Regional Manager-Region II
Ebasco Services Incorporated


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## LIST OF ACRONYMS

| | |
|---|---|
| ACGIH | American Conference of Governmental Industrial Hygienists |
| AIC | Acceptable Chronic Intake |
| ARARs | Applicable or Relevant and Appropriate Requirements |
| ASC | Acceptable Soil Concentration |
| ASTM | American Society of Testing and Materials |
| AWQC | Ambient Water Quality Criteria |
| BEHP | bis(2-ethylhexyl)phthalate |
| BNA | Base-Neutral/Acid Extractables |
| °C | Degrees Centigrade |
| CDI | Chronic Daily Intake |
| CDL | Contract Detection Limit |
| CERCLA | Comprehensive Environmental Response, Compensation, and Liability Act of 1980 |
| CLP | Contract Laboratory Program |
| CRAVE | Carcinogen Risk Assessment Verification Endeavor |
| DMAA | Dimethyl Arsenic Acid |
| DQO | Data Quality Objectives |
| ECRA | New Jersey Environmental Cleanup Responsibility Act |
| EDTA | Ethylenediaminetetra-acetate |
| EM | Electro Magnetic Conductivity Survey |
| EP | Extraction Procedure |
| EPIC | Environmental Photographic Information Center |
| ER | Ebasco River Sampling Station |
| EW | Ebasco Well |
| FS | Feasibility Study |
| GPD | Gallons Per Day |
| GPM | Gallons Per Minute |
| HEA | Health Effects Assessment |
| HSL | Hazardous Substances List |
| IDL | Instrument Detection Limit |
| IRIS | Integrated Risk Information System |
| Kd | Partitioning Coefficient |
| LL | Lined Lagoon |
| MCLGs | Maximum Contaminant Level Goals |
| MCLs | Maximum Contaminant Levels |
| MEP | Multiple Extraction Procedure |
| MG/KG | Milligrams Per Kilogram |
| MG/L | Milligrams Per Liter |
| MMAA | Monomethyl Arsenic Acid |
| MSL | Mean Sea Level |
| MW | Monitoring Well |
| NCDC | National Climatic Data Center |
| NCP | National Contingency Plan |
| NJAC | New Jersey Administrative Code |
| NJDEP | New Jersey Department of Environmental Protection |
| NJPDES | New Jersey Pollution Discharge Elimination System |
| NOAA | National Oceanic and Atmospheric Administration |
| ODW | Office of Drinking Water |
| OHEA | Office of Health and Environmental Affairs |
| OSHA | Occupational Safety and Health Administration |

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## LIST OF ACRONYMS (Cont'd)

| | |
|---|---|
| PCBs | Polychlorinated biphenyls |
| PMSA | Primary Metropolitan Statistical Area |
| PPB | Parts Per Billion |
| PPM | Parts Per Million |
| PSI | Pounds Per Square Inch |
| PVC | Polyvinyl Chloride |
| RCRA | Resource Conservation and Recovery Act |
| RI | Remedial Investigation |
| RI/FS | Remedial Investigation/Feasibility Study |
| RMCL | Recommended Maximum Contaminant Level |
| RfD | Reference Dose |
| SAS | Special Analytical Services |
| SNARL | Suggested-No-Adverse Response Level |
| SPDES | State Pollution Discharge Elimination System |
| SU | Standard Units |
| TCE | Trichloroethylene |
| TCL | Target Compound List |
| TOC | Top of Casing |
| TOC | Total Organic Carbon |
| UCS | Unconfined Compressive Strength |
| UG/L | Micrograms Per Liter |
| UL | Unlined Lagoon |
| USDA | United States Department of Agriculture |
| USEPA | United States Environmental Protection Agency |
| USGS | United States Geological Survey |
| UV | Ultraviolet |
| VES | Vertical Electrical Soundings |
| ViChem | Vineland Chemical Company |

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# EXECUTIVE SUMMARY

The River Areas Feasibility Study (FS) is one of three FS reports being prepared for the Vineland Chemical Company (ViChem) work assignment. The FSs include:

- The ViChem plant site proper;
- The River Areas, consisting of the Blackwater Branch (the receiving stream from the ViChem plant) and the Maurice River from its confluence with the Blackwater Branch to Union Lake; and
- Union Lake, an 870-acre impoundment on the Maurice River.

Three Remedial Investigation (RI) reports are being prepared as follows:

- The ViChem plant site proper;
- The River Areas, consisting of the Blackwater Branch, the Maurice River from its confluence with the Blackwater Branch to Union Lake, and the Maurice River below Union Lake to the Delaware Bay; and
- Union Lake.

The purpose of the River Areas FS was to develop, screen, and evaluate potential remedial alternatives to address sediment contamination found to cause increased health risks or environmental impacts. This report was prepared in accordance with the USEPA's March 1988 Draft Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA.

The ViChem site is ranked among the top ten hazardous waste sites in New Jersey and is ranked number 42 on the National Priorities List. ViChem has manufactured organic arsenic herbicides and fungicides at this plant since 1949. The 54-acre facility is located in the northwest corner of the city of Vineland in Cumberland County, New Jersey. The plant is situated in a partly residential and partly industrial area.

Detailed information is not available on the past use, storage, and disposal of all process materials at the plant. It is known, however, that waste salts containing arsenic were piled outdoors, and that precipitation contacting the piles flushed arsenic into the groundwater. Also, the plant previously discharged untreated process water into lagoons, and the water was allowed to percolate into the groundwater. The contaminated



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groundwater subsequently discharged into the Blackwater Branch and was distributed downstream in the Maurice River drainage system.

Previous investigations have shown elevated arsenic concentrations in surface waters and sediments as far as 26.5 river miles downstream from the plant in the Maurice River. It was suspected that a serious groundwater contamination problem existed at the plant.

In the River Areas RI it was determined that arsenic was the main contaminant of concern. Contamination was detected as follows:

- Arsenic concentrations in the surface water and sediments in the Blackwater Branch upstream of the ViChem plant and in the Maurice River upstream of its confluence with the Blackwater Branch were very low to undetected. Downstream from the plant, the arsenic concentrations in both media were elevated. The highest arsenic concentrations were observed in the Blackwater Branch adjacent to the plant; over 6,000 ug/l in the water and over 6,000 mg/kg in the sediment.

- A total of approximately 21,800 cubic yards of sediments under water in the Blackwater Branch downstream of the North Mill Road Bridge and in the upper Maurice River between the Blackwater Branch and Union Lake were contaminated with arsenic above the action levels of 20 mg/kg for areas of high accessibility and 120 mg/kg for areas of low accessibility established for this FS.

- A total of approximately 56,200 cubic yards of former sediments that are now exposed in the Blackwater Branch floodplain were also contaminated with arsenic above the 20 mg/kg action level established for these exposed sediments. These sediments had been under water previously in a swamp caused by a beaver dam at the North Mill Road Bridge. The beaver dam was removed in 1987. These sediments are now exposed.

- Arsenic in sediments positively correlated with increased organic content and increased fine size fraction content. Arsenic was not evenly distributed areally within the sediments. Its occurrence was probably more a function of organics and fine size fractions in the sediments than a function of distance from the source. Core results suggested that the sediments were probably subjected to mixing and redeposition.

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Since the River Areas are part of a dynamic system, the fate and transport of arsenic within the watershed as a whole was pertinent to this FS. Findings from the RI reports that relate to this FS are as follows:

- In the Plant Site RI, it was shown that groundwater discharge from the plant site was the main source of arsenic in the watershed. An estimated 6 metric tons of arsenic per year were being discharged into the Blackwater Branch from the plant site in 1987. The previous rate of release was probably much higher. The groundwater discharge flows into the Blackwater Branch; it does not flow beneath it.

- Union Lake has been a primary receptor of the arsenic released from the site. Of the estimated 500 metric tons of arsenic released over time, an estimated 140 metric tons are now bound to Union Lake's sediments. An estimated 6 metric tons are bound to the sediments in the Blackwater Branch and the upper Maurice River. The remainder is either bound to sediments in the lower Maurice River below Union Lake or has been transported to the Delaware Bay.

- The Blackwater Branch and the upper Maurice River above Union Lake basically behave as conduits for arsenic transport. That is, they presently transport arsenic released from the site into Union Lake. Because of this, it was estimated that if the source of arsenic were eliminated (e.g., if a groundwater remediation program were initiated at the ViChem site to prohibit contaminated groundwater from entering the Blackwater Branch), then the river water arsenic concentration should drop relatively quickly.

- It could not be determined what controls the arsenic concentrations in Union Lake's water. On one hand, the arsenic concentrations within the lake, entering, and leaving the lake were approximately the same. On the other hand, the lake's water and sediment were apparently at equilibrium, based on the mean arsenic concentration in the water and sediments, and the partition coefficient. Therefore, it could not be determined if the controlling mechanism for the lake water's arsenic concentration is the incoming water or desorption from the sediments. The significance of this is that it cannot be definitely stated that if the source of arsenic into the basin were eliminated, the lake's arsenic concentration would also be subsequently reduced. Almost certainly it would be reduced, but how quickly and by how much cannot be predicted.

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Based on the risk assessment in the River Areas RI, it was determined that the total risks from exposure to sediments and water, and from ingesting fish, were above the target risk of $1 \times 10^{-5}$. The fish ingestion risks were tenuously based on total arsenic concentrations. As discussed in the RI, the form of arsenic in the fish was not determined. Evidence suggests that 85% of the total arsenic may be in a water soluble organic form that is relatively nontoxic. This implies that risks calculated using total arsenic concentrations were probably too conservative.

A remedial action objective was established to address the contamination in the rivers. Since the river water contamination can be reduced by eliminating the source of groundwater entering the Blackwater Branch, and since this was one of the focuses of the Plant Site FS, remedial objectives for the river water were not considered. Also, since there was some question regarding the actual fish ingestion risks, remedial objectives for this problem were also not considered, pending guidance from the USEPA. Therefore, a remedial action objective was established only for the contaminated sediments, as follows:

- Minimize public access, either through containment, treatment, or institutional controls, to areas with unacceptably high sediment arsenic concentrations, particularly the exposed former sediments in the Blackwater Branch floodplain.

Remediating the sediment contamination was the focus of the FS.

The USEPA, in conference with the NJDEP, determined that the sediment target cleanup level should be 120 mg/kg arsenic in the submerged sediment, and 20 mg/kg of arsenic in the exposed sediments in the Blackwater Branch. A cleanup level of 120 mg/kg is acceptable for the submerged sediments. However, in order to provide an extra measure of protection of human health, a cleanup level of 20 mg/kg was established for the submerged sediments in the more accessible areas of the river including Almond Road Beach and the areas within 100 feet of either side of a river crossing. An action level of 20 mg/kg in the more accessible river areas corresponds to a risk of $2 \times 10^{-6}$, or two incidents of cancer per one million people exposed to the sediments. These are the sediment cleanup levels that USEPA directed be used for this FS.

Several interpretations of the site conditions by USEPA Headquarters Site Policy and Guidance Branch personnel affected this FS:

1) River sediments contaminated with arsenic are themselves the listed hazardous waste K 031. This is based on the belief that the river sediments were contaminated with



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arsenic from the listed hazardous waste K 031 produced on the ViChem site. If excavated, these sediments have to be treated and delisted prior to disposal as non-hazardous materials.

2) If disposal is off-site, delisting would involve a petition to the NJDEP. A substantive portion of this petition requires the treated sediments to have an arsenic concentration of less than 0.32 mg/l in the extract from an EP Toxicity Test. This concentration is stipulated by the VHS model, which is a substantive delisting tool.

3) If the treated sediments are disposed of on-site, a delisting petition to the NJDEP would not be required. The USEPA's Region II Regional Administrator could decide that nonhazardous disposal is appropriate on the basis of the treated sediments meeting the substantive delisting requirement, which in this case is the 0.32 mg/l arsenic level in an EP Toxicity extract from the treated sediments.

4) If the treated sediments cannot pass the EP Toxicity Test criterion of 0.32 mg/l arsenic, but have an EP Toxicity Test concentration of 1 mg/l arsenic or less, they cannot be disposed of as nonhazardous material, but could be disposed of as hazardous material in a RCRA Subtitle C landfill. The 1 mg/l criteria was termed a "treatability variance" for the sediment.

5) If the treated sediments do not pass the EP Toxicity Test criterion of 1 mg/l arsenic, they cannot be disposed of at all in any type of landfill facility (the "land ban"). A different treatment technology or remedial technology would have to be selected.

6) The river areas are considered part of the site, since they are within the "area of contamination" from the site. The areas adjacent to the rivers are not considered part of the site. This means that an "on-site" landfill cannot be constructed adjacent to the river areas, but must be located on the ViChem plant property.

Two bench-scale treatability tests, chemical fixation and chemical extraction, were performed. Based on the treatability studies, other information gathered in the RI, and information from vendors, it was expected that fixation could chemically stabilize or physically bind the arsenic to the sediments so that leachable arsenic concentrations would be less than 0.32 mg/l. The fixated product would have an unconfined compressive strength of 1,500 pounds per square foot. By meeting these criteria, the fixated product would be expected to meet

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substantive delisting requirements and could be disposed of as nonhazardous material. The extraction treatability test results showed that the resultant treated sand from a one-stage water wash contained 34 mg/kg arsenic, compared with an initial sediment concentration of 2,780 mg/kg. It is expected that a two-stage water wash would further reduce the arsenic concentration to below the more stringent action level of 20 mg/kg. Based on the results of EP Toxicity Tests conducted on untreated sediments and other information gathered in the RI, it is expected that the extracted sediments would have leachable arsenic concentrations below 0.32 mg/l. Thus they could be delisted and disposed of as nonhazardous material. The water used for the extraction process could be treated to meet MCLs and discharged back to the river. The sludge generated from the extraction process would be transported off-site to a licensed RCRA treatment and disposal facility. Since both treatment technologies were successful in the tests, both fixation and extraction were considered in the FS.

A number of general response actions and technologies were considered to achieve the remedial action objective. The general response actions included no action, containment, treatment and removal.

Technologies to meet the general response actions were identified. Activities involved with the no action response included monitoring, restricted use and public awareness. Containment technologies included capping the sediments with sand, clay and manmade liners. Removal and treatment technologies included dredging sediments under water, excavating floodplain sediments, extracting and fixating the removed sediments. In situ treatment methods were also identified.

These technologies were screened to eliminate technologies that are unproven, those that would not meet the remedial response objective, and those that would be difficult to implement due to the nature of the site and/or the nature of the contaminants.

The technologies that passed this screening were then combined to form overall remedial action alternatives in accordance with the NCP Section 300.68(f). The remedial alternatives developed to address contamination were:

<u>SOURCE CONTROL</u>

- Alternative 1: No Action
- Alternative 2A: Dredging/Excavation/Thickening/Fixation/ Off-Site Nonhazardous Landfill
- Alternative 2B: Dredging/Excavation/Thickening/Fixation/ On-Site Nonhazardous Landfill

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- Alternative 2C: Dredging/Excavation/Thickening/Fixation/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments
- Alternative 3A: Dredging/Excavation/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
- Alternative 3B: Dredging/Excavation/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal
- Alternative 3C: Dredging/Excavation/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/Off-Site Hazardous Sludge Disposal
- Alternative 4A: Dredging/Extraction/Dewatering/Off-Site RCRA Landfill
- Alternative 4B: Dredging/Excavation/Dewatering/On-Site RCRA Landfill

Dredging the sediments under water and excavating the exposed sediments in the Blackwater Branch floodplain were common to all of the alternatives except for Alternative 1, No Action.

Alternatives 2A, 2B, 2C, 3A, 3B, and 3C differed from one another in the type of sediment treatment (fixation or extraction) and in the location for disposal of the treated sediments (off-site in an existing nonhazardous landfill; on-site in a newly constructed nonhazardous landfill built for the treated sediments only; or deposited in the Blackwater Branch floodplain and on the Plant site). Alternatives 4A and 4B differed from the others in that the removed sediments would not be treated and would be disposed of in an existing off-site RCRA landfill or in a newly constructed on-site RCRA landfill.

An initial screening of these alternatives was performed based on three criteria: effectiveness, implementability and cost. The alternatives were screened against these criteria, and were compared one against another to find the most promising alternatives to take into detailed evaluation.

Factors considered to determine an alternative's effectiveness were protection of the public health and the environment, and reduction of the mobility, toxicity or the volume of the contamination. Factors considered to determine an alternative's implementability included overall feasibility of implementation, established or estimated reliability, and availability. Cost screening at this initial stage was performed on an order-of-

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magnitude basis; only those alternatives that exceeded the others' costs by an order of magnitude were eliminated on the basis of cost.

Alternative 1, No Action, was retained for evaluation because it would serve as the base case against which the other alternatives would be compared. Alternatives 2A, 2B, 3A, 3B, and 3C, which all met the remedial response objectives, were considered implementable, and did not vary by an order of magnitude in costs. These were all retained for further detailed evaluation. Alternative 2C was eliminated due to potential adverse impacts associated with depositing fixated materials in the sensitive floodplain ecosystem. Alternatives 4A and 4B were eliminated from further evaluation because they would not meet forthcoming land disposal restrictions and would not provide a permanent remedy.

The alternatives that passed the initial screening were then further evaluated in detail with respect to the nine criteria stipulated in CERCLA as amended, OSWER Directive No. 93SS.0-19 and the statutory factors described in OSWER Directive No. 93SS-21. The nine criteria are: short-term effectiveness; long-term effectiveness; reduction of toxicity, mobility, or volume of contamination; implementability; cost; compliance with ARARs; overall protection of human health and the environment; state acceptance; and community acceptance. A summary of the detailed evaluation of the alternatives that passed the initial screening is discussed below.

Alternative 1, No Action, would provide the baseline against which the other responses could be compared. There would be no substantial remediation activities involved; therefore, there would be no reduction in potential environmental contamination. Public access to the rivers would be reduced by sign posting and educational programs. This would not meet the statutory requirements of reducing the toxicity, mobility, or volume of contaminants. This alternative is easy to implement, but would not satisfy ARARs.

Alternative 2A would entail excavating the exposed contaminated sediments in the Blackwater Branch floodplain, dredging the submerged contaminated sediments in the Upper Maurice River and the Blackwater Branch, and treating them via fixation. After delisting by the NJDEP, the treated product would be disposed of in an off-site nonhazardous landfill. Clean fill would be placed in the excavated areas of the floodplain to restore it to its original condition. This alternative would permanently reduce negative health and environmental impacts in the rivers. It would reduce the toxicity, mobility, and volume of contaminants in the river. It would reduce the mobility and volume of contaminants overall, but not their toxicity. Fixation would bind the arsenic; it would not change its form. Long-term



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post-implementation management would be required. Possible environmental impacts include disturbing floodplain and/or wetlands areas during construction, and impacts from truck traffic.

Alternative 2B is the same as Alternative 2A, except that the treated sediments would be disposed of in a nonhazardous landfill built specifically for this purpose. The landfill would be constructed at the ViChem plant site. A delisting petition would not be required since the landfill is on site. The USEPA's Region II Regional Administrator could decide that the treated sediments met the substantive delisting requirements (0.32 mg/l arsenic in an EP Toxicity Test extract) and thus could be disposed of as nonhazardous material. The same effective changes in toxicity, mobility, and volume would be realized as with Alternative 2A, and the same permanent remediation in the rivers would be achieved with the same potential excavation impacts. However, this alternative would require long-term maintenance and monitoring to ensure that the landfill does not leach contaminants.

Alternative 3A entails the same excavation and dredging activities as Alternatives 2A and 2B. Instead of being fixated, the arsenic would be extracted from the sediments. The extracted sediments would be delisted via a petition to the NJDEP and be disposed of in an off-site nonhazardous landfill. The extractant would be treated with a fairly simple system to remove arsenic prior to its discharge into the rivers. The sludge containing the extracted arsenic would be disposed of off-site by a licensed vendor. This alternative would reduce the toxicity, mobility, and volume of contaminants in the river. This alternative would achieve a permanent solution and would require no long-term maintenance since the landfill would be off-site.

Alternative 3B is the same as Alternative 3A except that the extracted sediments would be disposed of in an on-site nonhazardous landfill. The landfill would be located at the ViChem Plant site. A delisting petition to NJDEP would not be required. The USEPA's Region II Regional Administrator could decide that the treated sediments met the delisting requirements. Administrative approvals and land acquisition would be required. This alternative would achieve the same effective reduction of toxicity, mobility, and volume of contaminants as 3A, and would also be a permanent remedy for the river sediments. However, long-term maintenance and monitoring would be required to ensure the landfill's integrity.

Alternative 3C is the same as Alternatives 3A and 3B except the treated exposed sediments would be deposited on the Blackwater Branch floodplain and the treated river sediments would be deposited on the plant site. The exposed sediments would be

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used as fill material for the areas that required remediation. The river sediments would be hauled to the plant site and deposited in the undeveloped areas of the site. This alternative would provide essentially the same reduction of toxicity, mobility and volume of contaminants achieved in the other extraction alternatives, with reduced disposal costs. Periodic monitoring of the floodplain, plant site, and downstream water would be required to measure the effectiveness of the treatment.

The volumes of sediment to be removed and the associated costs for Alternatives 2A, 2B, 3A, 3B and 3C were evaluated at the $1 \times 10^{-5}$ risk level for the Blackwater Branch floodplain sediments and the less accessible areas of the river, and $2 \times 10^{-6}$ for the more accessible areas of the river. A sensitivity analysis was also performed to determine the costs that would be associated with various submerged sediment volumes, which could result from the dynamics of the riverine system over time.

The sensitivity analysis was done by varying the quantity of sediments removed under water from the Blackwater Branch downstream of the North Mill Road Bridge and the upper Maurice River, keeping the quantity of exposed sediment removed from the Blackwater Branch floodplain constant. This took into account the inherent uncertainty in estimating the quantity of riverine sediments, which may have redistributed since they were sampled. Because a supplemental sampling program was undertaken in the Blackwater Branch floodplain specifically to estimate the volumes of sediments to be removed, and because these exposed sediments are not mobile like the riverine sediments, the floodplain sediments can be inventoried much more accurately.

Table E-1 presents the costs for the alternatives based on sediment volumes calculated from 1987 and 1988 data. This table also presents the cost sensitivity to variable sediment volumes. The cost differentials between Alternatives 2A, 2B, 3A, 3B and 3C are considerable; the most expensive and least expensive alternatives differ by a factor of five.

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TABLE E-1
SUMMARY OF COST ANALYSIS (1989 DOLLARS)

| ALT | PERCENTAGE OF SUBMERGED SEDIMENT TREATED | CAPITAL COST | | | ANNUAL O & M | | PRESENT WORTH |
|---|---|---|---|---|---|---|---|
| | | DIRECT | INDIRECT | TOTAL | LONG TERM | SHORT TERM | |
| 1 | DOES NOT APPLY | $ 35,000 | $ 9,450 | $ 44,450 | $ 49,455 | $ | $ 874,245 |
| 2A | 100 | $22,880,219 | $ 6,177,659 | $29,057,878 | $ 13,020 | $17,792,599 | $60,808,653 |
| | 0 | $20,084,875 | $ 5,422,916 | $25,507,791 | $ 13,020 | $29,812,886 | $52,800,049 |
| | 50 | $21,482,547 | $ 5,800,288 | $27,282,835 | $ 13,020 | $21,793,915 | $56,825,288 |
| | 200 | $25,675,563 | $ 6,932,402 | $32,607,965 | $ 13,020 | $16,317,416 | $68,536,278 |
| 2B | 100 | $ 8,684,740 | $ 2,344,880 | $11,029,620 | $ 79,698 | $17,792,599 | $43,665,831 |
| | 0 | $ 7,857,072 | $ 2,121,409 | $ 9,978,481 | $ 70,989 | $29,812,886 | $38,079,015 |
| | 50 | $ 8,270,906 | $ 2,233,145 | $10,504,051 | $ 75,343 | $21,793,915 | $40,894,553 |
| | 200 | $ 9,512,409 | $ 2,568,350 | $12,080,759 | $ 88,407 | $16,317,416 | $48,986,031 |
| 3A | 100 | $17,048,746 | $ 4,603,161 | $21,651,907 | $ 13,020 | $ 1,589,880 | $24,709,821 |
| | 0 | $15,261,006 | $ 4,120,472 | $19,381,478 | $ 13,020 | $ 1,680,218 | $21,156,577 |
| | 50 | $16,154,876 | $ 4,361,817 | $20,516,693 | $ 13,020 | $ 1,614,546 | $22,933,708 |
| | 200 | $18,836,486 | $ 5,085,851 | $23,922,337 | $ 13,020 | $ 1,607,166 | $27,675,868 |
| 3B | 100 | $10,446,483 | $ 2,820,550 | $13,267,033 | $ 54,448 | $ 1,589,880 | $16,875,075 |
| | 0 | $ 9,592,386 | $ 2,589,944 | $12,182,330 | $ 49,177 | $ 1,680,218 | $14,461,578 |
| | 50 | $10,019,434 | $ 2,705,247 | $12,724,681 | $ 51,812 | $ 1,614,546 | $15,669,554 |
| | 200 | $11,300,579 | $ 3,051,156 | $14,351,735 | $ 59,718 | $ 1,607,166 | $18,710,439 |
| 3C | 100 | $ 8,762,653 | $ 2,365,916 | $11,128,569 | $ 13,020 | $ 1,589,880 | $14,186,482 |
| | 0 | $ 7,507,506 | $ 2,027,027 | $ 9,534,533 | $ 13,020 | $ 1,680,218 | $11,309,632 |
| | 50 | $ 8,283,284 | $ 2,236,487 | $10,519,771 | $ 13,020 | $ 1,614,546 | $12,936,786 |
| | 200 | $ 9,426,129 | $ 2,545,055 | $11,971,184 | $ 13,020 | $ 1,607,166 | $15,724,715 |

NOTE:
1. The percent of sediment treated refers to the amount of submerged Blackwater Branch and River sediments. The floodplain sediments treated were held constant at 56,170 cubic yards.
2. Long Term O&M includes site monitoring and maintenance of the on-site landfill.
3. Short Term O&M includes the remediation cost requiring one year for all cases.
4. Periodic O&M of a site review (costing $25,000) once every five years is included in the present worth computations.

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## 1.0 INTRODUCTION

On May 9, 1986 the U.S. Environmental Protection Agency (USEPA) authorized Ebasco Services Incorporated (Ebasco) to conduct a Remedial Investigation/Feasibility Study (RI/FS) on the Vineland Chemical Company (ViChem) site in Vineland, New Jersey. The RI/FS was performed in response to Work Assignment Number 37-2LB8 under Contract Number 68-01-7250. Preparation of this report was accomplished pursuant to the approved Work Plan for the ViChem site dated November 17, 1986 as amended in December 1987.

Three RI and three FS reports have been prepared for the ViChem site. The reports, the areas they cover, and the dates of submission to USEPA are presented in Table 1-1.

The total study area is approximately 38 river miles long: 11 miles of riverine environment (including two miles upstream of the plant), 2 miles of lacustrine environment, and 25 river miles of estuarine environment. The study area is shown in Figures 1-1 and 1-2, and is described in Section 1.2.

### 1.1 PURPOSE AND ORGANIZATION OF THE REPORT

The objective of the River Areas FS was to develop and screen feasible remedial alternatives to remediate environmental contamination found in the Blackwater Branch and in the Maurice River from its confluence with the Blackwater Branch to Union Lake. The most promising alternatives were evaluated against a range of factors and compared against one another. This evaluation would provide a basis for the USEPA to select the best remedial alternative for the site. Specifically, the FS objectives were threefold:

- Identify feasible remedial technologies for containment, removal or treatment of arsenic contaminated sediments;
- Screen and assemble the feasible technologies into remedial alternatives for detailed analysis; and
- Evaluate and compare the remedial alternatives to provide the basis for the USEPA's selection of the best remedial alternative.

Subpart F of the NCP (40 CFR 300.61-300.71) sets forth the FS process by which remedial alternatives are assembled, evaluated, and selected. The factors that were considered in the process are cited under the requirements of Section 105.

This Revised Draft FS was prepared utilizing the data and information presented in all three draft RIs and all of the draft FSs. Ultimately, remedial measures in the River Areas

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TABLE 1-1

RI AND FS REPORTS PREPARED FOR THE VINELAND CHEMICAL COMPANY SITE

| TITLE | AREAS | MEDIA | DRAFT | REVISED DRAFT | FINAL DRAFT |
|---|---|---|---|---|---|
| Plant Site RI | ViChem Plant Site | Soil, groundwater | 7/19/88 | 3/10/89 | 6/23/89 |
| River Areas RI | Blackwater Branch, Maurice River between Blackwater Branch and Union Lake, Maurice River below Union Lake to Delaware Bay | Sediment, Surface Water, Biota | 9/8/88 | 2/17/89 | 6/23/89 |
| Union Lake RI[1] | Union Lake | Sediment, Surface Water, Biota | 6/21/88 | 4/28/89 | 6/23/89 |
| Plant Site FS | ViChem Plant Site | Soil, groundwater | 9/20/88 | 3/10/89 | 6/23/89 |
| River Areas FS[2] | Blackwater Branch, Maurice River between Blackwater Branch and Union Lake | Sediment | 10/5/88 | 2/17/89 | 6/23/89 |
| Union Lake FS | Union Lake | Sediment | 1/18/89 | 4/14/89 | 6/23/89 |

1 - Risk assessment submitted on April 20, 1987. First Draft RI submitted March 13, 1988. The June 21, 1988 RI incorporated the first revised Risk Assessment.

2 - No FS report is being prepared for the Maurice River below Union Lake. Sampling in this area was confirmational only.



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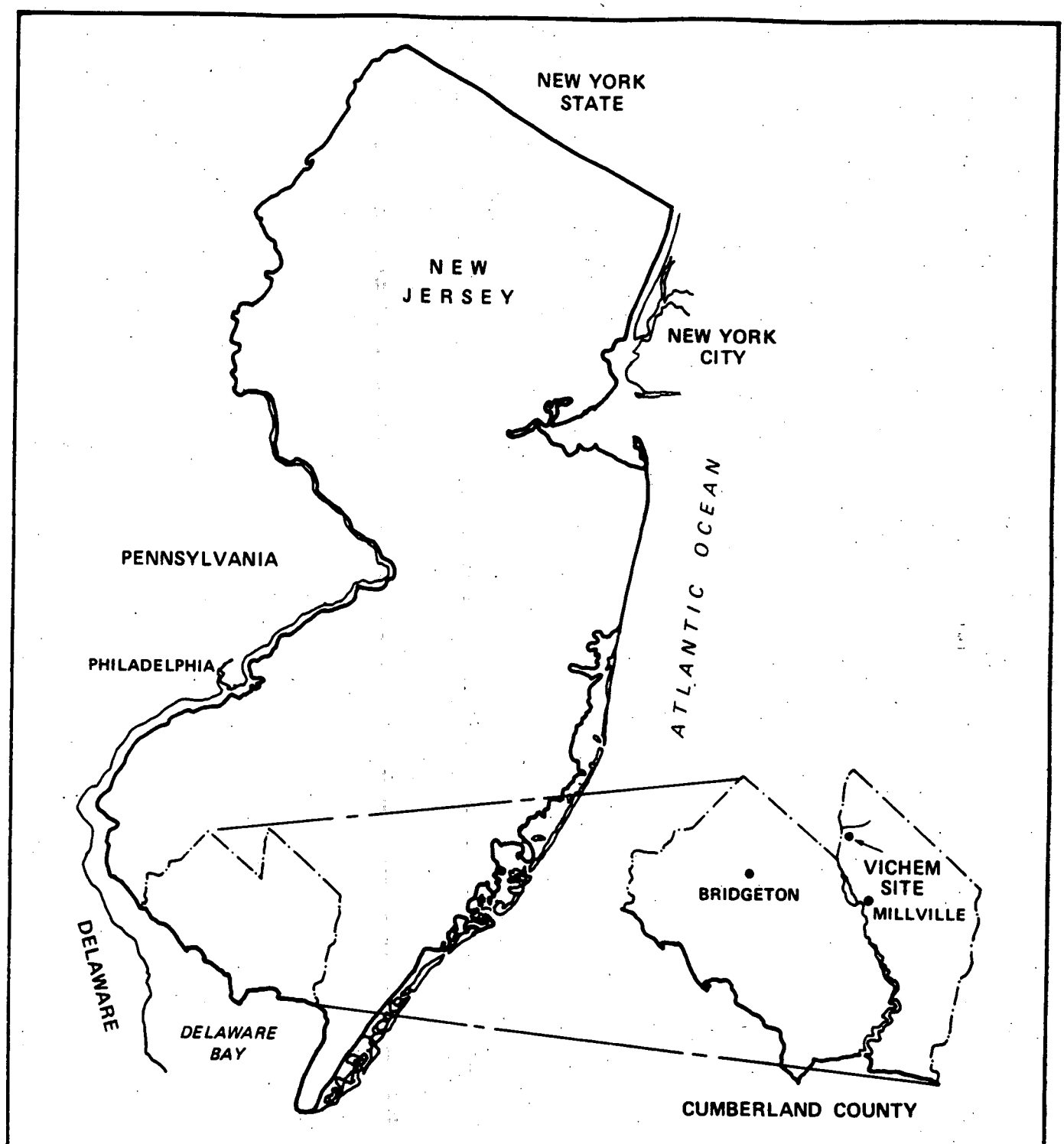


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VINELAND CHEMICAL COMPANY SITE

**FIGURE 1-1**

RIVER STUDY AREA
REGIONAL LOCATION MAP

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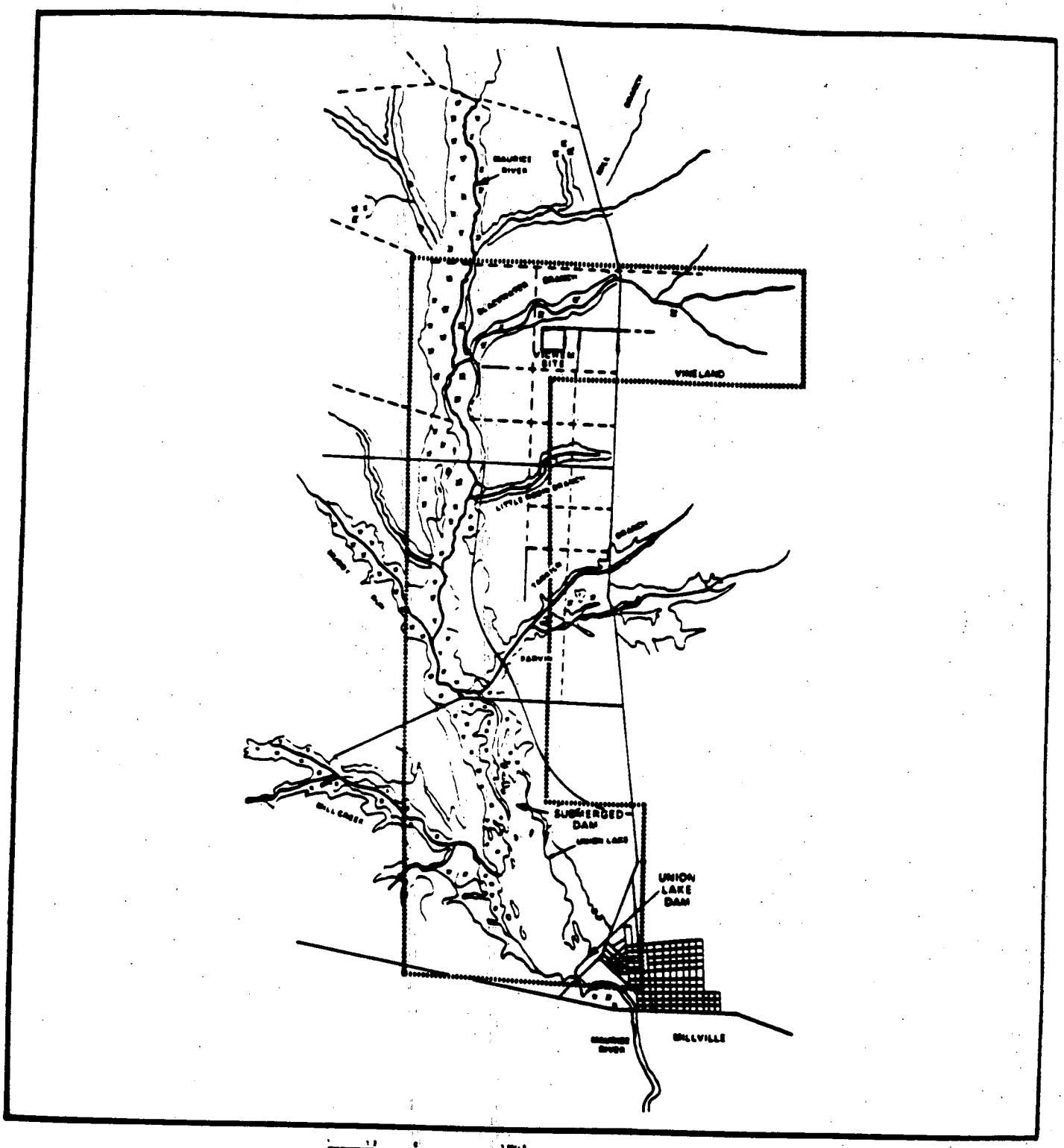


U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

**FIGURE 1-2**

VINELAND CHEMICAL COMPANY SITE STUDY AREA

SHEET 1 OF

EBASCO SERVICES INCORPORATED

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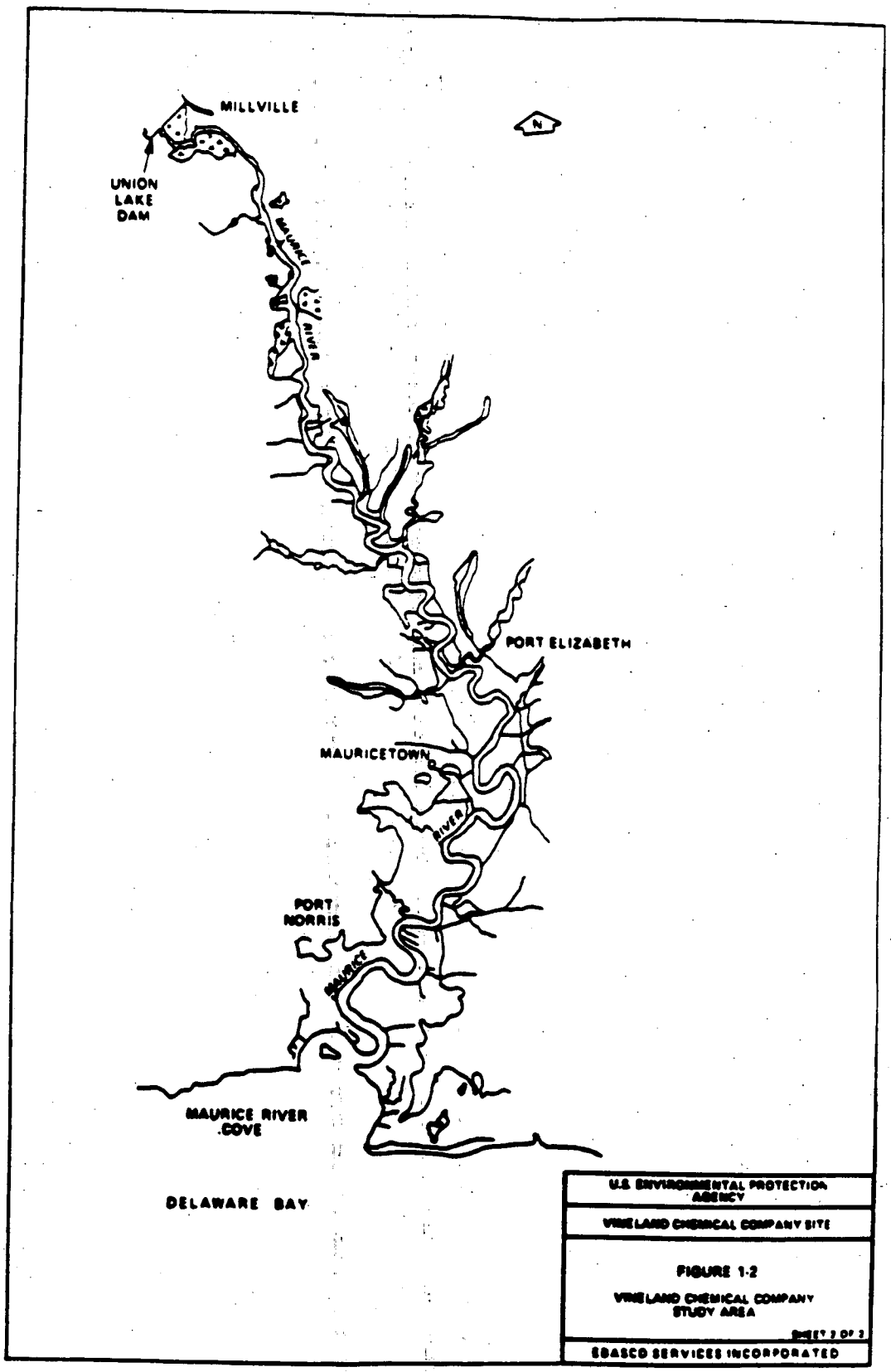
MILLVILLE
UNION LAKE DAM
MAURICE RIVER
PORT ELIZABETH
MAURICETOWN
PORT NORRIS
MAURICE RIVER COVE
DELAWARE BAY
N
U.S. ENVIRONMENTAL PROTECTION AGENCY
VINELAND CHEMICAL COMPANY SITE
FIGURE 1-2
VINELAND CHEMICAL COMPANY STUDY AREA
SHEET 2 OF 2
EBASCO SERVICES INCORPORATED

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must consider the source of contamination as well as the ultimate contaminant disposition.

This report is comprised of four sections and three appendices. It was prepared following the USEPA's Draft Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (USEPA, 1988a).

The Introduction, Section 1.0, provides background information regarding the site location, physical characteristics, contamination, history, and regulatory actions. The nature and extent of the contamination, as identified in the RI, are also presented.

Section 2.0 presents the feasible technologies with which to meet the general response actions, the technical criteria and the site-specific requirements that were used in the technology selection process, and the results of the remedial technology screening. A summary of the objectives for remedial action(s) is also presented, along with a summary of applicable environmental criteria and standards.

Section 3.0 presents the remedial alternatives, developed by combining the technologies that passed the screening in Section 2.0. Alternatives were developed in the three general categories required by the Superfund Amendments Reauthorization Act (SARA): no action, containment and treatment. The process for screening the remedial alternatives is also described. A description of the environmental and public health impacts and the estimated costs for each alternative are presented. The most promising alternatives to be taken into detailed evaluation in each of the three categories are identified.

Section 4.0 presents detailed evaluations of the most promising alternatives developed in Section 3.0. This section presents the detailed descriptions of the cost and non-cost features of each remedial alternative that passed the screening in Section 3.0. The analysis of each alternative against nine assessment criteria is presented. Finally, this section summarizes the remedial alternatives and compares them to one another.

All of the references and previous studies cited in this report, as well as the other documents used to conduct the FS, are listed in the References Section at the end of this report.

The report contains three appendices:

- Appendix A, Major Facilities and Construction Components, presents the construction components and associated quantities for the remedial alternatives in Section 4.0;

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- Appendix B, Capital and Operation and Maintenance (O&M) Cost Estimates, presents material and installation costs yielding direct and total construction costs for the remedial alternatives presented in Section 4.0, and presents the O&M costs for the alternatives as required; and

- Appendix C, Methods for Estimating Contaminated Sediment Volumes, presents stream cross-sections, contaminated floodplain areas, and a discussion of the calculations used to determine the volume of soil and sediment to be removed at the action levels.

## 1.2 BACKGROUND INFORMATION

### 1.2.1 Site Description

The Vineland Chemical Company plant site is located in a residential/industrial area in the northwest corner of the City of Vineland in Cumberland County, New Jersey. The plant location is shown in Figure 1-3.

The plant is bordered on the north by Wheat Road and the Blackwater Branch, a tributary to the Maurice River. Residential areas border the plant to the east, south and west along Orchard, Oak, and North Mill Roads.

ViChem has produced organic herbicides and fungicides at this location since 1949. ViChem currently produces two major herbicidal chemicals, disodium methanearsonate and monosodium methanearsonate. Table 1-2 lists chemicals used, manufactured, or known to be stored at the ViChem plant site.

The ViChem plant site is shown in Figure 1-4. The plant consists of several manufacturing and storage buildings, a laboratory, a worker change facility, a wastewater treatment plant and several lagoons. The manufacturing and parking areas shown in Figure 1-4 are paved. The lagoon area is unpaved and is devoid of vegetation. This area is characterized by loose sandy soils. The remainder of the site is covered by trees, grass, or shrubs.

The site is situated in a residential/industrial area. Twelve residences are shown in Figure 1-4 in the immediate vicinity of the plant. A number of other residences are located close to the plant along Wheat, Orchard, Oak, and North Mill Roads, as shown in Figure 1-5.

The Martex Manufacturing facility is located immediately north and west of the ViChem lagoon area. Martex reportedly produces packaging materials, although little information is available on the materials used or manufactured at this site.

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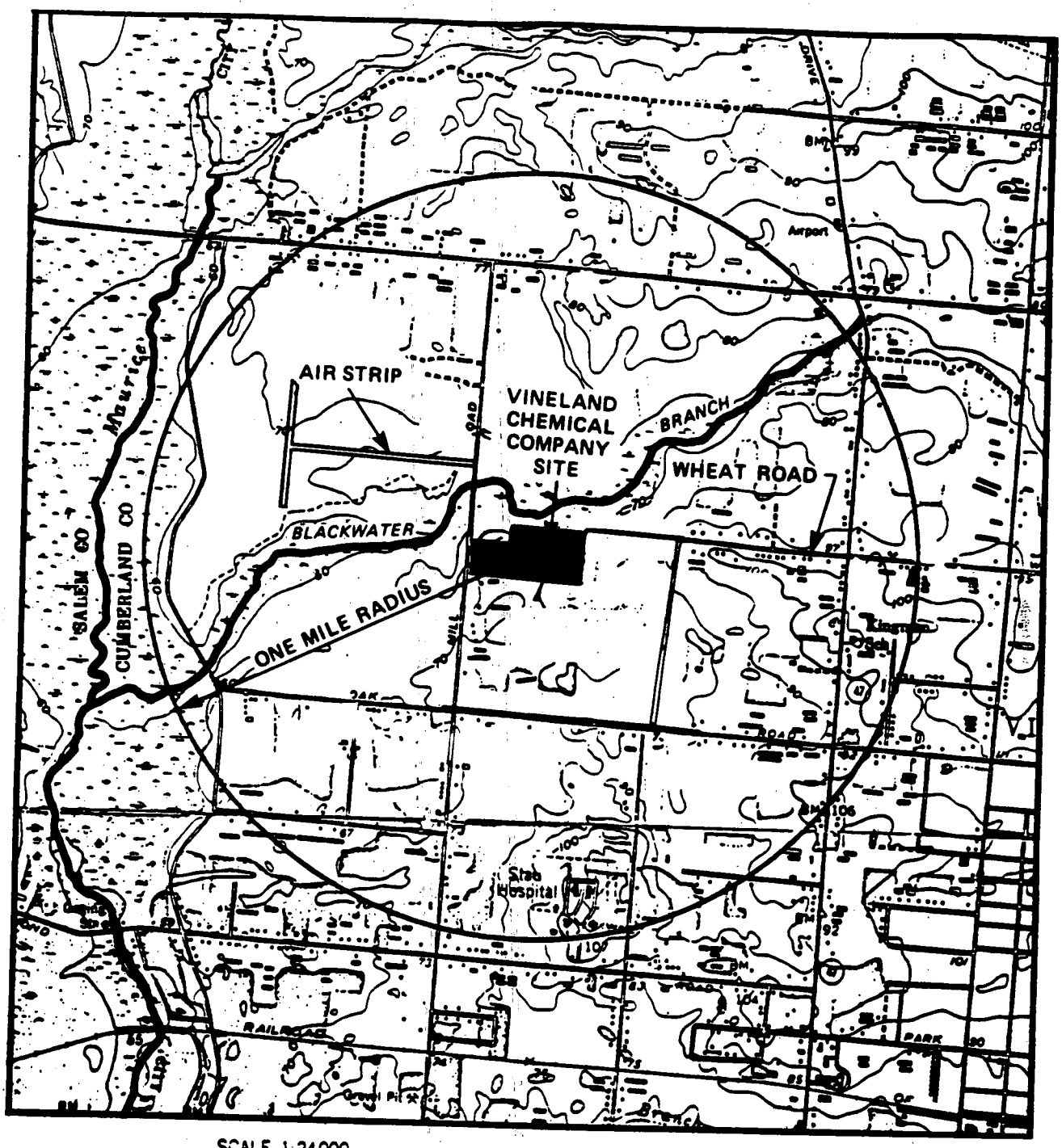


SCALE 1:24000

0 1 MILE

BASE MAP PREPARED BY U.S.G.S., 1977

| |
|---|
| U.S. ENVIRONMENTAL PROTECTION AGENCY |
| VINELAND CHEMICAL COMPANY SITE |
| FIGURE 1-3<br>VINELAND CHEMICAL COMPANY<br>ONE MILE RADIUS |
| EBASCO SERVICES INCORPORATED |

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TABLE 1-2

CHEMICALS USED, MANUFACTURED OR STORED AT VINELAND CHEMICAL PLANT

INORGANIC METALS AND SALTS

Arsenic
Mercury
Mercury (II) chloride
Mercury (I) chloride
Cadmium
Cadmium chloride

FLOCCULANTS

Aluminum
Iron

METAL ORGANIC ARSENIC COMPOUNDS

Disodium methanearsonate
Dodecyl and octylammonium methanearsonate
Monosodium acid methanearsonate
Calcium acid methanearsonate
Dimethylarsonic acid (Cacodylic acid)

ORGANIC MERCURY COMPOUNDS

Phenyl mercury dimethyldithiocarbamate
Phenyl mercuric acetate

HERBICIDES

Sodium 2,4-dichlorophenoxy acetate (2,4D)
2-4-dichlorophenoxy acetic acid
2-(4-chloro-2-methylphenoxy) propanoic acid (MCPP)

bis(dimethylthiocarbonyl)disulfide (thiram)

1,4-bis (bromoacetoxy)-2-butene
2,3-dibromopropionaldehyde

Alkylarylpolyether alcohol

SOLVENTS AND GENERAL ORGANIC CHEMICALS

Benzyl alcohol
Xylene
2,3 Benzofuran

Methanol
Epichlorolydrin
Acrolein
Isopropyl alcohol

Methyl chloride
Methylene chloride
Trichloroethane
Trichloroethylene

Tetrachloroethylene
Bromochloromethane

Methylene-bis-thiocymate
Hydrobromic acid

Tetrabutyl ammonium bromide
Bromo acetic acid





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TABLE 1-2 (Cont'd)

CHEMICALS USED, MANUFACTURED OR STORED AT VINELAND CHEMICAL PLANT

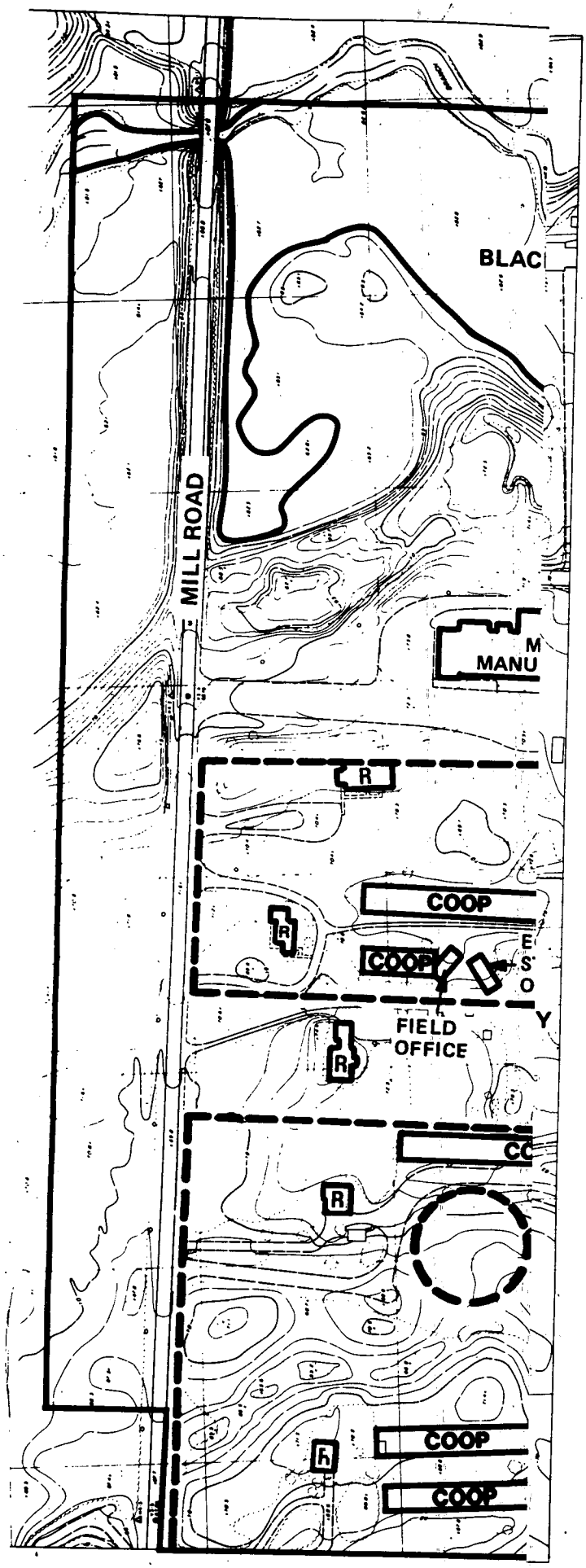
Glycerine
Triton X-100
Formaldehyde
Butanediol

Gasoline
Kerosene

POSSIBLE CHEMICALS FROM MANUFACTURING

Phenol
Chlorophenols
Chloroacetic acid
Chlorides
Arsenic trioxide
Arsenic pentoxide
Methyl chloride
Methanol
Sodium hydroxide
Calcium oxides, chlorides, sulfates
Mercury Oxides
Cadmium Salts

Compiled from
1) Miller, F., NJDEP Memo, Vineland Chemical Ground Water Pollution Problem, May 24, 1985
2) Sittig, M., Pesticide Manufacturing and Toxic Materials Control Encyclopedia, Noyes Data Corp., Park Ridge, NJ (1980)



R RESIDENCES

----- VICHEM PROPERTY BOUNDARY

LL LINED LAGOON

UL UNLINED LAGOON

0 100 200 300

SCALE IN FEET

TOPOGRAPHIC BASE PREPARED FOR U.S. ARMY CORPS OF ENGINEERS BY KUCERA INTERNATIONAL, JANUARY 19

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VINELAND CHEMICAL COMPANY SITE

FIGURE 1–4

VINELAND CHEMICAL COMPANY SITE PLAN

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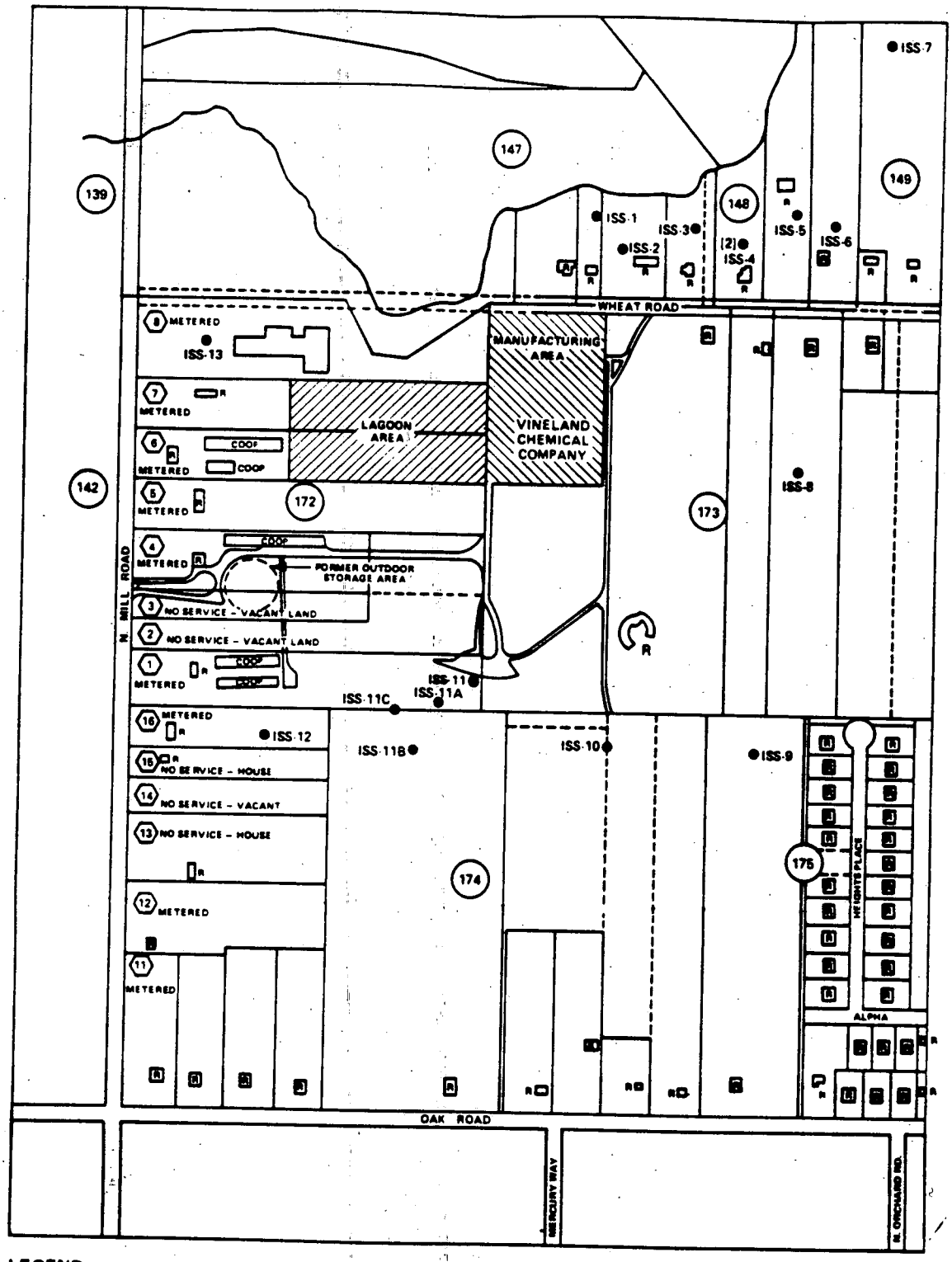


LEGEND:

172 BLOCK NUMBER

● SOIL SAMPLING LOCATIONS

R RESIDENCES

⬡ LOT NUMBER

0 200 400 600 800
SCALE IN FEET

NORTH

BASE MAP PREPARED BY CITY ENGINEER, WILLIAM G. AUSTIN, CITY OF VINELAND, OCTOBER 1971.

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1-5

RESIDENTIAL LOCATIONS SURROUNDING VINELAND CHEMICAL COMPANY SITE

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The Blackwater Branch is immediately north of the ViChem plant site, as shown in Figure 1-6. This stream flows east to west and discharges into the Maurice River approximately 1.5 river miles downstream from the plant. The upper Maurice River, shown in Figure 1-2, then flows approximately 7 river miles downstream into Union Lake, which is approximately 2 miles long. The Maurice River then flows approximately 25 river miles downstream from the lake into the Delaware Bay, as shown in Figure 1-2.

Some time between April 1985 and June 1986, beavers constructed a dam on the Blackwater Branch just downstream from the North Mill Road bridge. The dam flooded the Blackwater Branch to the approximate extent shown in Figure 1-4. The dam was removed in October 1987 to allow for construction of a new bridge. The Blackwater Branch is now flowing in its normal channel and the flooded areas have been drained.

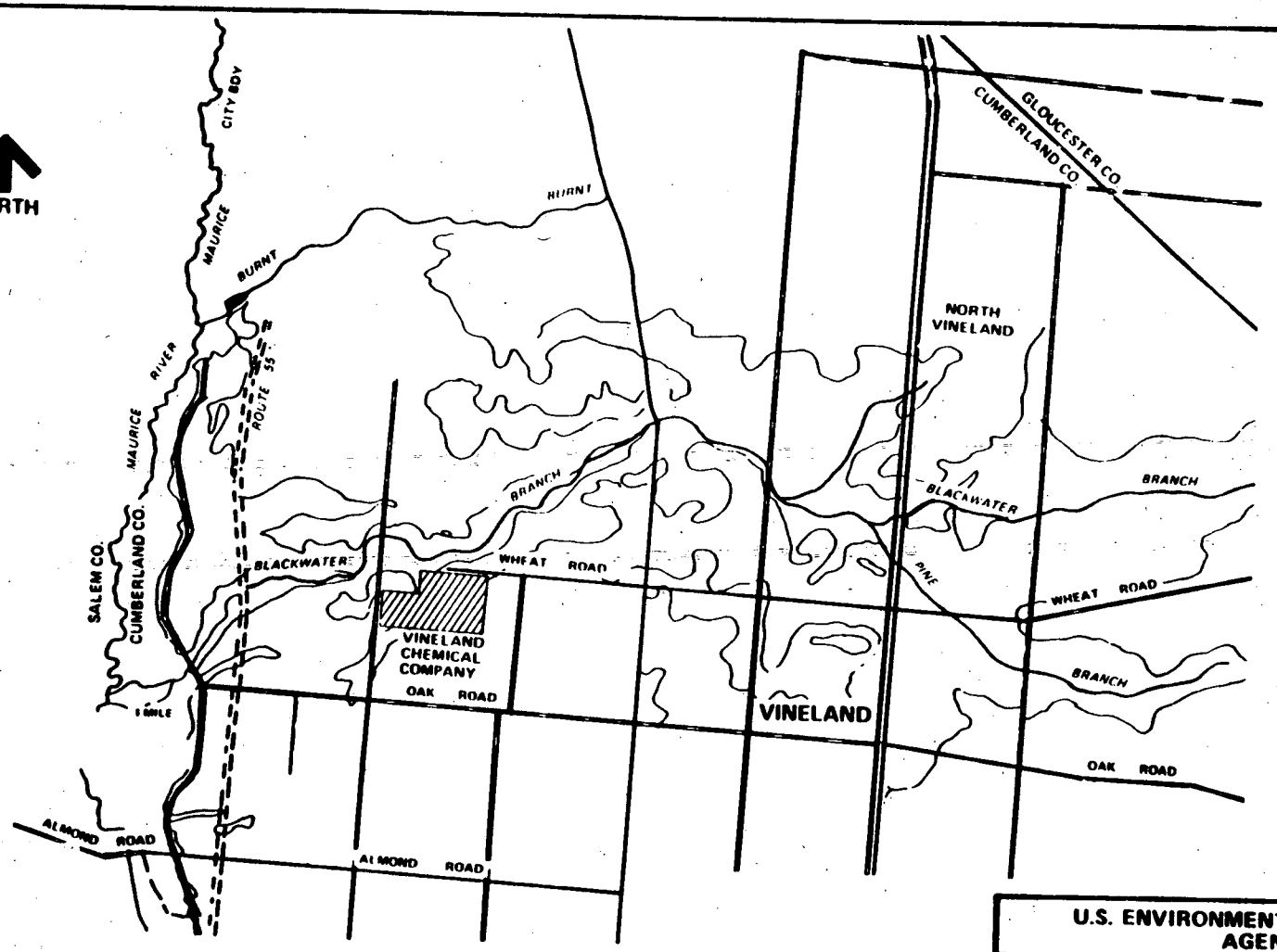
A wastewater treatment system is in operation at the ViChem plant. The system has a design capacity of approximately 25 gallons per minute (gpm), or 36,000 gallons per day (gpd), assuming 24 hours of operation. The system was designed to treat between 2,000 and 5,000 gpd of process water, 20,000 gpd of groundwater, which was to be pumped from the shallow water table, and storm runoff water as necessary. In addition, provisions were made to collect up to 60,000 gpd of non-contact cooling water in the event that a mechanical breakdown occurred and mixed the non-contact cooling water with the contaminated process water.

The wastewater treatment system consists of mix tanks, a reactor, filters and ancillary equipment. Ferric chloride is added to the first flash mix tank and caustic soda is added to the second mix tank to promote flocculation. The wastewater then enters the reactor where it is mixed with a polymer. This mixture then passes through a flocculation compartment where the large particles settle to the bottom and are removed to a rubber-lined tank. The reactor effluent is polished by a tertiary filter before discharge. The slurry in the rubber-lined tank is pumped into a vacuum filter and the dry solids are deposited in a dumpster for off-site disposal. Any liquid not meeting discharge requirements is reportedly recirculated for treatment.

Some of the lagoons shown in Figure 1-4 are used in the wastewater treatment system. Lagoon LL-1 is a lined lagoon with a 490,000-gallon capacity. This lagoon was designed to hold process water, groundwater and storm water as necessary prior to treatment. Water can be pumped from this lagoon to the plant at 25 gpm. Lagoon LL-2 is also a lined lagoon but it has a concrete base. It was previously used to store the arsenic contaminated waste salt K 031 produced as a byproduct of the herbicide manufacturing process, and later was used to hold the treatment plant sludge prior to disposal. It now holds water to



VIN 002 1218

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1 1/2 0 1 MILE

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VINELAND CHEMICAL COMPANY SITE

FIGURE 1–6

BLACKWATER BRANCH

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VIN 002 1219

be recirculated for retreatment. Lagoon UL-A is an unlined lagoon. This lagoon receives the non-contact cooling water and the treated discharge from the treatment plant. Because the site soils are sandy and this lagoon is unlined, inflow into the lagoon rapidly infiltrates into the groundwater.

The remaining lagoons shown in Figure 1-4, UL-B, UL-C, and UL-D, are all unlined and are not currently used in the water treatment system. However, aerial photographs provided by the USEPA's Environmental Photographic Information Center (EPIC) used in the USEPA's Site Analysis, Vineland Chemical Company (Simpson, 1988) show that UL-A, UL-B, UL-C, UL-D and LL-1 (which was previously unlined) were connected to one another in the past. The photographs show that all of the lagoons were filled with liquid.

The two lined lagoons, LL-1 and LL-2, are regulated by RCRA. The wastewater treatment plant and the unlined lagoon, UL-A, are regulated under the NJPDES program. Other active solid waste management units at the plant site include the trailers/tote bins used to store K 031 waste salts and treatment plant sludge, the septic system and leachfield, and the soil beneath the floors of the production buildings where past operating procedures reportedly produced spillage. Inactive/abandoned solid waste management units are basically areas where waste salts were improperly stored in the past, including the waste salt piles, sludge piles, chicken coops, and outdoor drum storage areas.

The treatment plant was designed to produce an effluent with an arsenic concentration of 0.05 milligrams per liter (mg/l). ViChem initially had difficulties achieving this level. Therefore, an interim standard of 0.7 mg/l was agreed to and ordered by NJDEP in December 22, 1981, with the understanding that the 0.05 mg/l level would eventually be met. Results from in-house tests performed daily by ViChem indicate that the effluent has been reduced to below the interim standard, but the levels are still greater than 0.05 mg/l when the influent concentrations are high and are less than 0.05 mg/l when the influent concentrations are low.

ViChem reports that it no longer treats either groundwater or process water. Reportedly, all of the water used in manufacturing the herbicides is consumed by the process and is included as inherent moisture in the product. ViChem ceased pumping and treating groundwater in July 1987 with the consent of the NJDEP. One of the reasons the NJDEP allowed ViChem to stop pumping and treating the groundwater was the NJDEP's concern that the treatment plant effluent, whatever its arsenic concentration, would cause a groundwater mound, driving existing groundwater contamination deeper into the groundwater and promoting off-site migration. The wastewater treatment plant now reportedly treats only storm water runoff intermittently.

VIN 002 1220

The herbicide manufacturing process produces approximately 1,107 tons of waste by-product salts each year. These wastes have an USEPA hazardous waste number of K 031 and are neither treated nor disposed of at the site, and are not stored on-site for more than 90 days. The salts are transported by licensed shippers to licensed facilities in Ohio and Michigan for disposal.

### 1.2.2 Site History

ViChem began manufacturing organic arsenical herbicides and fungicides at this plant in 1949. In addition to arsenical herbicides, the company also produced cadmium-based herbicides and used other inorganics such as lead and mercury. Table 1-2 presented a list of chemicals used, manufactured or stored at the ViChem plant site.

As early as 1966, the NJDEP observed ViChem discharging untreated wastewaters with unacceptable arsenic concentrations (67 mg/l) into the unlined lagoons. An unknown quantity of arsenic rapidly infiltrated into the groundwater from the lagoons. On February 8, 1971, ViChem was ordered to install and provide industrial wastewater treatment and/or disposal facilities. The wastewater treatment works did not become operational until March 1980.

Waste salts from the herbicide production process were stored on-site in uncontrolled piles on the soil, in the concrete lagoon LL-2 (which at the time was unlined), and in abandoned chicken coops on the plant property. The storage of salts in piles was observed in April 1970 and in the coops in April 1973. It was not until 1978 and many court orders that the salts were containerized and removed. These salts reportedly contained one to two percent arsenic (RCRA Part B Permit Application, 1980). As these salts have a high solubility, precipitation contacting these piles rapidly dissolved the salts and carried an unknown quantity of arsenic into the groundwater.

Between 1975 and 1976, ViChem was fixating the waste salts for disposal at the Kin-Buc Landfill. The process involved mixing the dried salts with ferric chloride and soda ash, reportedly reducing the solubility. The process was stopped in 1976 when the Kin-Buc Landfill voluntarily stopped accepting all chemical wastes, including the fixated salts. ViChem then resumed piling the untreated waste salts on the soil surface at the plant site.

A court order issued on January 26, 1977, required ViChem to containerize the waste salts from the chicken coops and piles, and then store the drums in a warehouse off-site. In June 1979, another order was issued for the disposal of the stored drums in an approved landfill. Removal and disposal of these drums was not completed until June 30, 1982.



VIN 002 1221

Currently the waste salts and the sludge from the wastewater treatment systems are stored in large-capacity trailers and tote bins. The tote bins are filled at the point of generation in the manufacturing buildings, and then emptied into the trailers. The NJDEP believes that releases are unlikely from this system. The salts and sludge are transported to licensed facilities as mentioned above. During peak production, as many as four or five trailers are filled and removed per week.

Aerial photographs provided by the USEPA's Environmental Photographic Information Center (EPIC) and conversations with ViChem employees indicated several possible locations of past contamination. The cleared area in the southwest corner of the site shown as a "former outdoor storage area" in Figure 1-4 was at one time occupied by two chicken coops. Sometime between November 1975 and March 1979, both coops were destroyed. These coops were reportedly used to store process chemicals and/or waste. The materials stored in the coops may have percolated into the groundwater. This area is now devoid of vegetation. Photographs also show many other locations containing mounded material and/or drums. These include the lagoon area and locations along the plant road. The waste salts were reportedly mounded so high at times beyond Lagoon LL-2 that the salts spilled over onto the soil in the lagoon.

It is alleged that the floors of the manufacturing plant have been leaking arsenic compounds into the underlying sands for years. The original floors of the buildings were brick and were allegedly in need of repairs several years ago. Allegedly, when the old bricks were removed, the soil contained crystalline wastes from previous spills. It is not known whether the soils were removed when the floors were replaced, although in Ebasco's Phase II investigation the soils below building #9 were sampled and had high arsenic concentrations (see Section 4.0 of the Plant Site RI). The floor of the building was solid and in good repair during Ebasco's 1987 investigation.

In response to a series of Administrative Consent Orders issued by the NJDEP, ViChem instituted some cleanup actions and modified the production process. The cleanup actions included stripping the surface soils in the manufacturing area, piling these soils in the clearing by well cluster EW-15, and paving the manufacturing area; installing a storm water runoff collection system; removing the piles of waste salts; and installing a groundwater pump and treat system, including the wastewater treatment plant. Modifications to the production process included installing a water system where mixing of process water and non-contact cooling water was unlikely, lining two of the lagoons used in the wastewater treatment system (LL-1 and LL-2), and properly disposing of the waste salts.



VIN 002 1222

The evidence described above suggested that a serious groundwater contamination problem existed at the ViChem plant site, and that the groundwater was discharging into the stream and degrading the downstream water quality. This RI/FS was undertaken to investigate the extent of contamination and to evaluate remedial alternatives for rehabilitating the groundwater, soil, downstream sediments and surface waters.

### 1.2.3 Permit Actions

On December 2, 1985, the USEPA informed ViChem that its interim status for the lined RCRA impoundments was terminated as a matter of law on November 8, 1985 because of failure to comply with Section 3005(e)2 of RCRA. The USEPA determined that the company: (a) failed to certify compliance with the applicable financial assurance requirements for closure and post-closure care; (b) failed to certify that required liability insurance was ever actually obtained; and (c) failed to certify the preparation of a groundwater monitoring program meeting the requirements applicable to interim facilities. The company was to cease placing hazardous waste into the two lined lagoons.

ViChem submitted applications for RCRA and NJPDES permits. The RCRA permit application was for storage of hazardous wastewaters in the two lined lagoons. The NJPDES discharge to groundwater permit application was for discharge of non-contact cooling water to the unlined lagoon UL-A.

In April 1986, the NJDEP advised ViChem of its intent to deny both the RCRA and NJPDES permits. The technical and administrative bases for the tentative decision to deny the NJPDES permit were: (a) the discharge of 200,000 gallons per day (gpd) of non-contact cooling water into the unlined lagoons' increased hydraulic gradients, thereby forcing contaminated groundwater deeper into the aquifer and further off-site; and (b) the treatment works were unable to meet the discharge criterion of 0.05 mg/l for arsenic. The technical bases for denying the RCRA permit application were inadequate closure, post-closure, and liability assurance requirements, and an inadequate groundwater monitoring program. The administrative basis for denial was the failure to submit a complete hazardous waste facility permit application, given adequate time to do so. The NJPDES permit denial is being appealed by ViChem.

### 1.2.4 Previous Investigations

Since 1978, a number of studies have been performed by or for the NJDEP Office of Science and Research in the Maurice River watershed and at the ViChem plant site. ViChem itself has also conducted some investigations into the groundwater plume at the plant.

VIN 002 1223

In the years 1979 to 1980, the NJDEP initiated a sampling program in the Blackwater Branch and the Maurice River downstream from the site. The results showed that the sediment arsenic concentrations in the Maurice River were the highest seen anywhere within the State of New Jersey. The study showed that the Almond Beach weir, the submerged dam in Union Lake, the lower main dam in Union Lake, and the tidal creeks of the Maurice River estuary below Union Lake contained arsenic-contaminated sediments. Elevated arsenic concentrations were found in sediments as far from the site as the Delaware Bay, approximately 36 river miles downstream from the site. Also, the arsenic concentration in the surface water decreased downstream from the site but did not reach the Federal Primary Drinking Water Standard for arsenic, 0.05 mg/l or 50 ug/l, until 26.5 river miles downstream from the ViChem plant site.

In 1978, ViChem commissioned a surface geophysical survey of the site at the direction of the NJDEP. The survey noted that areas of probable contamination were the lagoon area, the area north of the lagoons to the Blackwater Branch, the former outdoor storage area shown in Figure 1-4, and areas along the plant road between the former outdoor storage area and the lagoons. The report also contended that the probable groundwater contamination was shallow and recommended locations for installing extraction wells.

In 1979, NJDEP sampled soils in the ViChem plant site area. Samples were taken at the surface and at depth. The study showed arsenic concentrations ranging from undetected to 864 mg/l at various locations in the plant site area.

In 1981, the NJDEP performed a surface geophysical survey of the plant area. The study identified two areas of probable groundwater contamination, one northwest of the lagoons toward the Blackwater Branch and the other near the former outdoor storage area. The study estimated that the probable maximum depth of the contaminant plume was approximately 40 feet.

In 1982, ViChem commissioned a groundwater investigation of the plant site. In this study, previous investigations were reviewed and a scheme to remove arsenic from the contaminated aquifer was proposed. This study included several sets of water quality data. Approximately 4-1/2 years of monthly arsenic concentrations at ViChem well MW-1 were presented along with data from ViChem wells MW-6 and MW-10. These data showed a marked drop in the arsenic concentration in the groundwater between 1978 and 1981. The study also presented monthly levels of arsenic in the Blackwater Branch at North Mill Road, and in the Maurice River at the Almond Road weir. The study postulated that the arsenic load at North Mill Road was very similar to the arsenic load at Almond Road, implying that the river system was, essentially, a conduit for arsenic transport into Union Lake.



VIN 002 1224

The study reviewed processes for arsenic cleanup at the site and recommended a groundwater pump and treat program along with controlled soil leaching.

In 1982, an employee of ViChem was diagnosed as having subacute arsenic poisoning. The New Jersey Department of Health then conducted a "Cross-Sectional Evaluation of Arsenic Exposure and Toxicity at the Vineland Chemical Company." The study revealed that employees had elevated arsenic concentrations in their hair and urine, but only exhibited minor symptoms associated with arsenic trioxide dust on the skin and mucous membranes. As a result of this survey, the arsenic-handling practices in the production facility were improved.

Two studies were conducted by the NJDEP and Rutgers University from 1980 to 1982 in Union Lake. The studies showed that Union Lake is chemically stratified during the summer. This stratification creates seasonal anaerobic conditions in the bottom sediments, which are conducive to the formation of toxic arsenical compounds from the contaminated sediments (NJDEP, 1986). The Rutgers University work included sampling and analysis of water and sediments, as well as speciation of arsenic [trivalent-As (III), pentavalent-As (V), monomethyl arsenic acid (MMAA) and dimethyl arsenic acid (DMAA)(Faust, 1983)]. This study concluded that the waters and bottom sediments were highly contaminated with substantial quantities of arsenic, and that total arsenic concentrations in all lake water samples exceeded the NJDEP and USEPA drinking water standard of 50 ug/l. In sediments, the order of predominance of the four arsenic species (in descending order) was: As (V), As (III), MMAA, DMAA. In four of the sediments, the inorganic arsenate was between 73% and 88% of the total arsenical species. In water, the order of predominance was MMAA, As (III), As (V), DMAA. The results of the resampling efforts revealed a seasonal pattern of arsenic concentrations within the lake water with the greatest concentrations occurring during the summer. Additional NJDEP sediment sampling near the spillway area of Union Lake in April 1986 again showed arsenic contamination within the sediments and showed that contamination within the sediments was a surficial phenomenon.

In a 1983 to 1985 study by Rutgers University (Winka, 1985), it was shown that arsenic may exist in many species in the watershed, and that these species may be transformed by changes in physical condition and season. Results indicated that within the water column, the inorganic arsenic species may be one half of the total arsenic. Arsenic was not easily solubilized under aerobic conditions. The concern raised by these findings is that when an anaerobic condition develops on the bottom of Union Lake, the arsenic would be readily converted into the more toxic As (III) and As (V) forms. The more toxic forms could then be released to the water column upon seasonal turnover of the

VIN 002 1225

stratified layers. However, as these compounds are relatively insoluble, they are expected to precipitate back to the lake bottom within a relatively short period of time.

In 1982, ViChem commissioned a pumping test to be performed on the shallow aquifer underlying the lagoon area. The pumping test estimated a transmissivity in the shallow aquifer of approximately 50,000 gpd/ft, and a storage coefficient of between 0.1 and 0.04.

In 1985, ViChem's RCRA Part B permit application was submitted to the NJDEP. The application included a description of the wastewater and groundwater handling, and a description of the wastewater treatment process and facility design. The application also included data on the production rates at the plant and the toxicity of the wastes generated. Arsenic concentrations in the Blackwater Branch through time were also presented.

In 1986, ViChem commissioned a pumping test to be performed in the deeper groundwater below the site. The plant's production well, screened from 130 to 165 feet below the ground, was used as the pumping well and a deep monitoring well was installed in the lagoon area. The pumping test was conducted for 24 hours, with water levels measured in the deep monitoring well and several shallow monitoring wells near the discharge in the lagoon area. The report concluded that the "clay layer," reportedly encountered from 120 to 135 feet below the ground and which the production well is screened below, acts as a confining layer and prevents downward migration from the overlying aquifer. However, Ebasco's review of this pumping test data revealed that there was significant leakage across this "clay layer" during the pumping test.

The USEPA's Environmental Photographic Information Center (EPIC) produced a report in March 1988 on the ViChem plant site. The report presents an aerial photographic analysis of the ViChem plant site and surrounding area. The first photograph presented was taken in March 1951 and the last was taken in November 1987. A total of 11 photographs were presented in the report.

Among other things, the analysis of the photographs shows areas of "Vegetation Damage" and "Vegetation Stress" along the Blackwater Branch beginning with a September 1979 photograph. None of the prior photographs show vegetation damage or stress, and all of the later photographs show some vegetation damage and/or stress.

Some of the damaged areas are in the portion of the Blackwater Branch, which was inundated with water from the beaver dam. However, the beaver dam was not constructed until some time after April 1985, much later than the first indication of vegetation damage/stress. A topographic base map for the site



VIN 002 1226

that was flown in April 1985 shows the Blackwater Branch flowing in its normal channel at that time. It should be pointed out that the damaged/stressed areas are coincident with the contaminated groundwater plume coming off the ViChem plant site.

In 1988, the USEPA's Environmental Response Branch prepared a bioassessment on the Blackwater Branch and the upper Maurice River. The report concluded that there was an adverse impact to the benthic communities in the Blackwater Branch downstream from the ViChem plant site. The impact takes the form of lower species diversity and a toxic response in bioassay tests done with the sediments. The impact lessens in the Maurice River, probably resulting from dilution. This report is presented as an appendix to the River Areas RI report (Ebasco, 1989c).

In addition to the above studies, Ebasco, under contract with the USEPA, prepared RI reports for three portions of the ViChem plant site: the ViChem plant area (Ebasco, 1989a), the River Areas north of Union Lake (Ebasco, 1989c) and Union Lake (Ebasco, 1989e). Pertinent findings from these RI reports are as follows:

- There is a heavily contaminated arsenic plume in the shallow groundwater underneath the site within an aquifer termed the upper sand in the plant RI report. No arsenic contamination was seen below the base of the upper sand, ranging from 40 to 70 feet below the ground surface. A unit termed the banded zone, which contains clay laminae, was found at the base of the upper sand and apparently prevents the downward migration of arsenic.

- The groundwater in the upper sand discharges into the Blackwater Branch and, thus, provides the arsenic flux into this stream and the Maurice River.

- The arsenic flux in the groundwater was estimated at 6 metric tons per year in 1987. It was estimated that a total of approximately 500 metric tons of arsenic has been transported off the site through time.

- The Blackwater Branch floodplain is contaminated with substantial quantities of arsenic. This area was previously inundated with floodwaters from the beaver dam. Since the dam was breached, the floodplain is now exposed. The exposed floodplain sediments contain very high arsenic concentrations in places (up to 4,000 mg/kg).

- The Blackwater Branch and the upper Maurice River basically behave as conduits, transferring arsenic from the plant site into Union Lake. The inventory of arsenic bound to the river sediments was estimated to

VIN 002 1227

be approximately six metric tons. This arsenic was apparently bound to fines and organics in the sediments.

- Union Lake is contaminated with substantial quantities of arsenic, with a mean dissolved arsenic concentration in the water of approximately 56 ug/l, which is above the 50 ug/l Federal Primary Drinking Water Standard for arsenic. The mean arsenic concentration in the sediment is approximately 74 mg/kg, significantly higher than the background arsenic concentration in the Maurice River above the confluence with the Blackwater Branch which is less than 2 mg/kg. The highest arsenic concentration detected in the sediments was over 1,200 mg/kg. It was estimated that approximately 140 metric tons of arsenic was bound to Union Lake's sediments.

- The controlling factor for the lake's water arsenic concentration could not be determined. On one hand, the arsenic concentration in the water coming in, within and flowing out of the lake was approximately the same. This suggests that the upstream arsenic concentration controls the lake's arsenic concentration. On the other hand, the lake water and sediments were apparently in equilibrium, based on the sediment arsenic concentration, the water arsenic concentration, and the partition coefficient. Since the predicted equilibrium concentrations were approximately equal to the incoming water concentration, the controlling factor for the lake's water concentration could not be determined.

- The Maurice River below Union Lake had elevated sediment and water arsenic concentrations. The water arsenic concentration did not fall below 50 ug/l until approximately 10 miles downstream from the lake (20 miles downstream from the plant). The water concentration dropped sharply when the tidal front was reached. The arsenic inventory in the sediments could not be determined; however, it was established that possibly as much as half of the arsenic released off of the site was stored in the lower Maurice River sediments.

- It was estimated that if the source of arsenic into the watershed (groundwater discharge off of the ViChem plant) were stopped, the water arsenic concentration in the Blackwater Branch and the upper Maurice River would drop relatively quickly. These portions of the watershed are believed to act as conduits for the arsenic flux and do not bind substantial quantities of arsenic relative to that in the lake. It was also estimated that if the source of arsenic were eliminated the lake

water's arsenic concentration would drop, although how much and how quickly was not known. Arsenic may continue to desorb from the sediments and maintain a somewhat elevated arsenic concentration in the future. At a minimum the concentration should not increase over what is present now and the present concentration is close to the MCL of 50 ug/l.

### 1.2.5 Community Concerns

In 1984, after the ViChem site was added to the National Priorities List, USEPA implemented a community relations program to inform area residents about the Superfund-related activities and to obtain their input. Community concern increased from moderate to relatively high and also became more specific. The involvement of organized environmental groups generated media attention and increased public awareness of the site.

As a result of USEPA's community relations activities, five major community concerns were identified:

- Human health risks from exposure to contaminated groundwater because some of the residents relied on groundwater for potable water;
- Human health risks from exposure to contaminated surface water because local rivers and lakes are used for recreation;
- Frustration over the perceived lack of remedial action at the site;
- A perceived lack of cooperation on behalf of ViChem during the remedial response process; and
- A perception of inadequate information from the NJDEP.

## 1.3 SUMMARY OF THE RI REPORT

The major findings of the River Areas RI as they relate to this FS are summarized below.

### 1.3.1 Physical System

The drainage basin area at various points along the Maurice River was presented in the RI. The basin area above the river's mouth at the Delaware Bay is approximately 380 square miles (sq mi). The USGS maintains a stream flow gaging station on the Maurice River at Norma, corresponding to Ebasco's sampling station ER-7 (see Figure 1-7). The drainage basin area above this point is 112 sq mi. The drainage basin area of the Blackwater Branch at the North Mill Road Bridge, Ebasco's station ER-4, was estimated to be 14 sq mi.



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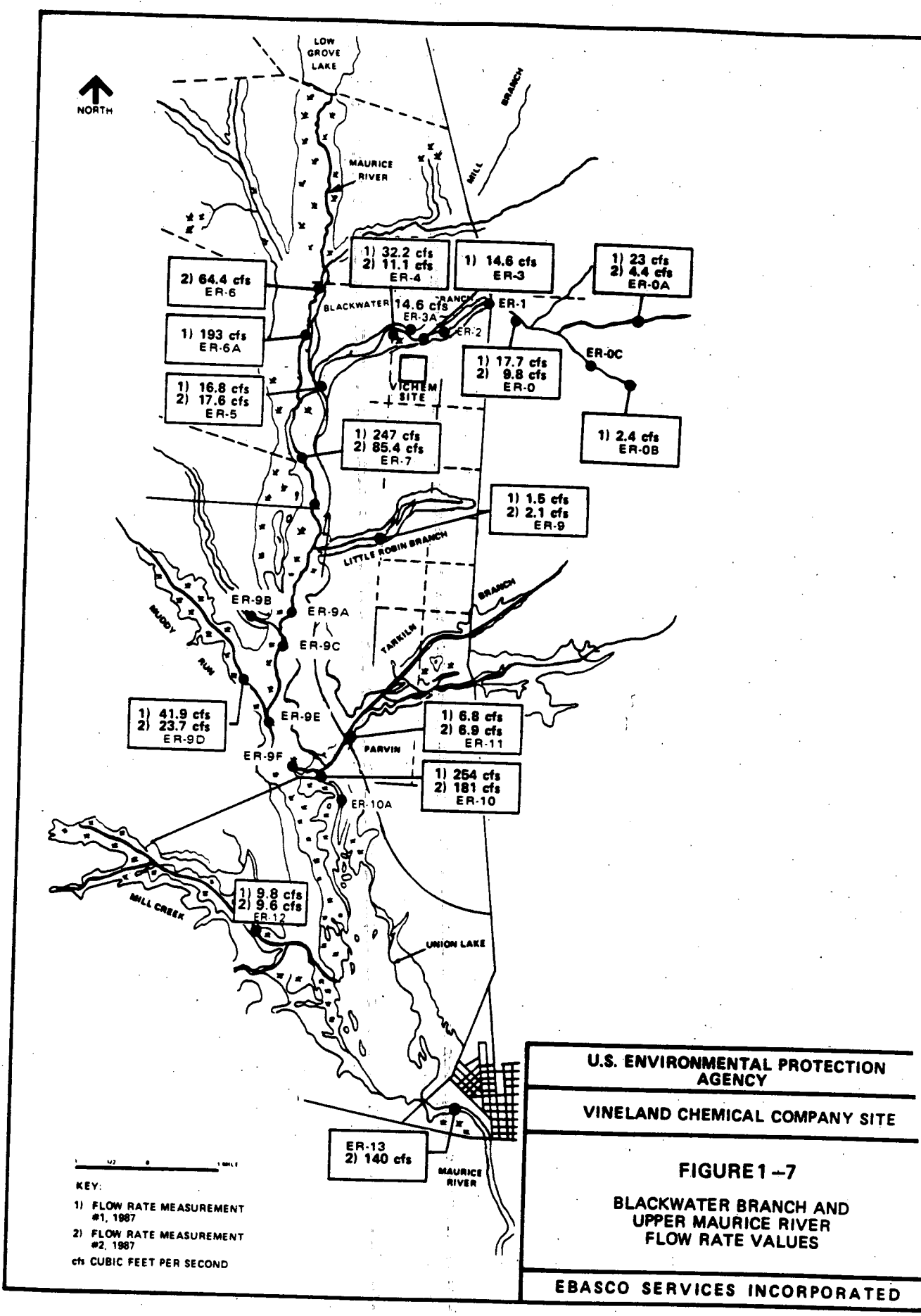


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VINELAND CHEMICAL COMPANY SITE

FIGURE 1-7

BLACKWATER BRANCH AND UPPER MAURICE RIVER FLOW RATE VALUES

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VIN 002 1230

Flows were measured at Ebasco's sampling stations during the RI. These are presented in Figure 1-7. The flows ranged from a low of 2.4 cubic feet per second (cfs) on the Blackwater Branch upstream from the ViChem plant to a maximum of approximately 250 cfs on the Maurice River.

The mean flow at the Norma gaging station for the 56-year period of record since 1932 is 167 cfs. The lowest recorded flow is 23 cfs. The 7-day Q10, the lowest mean flow expected to occur for seven days once every 10 years, is 37 cfs.

The mean and low flows of the Blackwater Branch at North Mill Road were estimated by applying the ratio of the drainage basin area at this point (14 sq mi) and the drainage basin area at Norma (112 sq mi) to the mean and low flows at Norma. The estimated mean flow of the Blackwater Branch at North Mill Road was 21 cfs, with the estimated lowest flow being 3 cfs. The 7-day Q10 is approximately 4.9 cfs.

A water balance was calculated from the data collected at the Norma gage and was presented in the RI. The water balances for the water years 1981-82, 1982-83, and 1984-85 are shown in Table 1-3.

The balance showed that slightly more than half (52%) of the available rainfall was lost to evapotranspiration, while slightly less than one quarter appeared in the stream as surface runoff. The remaining 26% (11.5 inches) recharged the groundwater and appeared in the stream as base flow.

It was estimated that the Maurice River in general was an effluent stream; that is, the river was recharged by the groundwater rather than recharging the groundwater itself. This estimate was based on several observations:

- Figure 1-8 shows water levels measured in the upper sand aquifer and the Blackwater Branch at the ViChem site. The groundwater flow direction was toward the Blackwater Branch. The groundwater elevations were higher than the stream elevations, indicating an upward gradient. It was estimated that approximately 492,000 gallons of groundwater flowed off the ViChem site per day and recharged the Blackwater Branch, as shown in Table 1-4.

- The water balance suggested that there was a significant component of base flow to the Maurice River, corresponding to approximately one quarter of the rainfall in the basin. This indicates that the groundwater recharges the stream and not vice versa.



VIN 002 1231

TABLE 1-3

SUMMARY OF ESTIMATED AVERAGE WATER BALANCE
MAURICE RIVER WATERSHED

| ITEM | 1981-1982 INCHES PER YEAR | 1982-1983 INCHES PER YEAR | 1983-1984 INCHES PER YEAR | AVERAGE OF 1981-1984 INCHES PER YEAR |
|---|---|---|---|---|
| Water Gains | | | | |
| Precipitation | 38.6 | 40.9 | 52.8 | 44.1 |
| Water Losses | | | | |
| Evapotranspiration | 23.6 | 20.7 | 24.3 | 22.9 (52%) |
| Surface Runoff | 5.5 | 11.0 | 13.1 | (22%) |
| Groundwater Base Flow | 9.5 | 9.2 | 15.4 | 11.5 (26%) |

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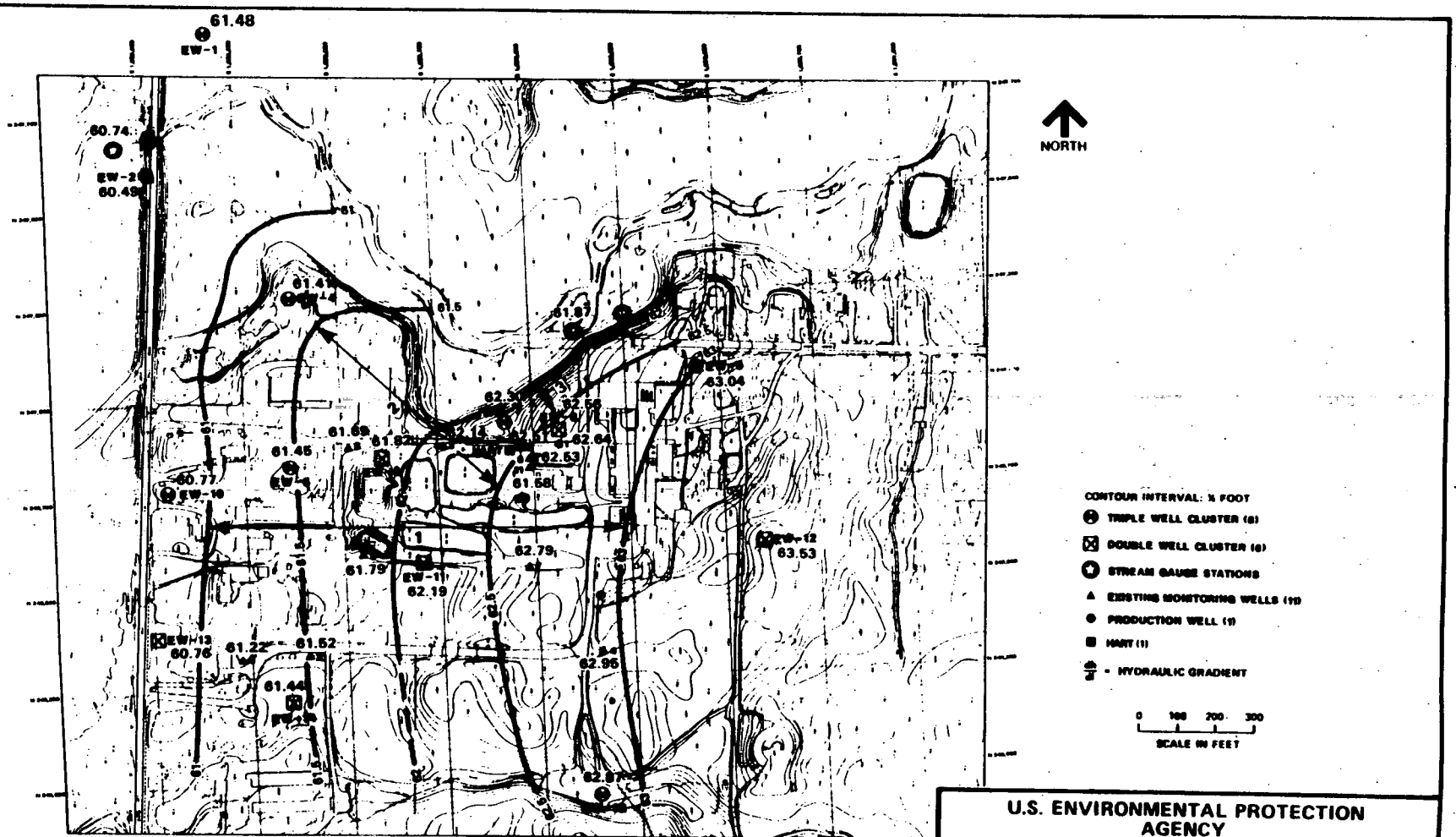


U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1–8

WATER TABLE ELEVATIONS – 10/19/87
SHALLOW, MW's & STREAM GAUGES

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TABLE 1-4

GROUNDWATER FLOW OFF SITE FROM UPPER SAND

| Date | $Q_1$* | $Q_2$* | $Q_3$* | Total |
|---|---|---|---|---|
| 10/19/87 | 158,922 | 70,753 | 261,241 | 490,916 |
| 11/21/87 | 150,093 | 70,753 | 146,295 | 367,141 |
| 1/27/88 | 158,922 | 44,337 | 365,738 | 618,997 |
| Average | 156,000 | 78,000 | 258,000 | 492,000 |

* All flows in gallons per day along vectors 1, 2 and 3.

VIN 002 1234

- The USGS flow data collected at Norma showed that the lowest recorded flow during the 56-year period of record since 1932 was 23 cfs. If the Maurice River were a losing stream, recharging the groundwater, it would be expected that during droughts the flow would drop to zero. Since this has not occurred since 1932, it is reasonable to expect that the Maurice River is recharged by the groundwater.

- The Cumberland County Water Resources Report from 1971 shows the generalized water levels in the Cohansey-Kirkwood aquifer, which comprises the near surface geology in the area (Rooney, 1971). These water levels are presented in Figure 1-9. The generalized groundwater flow lines point toward the Maurice River, indicating that the stream is recharged by the groundwater.

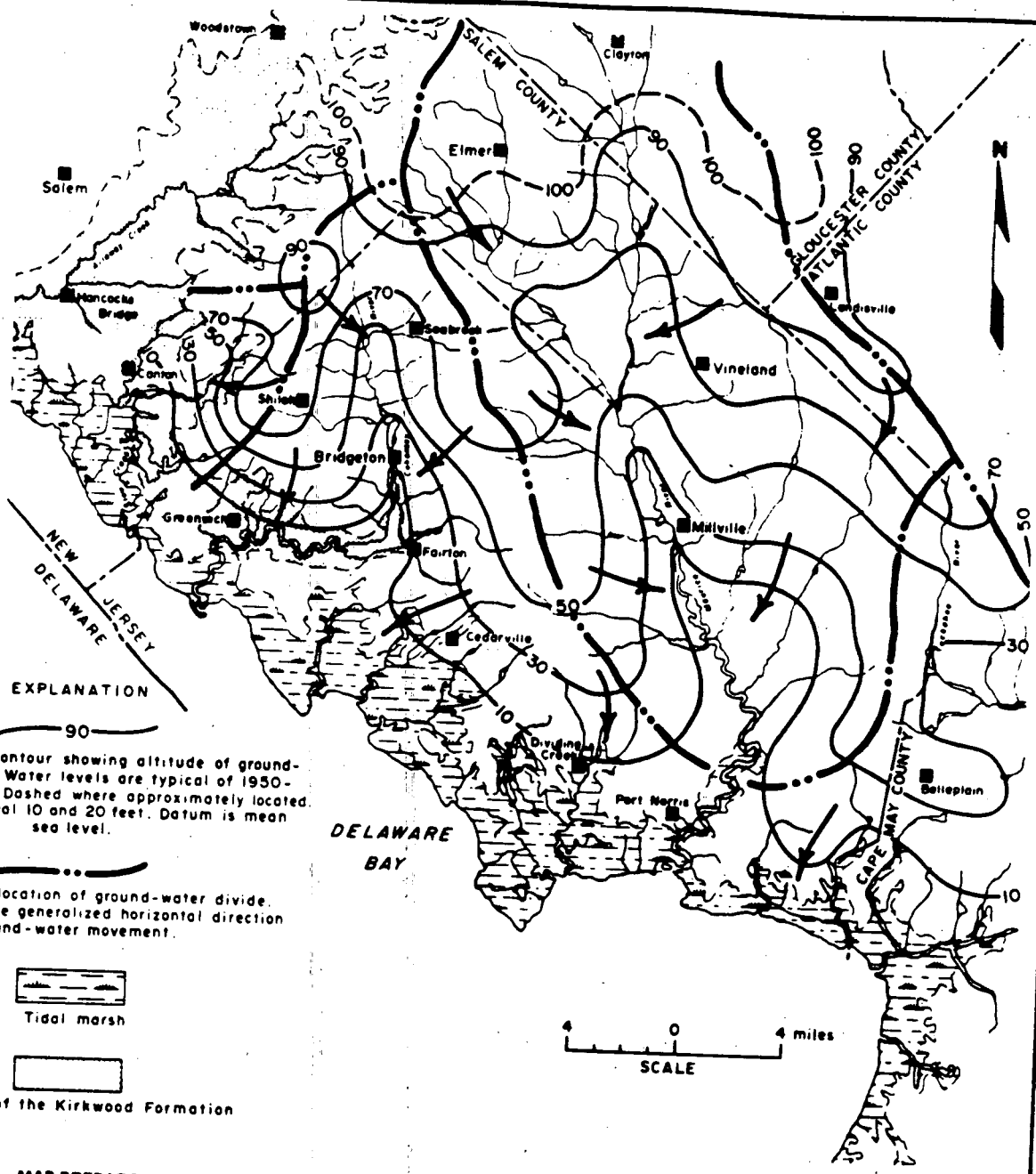
The above discussion was relevant to the River Areas in terms of contaminant migration. If a stream were contaminated and recharged the groundwater, then groundwater may become contaminated as well. If, however, the groundwater recharges the stream, then surface water contamination should remain channelized within the stream and should not migrate to the groundwater. While data were not available along the entire length of the Blackwater Branch and upper Maurice River, the available information suggested that surface water contamination should remain in the stream channel and should not migrate to the groundwater.

The floodplain boundary was discussed in the RI. Table 1-5 presents the distance of the 100-year flood boundary from the Maurice River at the Ebasco sampling stations. This information was obtained from the NJDEP Division of Coastal Resources.

In the Blackwater Branch, immediately adjacent to the site by stations ER-3, -3A, and -4, the flood boundary was affected by the topography. The 100-year floodplain was at the 66- to 67- foot elevation. The boundary therefore very closely approximates the limit of the flooding in the Blackwater Branch caused by the beaver dam, shown in Figure 1-4.

According to the Soil Survey of Cumberland County (USDA, 1978), the soils within the Blackwater Branch and the upper Maurice River floodplains are classified under the Muck-Atkinson- Berryland association, and are mostly Muck soils. These are lowland, nearly level, poorly drained organic and sandy soils. They are predominantly wooded, with Atlantic white cedar being most dominant. The water table is high for six months or more, which causes severe limitations for most uses. If drained, these soils have low available water capacities. Muck soils have low bearing capacities and if drained subside severely.

VIN 002 1235




EXPLANATION

90

Water-level contour showing altitude of ground-water levels. Water levels are typical of 1950-1960 period. Dashed where approximately located. Contour interval 10 and 20 feet. Datum is mean sea level.

Approximate location of ground-water divide. Arrows indicate generalized horizontal direction of ground-water movement.

Tidal marsh

Outcrop area of the Kirkwood Formation

**MAP PREPARED BY:** J. G. ROONEY, GROUNDWATER RESOURCES, CUMBERLAND COUNTY, N.J. USGS, WATER RESOURCES DIVISION, 1971.

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 1-9

GENERALIZED WATER LEVELS IN THE COHANSEY-KIRKWOOD AQUIFER

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VIN 002 1236

TABLE 1-5

100-YEAR FLOODPLAIN BOUNDARY
MAURICE RIVER

| | STATION NUMBER | APPROXIMATE FLOODPLAIN DISTANCE - 100-YEAR FLOOD BOUNDARY |
|---|---|---|
| UPPER MAURICE | ER-5 | <200 feet from the Maurice River |
| | ER-6 | <200 feet from the Maurice River |
| | ER-7 | <600 feet from the Maurice River |
| | ER-8 | <400 feet from the Maurice River |
| | ER-9 | On Little Robin Branch-Not Available |
| | ER-9A | <200 feet from the Maurice River |
| | ER-9B | <200 feet from the Maurice River |
| | ER-9C | <700 feet from the Maurice River |
| | ER-9D | <200 feet from the Maurice River |
| | ER-9E | <2000 feet from the Maurice River |
| | ER-9F | <1200 feet from the Maurice River |
| | ER-10 | <1200 feet from the Maurice River |
| | ER-10A | <1200 feet from the Maurice River |
| | ER-11 | On Parvin Branch-Not Available |
| | ER-12 | On Mill Creek-Not Available |
| | ALL EL's | In Union Lake-Less than 200 feet from Union Lake, mostly on banks |
| | ER-13 | <500 feet from Maurice River |
| | ER-14 | <900 feet from Maurice River |
| LOWER MAURICE | ER-20-37 | Varies between approximately 1,600 feet wide at north end of the Lower Maurice River to approximately 3,600 feet wide farther south near EA-37 |
| | ER-38-50 | Assumed to be similar to ER-20-37, Maps Not Available |

All "less than signs": One side of the river has 100-year Flood Boundary this distance from the river and the other side is th same or closer.

Source: Floodway Flood Boundary and Floodway Map, National Flood Insurance Program, NJDEP, Division of Coastal Resources, Trenton, NJ 1982-1985

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### 1.3.2 Nature and Extent of Contamination

The main contaminant of concern in the river areas was arsenic. Arsenic was detected at elevated concentrations in the sediment and surface water in the Blackwater Branch downstream from the ViChem plant, the upper Maurice River below its confluence with the Blackwater Branch, Union Lake, and the Maurice River below Union Lake. Arsenic concentrations were very low to undetected upstream from the plant.

The surface water arsenic concentrations in the Blackwater Branch and the upper Maurice River are shown in Figure 1-10. The highest arsenic concentration was observed in the flooded swamp caused by a beaver dam on the Blackwater Branch (over 6,000 ug/l). The swamp was directly adjacent to the ViChem plant and in the direction of the arsenic-contaminated ground-water plume emanating from the plant site. This swamp has been drained since the sampling took place through the removal of the beaver dam.

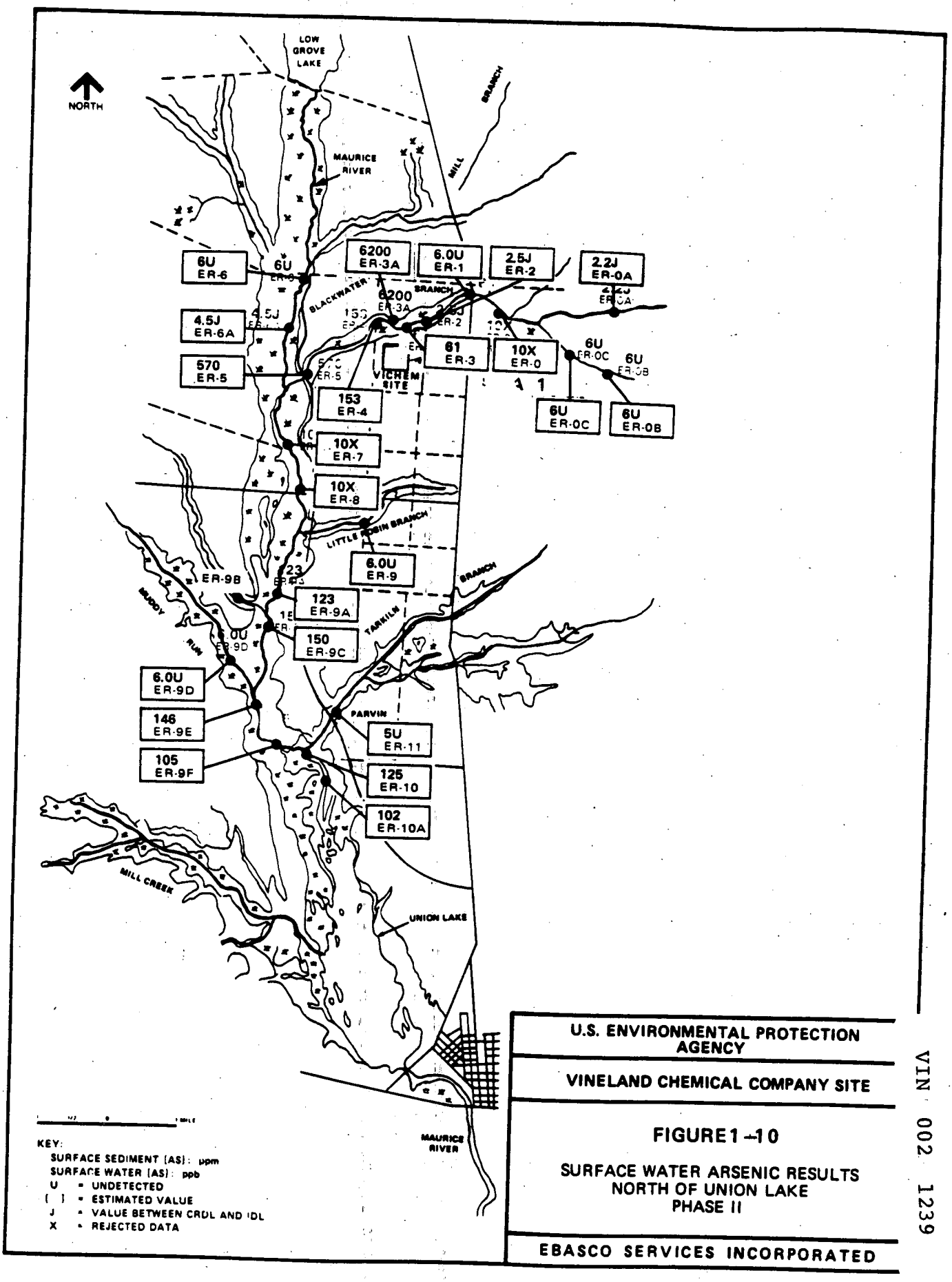
The arsenic concentration in the surface water decreased progressively downstream in the upper Maurice River, probably as a result of dilution. All of the tributaries to the Maurice River between the Blackwater Branch and Union Lake had undetected arsenic concentrations.

The total arsenic concentration in the Maurice River did not drop below 50 ug/l, the Federal Primary Drinking Water Standard for arsenic and the New Jersey Surface Water Standard for arsenic, until approximately 21 river miles downstream from the ViChem plant at station ER-37 in the lower Maurice River. In the 1979 sampling performed by the NJDEP, the total arsenic concentration in the surface water did not drop below 50 ug/l until approximately 26.5 river miles downstream from the site. All of the stations in the Blackwater Branch and the upper Maurice River had arsenic concentrations above 50 ug/l.

The surface sediment (0-1') arsenic concentrations are shown in Figure 1-11. Unlike the surface waters, there was no clear pattern of arsenic distribution aerially in the sediments. Some concentrations were higher further downstream than upstream. The sediment arsenic distribution is more likely controlled by arsenic's chemical partitioning to material of fine grain size and by the local deposition rate than by strict distance downstream from the site.



VIN 002 1238




U.S. ENVIRONMENTAL PROTECTION AGENCY

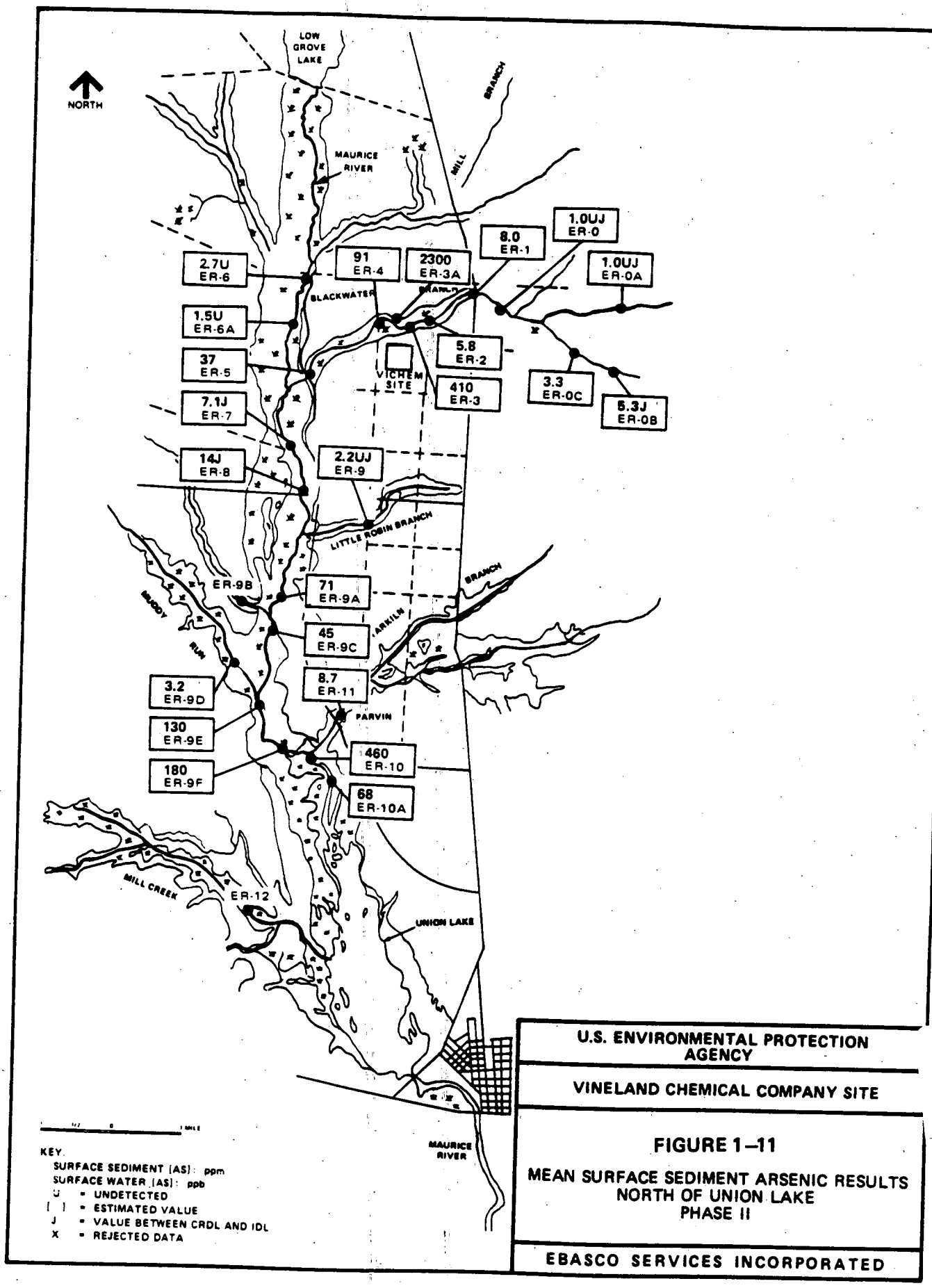
VINELAND CHEMICAL COMPANY SITE

FIGURE 1-10

SURFACE WATER ARSENIC RESULTS
NORTH OF UNION LAKE
PHASE II

EBASCO SERVICES INCORPORATED

VIN 002 1239




U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

**FIGURE 1–11**

**MEAN SURFACE SEDIMENT ARSENIC RESULTS NORTH OF UNION LAKE PHASE II**

EBASCO SERVICES INCORPORATED

VIN 002 1240

Sediment core samples were obtained in the Blackwater Branch and the upper Maurice River. The results of the chemical analyses and descriptions of the physical characteristics of the samples are presented in Appendix C. The arsenic concentration in the sediment cores was variable. In some cores the arsenic concentration was higher at the surface than at depth, while in some others the concentration was higher at depth. In some cross-sectional studies one core showed higher concentrations at the surface while another core showed the opposite. This was interpreted to indicate that the sediments were subject to mixing, resuspension and redeposition.

**Fish samples were taken in the upper Maurice River.** No pesticides/PCBs were found in the three fish samples taken; however, arsenic was detected in one of the fish samples, as shown in Figure 1-12. The arsenic concentration was within the range of normal background levels in fish and shellfish.

Other compounds detected in the river areas included mercury, lead, cadmium, chromium, antimony, toluene, TCE, Gamma-BHC, DDT, and Endosulfan sulfate. These compounds were generally detected at very low concentrations and posed no significant health or environmental risks, with the exception of mercury. An increased health risk from ingesting fish containing mercury was calculated. However, the calculation was based on the mercury concentration in the water and the bioconcentration factor for mercury in fish, not on actual measurements of mercury in fish tissue.

### 1.3.3 Contaminant Fate and Transport

The ViChem plant was shown to be the only significant source of arsenic to the Maurice River drainage basin. All river sections downstream from the site showed elevated levels of arsenic in both water and sediments. The levels of arsenic in all of the other tributaries studied were very low to undetected. Small sources below the Union Lake dam cannot be ruled out but no evidence exists for any inputs.

Based on samples collected by ViChem at North Mill Road, an estimated 500 metric tons of arsenic has been transported past North Mill Road into the Blackwater Branch and upper Maurice River over time. Instantaneous flux measurements by a number of investigators agree with the historic trend at North Mill Road and indicated that the flux from the site was 4 to 8 metric tons/yr in 1987. These fluxes were confirmed by cross checking Ebasco, USGS and ViChem data. Arsenic was transported in the basin in both dissolved and suspended forms. Arsenic concentrations varied throughout the year, inversely correlating with water flow.

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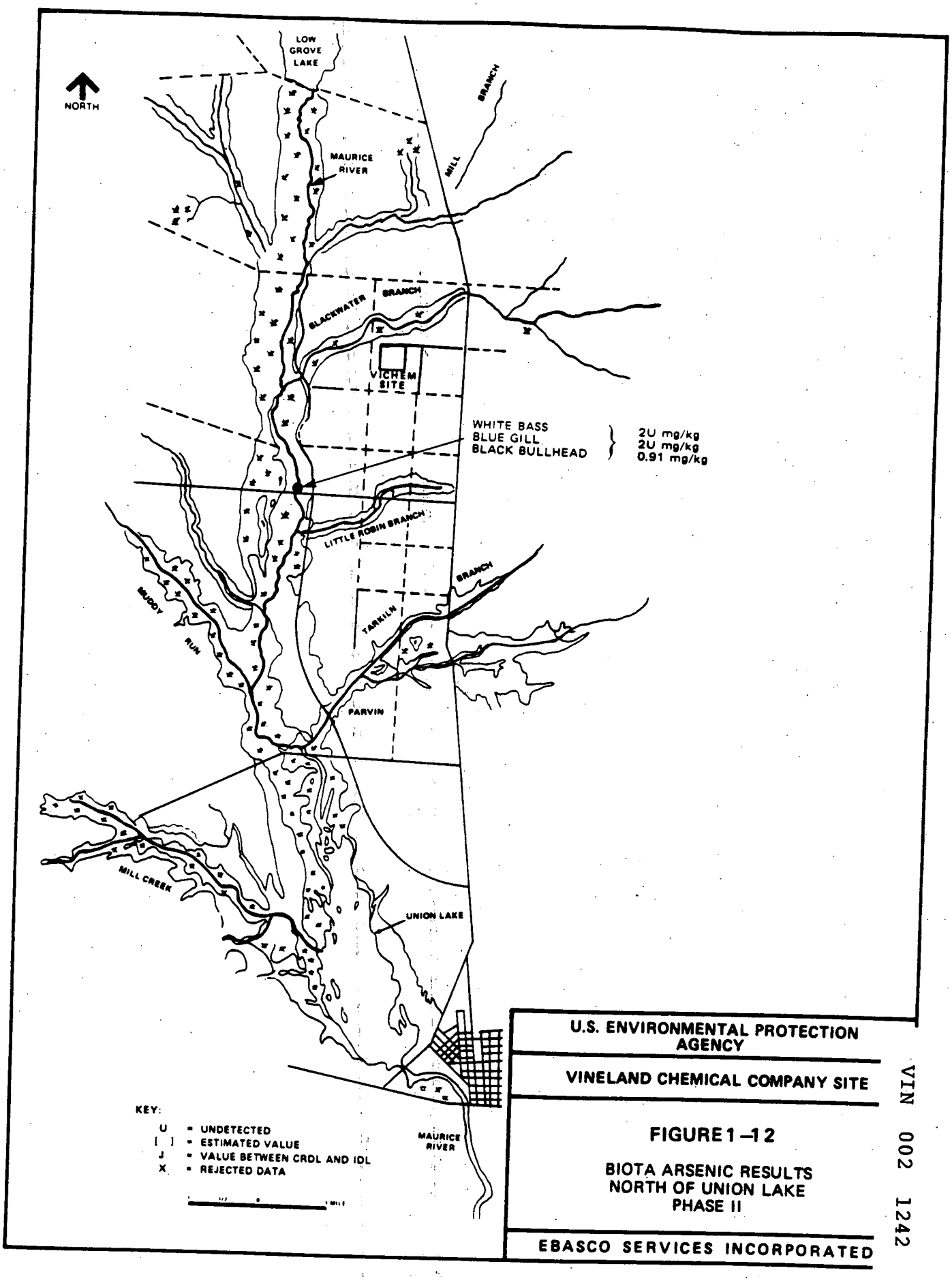


U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

**FIGURE 1-12**

BIOTA ARSENIC RESULTS
NORTH OF UNION LAKE
PHASE II

EBASCO SERVICES INCORPORATED

VIN 002 1242

Arsenic concentrations in the sediments of the Blackwater Branch and upper Maurice River positively correlated with total organic carbon content, iron content and percent clay. These data suggested that arsenic was bound to the sediments via organic carbon and ferric hydroxide matrices, which coat the finer sediments fractions. Leach tests of Union Lake sediments by Winka (1985) showed that 50 to 70 percent of the sediment-bound arsenic was not easily extractable. The fraction retained correlated positively with the percent of organic matter.

The Blackwater Branch and upper Maurice River appeared to be simple conduits for arsenic released from the site based on the arsenic mass balance for 1987 and the low inventory of arsenic in the sediments, approximately 6 metric tons. The effect of Union Lake on the present arsenic balance was unclear. Mass balance calculations showed it to be a simple conduit. However, sediment-water equilibria show that the lake water and sediments were near equilibrium. Given these conflicting mechanisms, the present fate of arsenic in the lake was not predictable. The large inventory of arsenic in the lake sediments (140 metric tons) showed that the lake has been a sink for arsenic in the past. In view of the low river sediment loads, the lake is most likely a depository for much of the arsenic. The lower Maurice River may have captured on the order of 50% of the arsenic that escaped from Union Lake in its estuarine sediments. The remaining arsenic has probably been transported to Delaware Bay.

Future arsenic levels are difficult to predict in certain parts of the basin even if the arsenic flux to the basin from the site is halted. The level of waterborne arsenic in the upper Maurice River and the Blackwater Branch should drop relatively quickly if the source of arsenic is eliminated (e.g., if groundwater remediation were undertaken at the ViChem plant site) due to the low arsenic inventory in the sediments of the rivers. Since it is not clear what is controlling the water column arsenic inventory in Union Lake at present, it is difficult to predict future levels of arsenic in the lake. Almost certainly though, the lake arsenic levels will decrease if the source of arsenic from the site is eliminated.

### 1.3.4 Risk Assessment

In the Blackwater Branch and the upper Maurice River, a semi-quantitative risk assessment for populations potentially exposed to the river sediments, water, and fish was prepared. Quantitative exposure models were developed. Measured contaminant concentrations were used to calculate site-specific carcinogeni risks, and to estimate probable noncarcinogenic risks. Risks wer estimated for both "worst case" and "most probable" exposur scenarios to determine the likely range of risks. The worst-cas scenario essentially assumed that the rivers were dry, a conditio

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now seen in the exposed Blackwater Branch floodplain since the beaver dam was drained. The most probable exposure scenario represented conditions characterized by flowing water in the stream channels, seen throughout the remainder of river areas.

The existing carcinogenic risks in the Blackwater Branch are shown in Tables 1-6 and 1-7. The total worst-case and most probable carcinogenic risks were $5x10^{-3}$ and $5x10^{-5}$, respectively. The noncarcinogenic risks in the Blackwater Branch are shown in Table 1-8. All are less than unity, indicating little potential for an adverse health impact.

The carcinogenic risks in the upper Maurice River are shown in Tables 1-9 and 1-10. The worst-case and most probable risks were $1x10^{-3}$ and $1x10^{-4}$, respectively. The noncarcinogenic risks shown in Table 1-11 were all less than unity. At the Almond Road beach, a popular local recreational area on the upper Maurice River, the total worst-case and most probable risks were $7x10^{-5}$ and $9x10^{-6}$, respectively, as shown in Table 1-12.

In all of the areas studied, ingestion, either of sediment, water or fish, composed essentially all of the risks. Dermal contact with the water and inhalation were insignificant.

The ingestion of fish with the arsenic concentrations found in this study posed risks above the $1x10^{-6}$ target level. However, it was pointed out in the RI that the actual risks may be much lower than the calculated risks. The form of arsenic in fish is generally nontoxic and is easily excreted by humans. Also, the level of arsenic found in the fish was within the range of arsenic normally found in fish and shellfish.

An environmental assessment was prepared by the USEPA's Environmental Response Team and was included as an appendix in the RI. The study concluded that an adverse environmental impact had occurred in the Blackwater Branch close to the ViChem site, but that the impact lessened downstream in the Maurice River. The impact took the form of lowered species diversity in the benthic community and an adverse response in bioassay tests performed using Blackwater Branch sediments. The primary reason cited for a lessened adverse impact in the Maurice River was flow dilution.

An increased health risk from ingesting mercury in fish was calculated. However, it was noted that the risk was based on estimated mercury concentrations in the biota determined from the mercury concentration in the surface water and the bioconcentration factor. The biota samples were not analyzed for mercury; therefore their actual mercury concentration is unknown.

A data quality analysis was performed and the limitations of t risk assessment were discussed. It was concluded that while t analytical data used were of the highest quality, there wa



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TABLE 1-6

SUMMARY OF WORST-CASE CANCER RISKS FROM EXPOSURE PATHWAYS IN BLACKWATER BRANCH USING MAXIMUM CONCENTRATIONS OF ARSENIC IN SEDIMENT (3760 mg/kg), WATER (6200 ug/l)

| | INGESTION[1] | | | DIRECT CONTACT[1] | INHALATION[2] | TOTAL CANCER RISK FROM ALL EXPOSURE PATHWAYS |
|---|---|---|---|---|---|---|
| | Bottom Sediment | Stream Water | Total Ingestion | Stream Water | Exposed Sediment | |
| Cancer Risk | $2 \times 10^{-3}$ | $3 \times 10^{-3}$ | $5 \times 10^{-3}$ | $6 \times 10^{-5}$ | $1 \times 10^{-5}$ | $5 \times 10^{-3}$ |
| Percent of Total Exposure[3] | 38.1% | 60% | 98.1% | 1.15% | 0.19% | 100% |

1 These risks reflect a 70-year chronic exposure to Blackwater Branch.

2 This risk is calculated assuming drought conditions for 5 years.

3 The percentage of total exposure are calculated before cancer risks are rounded to 1 significant figure.

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TABLE 1-7

SUMMARY OF "MOST PROBABLE CASE" CANCER RISKS FROM EXPOSURE PATHWAYS IN BLACKWATER BRANCH USING MEDIAN CONCENTRATIONS OF ARSENIC IN SEDIMENT (229 mg/kg), WATER (361 ug/l)

| | INGESTION[1] | | | DIRECT CONTACT[1] | INHALATION[2] | TOTAL CANCER RISK FROM ALL EXPOSURE PATHWAYS |
|---|---|---|---|---|---|---|
| | Bottom Sediment | Stream Water | Total Ingestion | Stream Water | | |
| Cancer Risk | $2 \times 10^{-5}$ | $3 \times 10^{-5}$ | $5 \times 10^{-5}$ | $8 \times 10^{-7}$ | $8 \times 10^{-8}$ | $5 \times 10^{-5}$ |
| Percent of Total Exposure[3] | 37.4% | 60.2% | 97.5% | 1.5% | 0.14% | 100% |

1 These risks reflect a 70-year chronic exposure to Blackwater Branch.

2 This risk is calculated assuming drought conditions for 5 years.

3 The percentage of total exposure are calculated before cancer risks are rounded to 1 significant figure.

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TABLE 1-8

SUMMARY OF WORST-CASE CHRONIC HAZARD INDICES FROM EXPOSURE TO NON-CARCINOGENS IN BLACKWATER BRANCH

| | INGESTION | | DIRECT CONTACT | CUMULATIVE INTAKE FROM MULTIPLE EXPOSURES |
|---|---|---|---|---|
| | Sediment | Stream Water | Stream Water | |
| Mercury CDI[1] | $6.1 \times 10^{-8}$ | $1.0 \times 10^{-6}$ | $1.7 \times 10^{-8}$ | $1.1 \times 10^{-6}$ |
| AI | $(1.4 \times 10^{-3})$[2] | $(3.0 \times 10^{-4})$[4] | $(3.0 \times 10^{-4})$[4] | |
| CDI/AI (Hazard Index) | $4.4 \times 10^{-5}$ | $3.3 \times 10^{-3}$ | $5.7 \times 10^{-5}$ | $3.3 \times 10^{-3}$ |
| Lead CDI | $4.3 \times 10^{-4}$ | NA | NA | $4.3 \times 10^{-4}$ |
| AI[3] | $1.4 \times 10^{-3}$ | NA | NA | |
| CDI/AI (Hazard Index) | 0.3 | NA | NA | 0.3 |

1. CDI[1] - Site-specific chronic intake rate (mg/kg/day) for the exposure pathway listed based on the maximum concentration found in the particular matrix listed.

2. AI - Acceptable chronic intake rate (mg/kg/day) for inorganic mercury and compounds.

3. This acceptable chronic intake rate is for inorganic lead and compound.

4. AI Acceptable chronic intake (mg/kg/day) for alkyl mercury and compounds.

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TABLE 1-9

SUMMARY OF WORST-CASE CANCER RISKS FROM EXPOSURE PATHWAYS IN UPPER MAURICE RIVER USING MAXIMUM CONCENTRATIONS OF ARSENIC IN SEDIMENT (922 mg/kg), WATER (150 ug/l)

| | INGESTION[1] | | | | DIRECT CONTACT[1] | |
|---|---|---|---|---|---|---|
| | Bottom Sediment | Stream Water | Fish[2] | Total Ingestion | Stream Water | TOTAL CANCER RISK FROM ALL EXPOSURE PATHWAYS |
| Cancer Risk | $5 \times 10^{-4}$ | $8 \times 10^{-5}$ | $8 \times 10^{-4}$ | $1 \times 10^{-3}$ | $1 \times 10^{-6}$ | $1 \times 10^{-3}$ |
| Percent of Total Exposure[3] | 35.4% | 5.5% | 59.3% | 100% | 0.11% | 100% |

1 These risks reflect a 70-year chronic exposure to upper Maurice River.

2 This risk is calculated from arsenic concentration in fish tissue.

3 The percentage of total exposure are calculated before cancer risks are rounded to 1 significant figure.

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TABLE 1-10

SUMMARY OF "MOST PROBABLE CASE" CANCER RISKS FROM EXPOSURE PATHWAYS IN UPPER MAURICE RIVER USING MEDIAN CONCENTRATIONS OF ARSENIC IN SEDIMENT (70.8 mg/kg), WATER (124 ug/l)

| | INGESTION[1] | | | | DIRECT CONTACT[1] | |
|---|---|---|---|---|---|---|
| | Bottom Sediment | Stream Water | Fish[2] | Total Ingestion | Stream Water | TOTAL CANCER RISK FROM ALL EXPOSURE PATHWAYS |
| Cancer Risk | $6 \times 10^{-6}$ | $1 \times 10^{-5}$ | $1 \times 10^{-4}$ | $1 \times 10^{-4}$ | $3 \times 10^{-7}$ | $1 \times 10^{-4}$ |
| Percent of Total Exposure[3] | 4.1% | 7.4% | 88.5% | | 0.18% | 100% |

1. These risks reflect a 70-year chronic exposure to upper Maurice River.
2. This risk is calculated from arsenic concentration in fish tissue.
3. The percentage of total exposure are calculated before cancer risks are rounded to 1 significant figure.

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VIN 002 1249

TABLE 1-11

SUMMARY OF WORST-CASE CHRONIC HAZARD INDICES FROM EXPOSURE TO NON-CARCINOGENS IN UPPER MAURICE RIVER

| | INGESTION | | | DIRECT CONTACT | CUMULATIVE INTAKE FROM MULTIPLE EXPOSURES |
|---|---|---|---|---|---|
| | Sediment | Stream Water | Fish | Stream Water | |
| Mercury CDI[1] | $4.3 \times 10^{-7}$ | $6.4 \times 10^{-7}$ | $3.6 \times 10^{-3}$ | $1.1 \times 10^{-8}$ | $3.6 \times 10^{-3}$ |
| AI | $(1.4 \times 10^{-3})$[2] | $(3.0 \times 10^{-4})$[3] | $(3.0 \times 10^{-4})$[3] | $(1.4 \times 10^{-3})$[2] | |
| CDI/AI (Hazard Index) | $3.1 \times 10^{-4}$ | $2.1 \times 10^{-3}$ | 12 | $7.9 \times 10^{-6}$ | 12 |
| Endosulfan sulfate[4] CDI | $5.9 \times 10^{-8}$ | NA | NA | NA | $5.9 \times 10^{-8}$ |
| AI | $5.0 \times 10^{-5}$ | NA | NA | NA | |
| CDI/AI (Hazard Index) | $1.2 \times 10^{-3}$ | NA | NA | NA | $1.2 \times 10^{-3}$ |

1. CDI - Site-specific chronic intake rate (mg/kg/day) for the exposure pathway listed based on the maximum concentration found in the particular matrix listed.

2. AI - Acceptable chronic intake (mg/kg/day) for inorganic mercury and compounds.

3. AI - Acceptable chronic intake (mg/kg/day) for alkyl mercury and compounds.

4. AI - Acceptable chronic intake (mg/kg/day) for endosulfan is used since there is no acceptable intake established for endosulfan sulfate.

NA - Not applicable. The chemical parameter was not detected within the stream water.

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VIN 002 1250

TABLE 1-12

SUMMARY OF CANCER RISKS FROM MAJOR EXPOSURE PATHWAYS AT ALMOND ROAD BEACH

| | INGESTION[1] | | DIRECT CONTACT[1] | TOTAL CANCER RISK FROM ALL EXPOSURE PATHWAYS |
|---|---|---|---|---|
| | SEDIMENT BOTTOM SEDIMENT | STREAM WATER | STREAM WATER | |
| **Worst-Case** | | | | |
| Cancer Risk | $2 \times 10^{-5}$ | $5 \times 10^{-5}$ | $9 \times 10^{-7}$ | $7 \times 10^{-5}$ |
| Percent of Total Exposure[2] | 25.9% | 72.5% | 1.4% | 100% |
| **Most Probable Case** | | | | |
| Cancer Risk | $1 \times 10^{-6}$ | $8 \times 10^{-6}$ | $2 \times 10^{-7}$ | $9 \times 10^{-6}$ |
| Percent of Total Exposure[2] | 14.2% | 83.5% | 2.1% | 100% |

1. These risks reflect a 70-year chronic exposure to upper Maurice River.
2. The percentage of total exposure are calculated before cancer risks are rounded to 1 significant figure.

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enough uncertainty in the exposure assumptions to attach confidence in the risk calculations only within one order of magnitude.

### 1.3.5 Recommended Remedial Action Objectives

The source of the arsenic contamination to the river system is the groundwater discharge off the ViChem site. Before any remedial action is taken in the river area, this source should be eliminated.

The formerly flooded area near the Blackwater Branch contains very high arsenic concentrations. This area is now exposed since the beaver dam was breached, making public access to the former sediments more likely. There are other areas where sediment arsenic concentrations are elevated and are estimated to pose potential health risks. Table 1-13 presents sediment arsenic concentrations that produce various risk estimates, based on the worst case and most plausible pathway models. Public access to areas with sediment arsenic concentrations greater than that deemed acceptable by the USEPA, considering Table 1-13, should be eliminated. This can be accomplished by some type of remedial action such as removal, or through sign posting.

The river water is contaminated with arsenic. However, the data indicates that once the arsenic source from the plant is eliminated, the river arsenic concentration should decrease. Because of this and because of the infeasibility of treating a flowing stream, no remedial action other than removing the source of arsenic (the groundwater discharge) is recommended. A monitoring program should be implemented to monitor/verify the effectiveness of any remedial action. Since groundwater contamination was one of the focuses of the plant site FS (Ebasco, 1988b), surface water remedial alternatives are not considered in this FS.

The fish in the river contain some arsenic; however there are limited remedial alternatives for this problem. If the USEPA risk managers determine, either through additional sampling or a further review of the literature, that the fish arsenic concentration is unacceptably high, then a remedial action such as posting signs banning fishing could be taken. Detailed consideration should be given before taking this action, however, due to the uncertainties of the risk estimates and the popularity of this activity to the local population. Because of the uncertainties regarding fish ingestion, remedial alternatives for the fish ingestion risks are not considered in this FS.

In summary, the recommended remedial action objective for the river areas is as follows:

VIN 002 1252

TABLE 1-13

CALCULATED RISK FROM SEDIMENTS
AT
VARIOUS ARSENIC CONCENTRATIONS

| CALCULATED RISK[1] | SEDIMENT ARSENIC CONCENTRATION (mg/kg)[2] |
|---|---|
| Worst Case: | |
| $1 \times 10^{-4}$ | 200 |
| $1 \times 10^{-5}$ | 20 |
| $1 \times 10^{-6}$ | 2 |
| $1 \times 10^{-7}$ | 0.2 |
| Most Probable Case: | |
| $1 \times 10^{-4}$ | 1200 |
| $1 \times 10^{-5}$ | 120 |
| $2 \times 10^{-6}$ | 20 |
| $1 \times 10^{-6}$ | 12 |
| $1 \times 10^{-7}$ | 1.2 |

[1] Calculated risks assume sediment exposure pathways only.

[2] Contract Laboratory Program Required Detection Limit for arsenic in soil/sediment is approximately 1 mg/kg.



VIN 002 1253

- Minimize public access, either through containment, removal, or institutional controls, to areas with unacceptably high sediment arsenic concentrations, particularly the exposed former sediments in the Blackwater Branch floodplain.

This FS report will concentrate on remedial alternatives for the contaminated sediments in the Blackwater Branch and the Maurice River between the Blackwater Branch and Union Lake.

### 1.3.6 Additional Data Needs

Some additional data needs were presented in the RI. The need to obtain these data is dependent in some instances on the remedial actions chosen for the river areas. The needs are discussed below.

- Additional studies to determine the adsorption/desorption rates of arsenic from the sediments should be performed. These could aid in determining the fate and transport of arsenic within the sediments. Presently, it is known that arsenic can desorb from the sediments, but the extent to which this desorption will influence the water quality of the Blackwater Branch and the lower Maurice River is unknown since the partitioning mechanisms and the sorption rates are not known. Detailed information on these processes would help determine if remediation of sources upstream of Union Lake would lower the arsenic concentration in the lake and the lower Maurice River.

- The mass balance of arsenic coming in and out of the lake should be determined to aid in delineating whether the lake water arsenic content is controlled by upstream input from the river or by desorption from the sediments. This could be accomplished by measuring the flow and arsenic concentration of the lake's outflow, and comparing this with the flow and arsenic concentration at the USGS gaging station at Norma, upstream from the lake.

  Logistically, the sampling program would be fairly simple to put in place. The USGS gaging station at Norma is now operational, and the frequency of sampling could be increased to monthly or semi-monthly sampling for both dissolved and total arsenic. Some type of flow measuring device could be easily installed on the dam at the controlled outlet of Union Lake. Water samples could be obtained on the same frequency as samples from the Norma station. A comparison of the results through time would provide valuable data to determine the arsenic balance of



VIN 002 1254

the lake. If the program were started relatively quickly, a data base would be established prior to performing any remedial action at the lake, and would help to determine its effectiveness. Also, this type of sampling would have a relatively low cost.

- As data are being gathered for the above, mathematical models should be developed to forecast the future distribution of the sediments. Present day data would be used to calibrate and optimize the model to an extent that would enable accurate predictions of sediment and surface water concentrations of arsenic in and below the Maurice River. Thus areas that would be most sensitive to remediation efforts could be focused upon prior to the actual cleanup. This would also aid in determining the long-term effectiveness of remediation.

- The areas of suspected contamination found to be sensitive to natural river dynamics would require verification sampling prior to remediation. Verification sampling would serve as a "reality testing" mechanism to help avoid the costly remediation of a potentially uncontaminated area while better defining areas requiring remedial actions. Since the river is a dynamic system, it is likely that any sampling conducted well in advance of a remediation would not represent the conditions during remediation. Therefore, the additional sediment sampling should be conducted as close to the time of remediation as possible.



VIN 002 1255

VIN 002 1256

## 2.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

### 2.1 INTRODUCTION

The purpose of this section is to develop a remedial action objective for the contaminated sediments and to identify and screen the most appropriate technologies to remediate the contamination. The technologies are combined into remedial action alternatives for source control in Section 3.0.

This section describes a three-step process for identifying and screening potential technologies. First, the remedial action objective for the contamination is developed based on contaminant characterization, risk assessment, and compliance with applicable or relevant and appropriate requirements (ARARs). Second, technology screening criteria are developed based on the remedial action objective, site-specific requirements and contaminant characteristics. General response actions, which address the site problems and meet cleanup goals and objectives, are identified. Third, potential technologies associated with each response action are identified and evaluated. The technology types are screened to determine those that are feasible or applicable to the site based upon the established criteria. The technologies that pass this screening are combined into remedial alternatives in Section 3.0.

In some cases, selected process options rather than a large set of essentially similar individual technologies are evaluated to simplify the screening process. Process options are relatively similar or equivalent technologies that will achieve the same or a similar end result, or are closely related to one another. When a group of technologies is evaluated as a process option, this implies that the use of any of the technologies would be similar. This simplifies the technology screening process.

This section is comprised of three subsections as follows:

- 2.2 Remedial Action Objective
- 2.3 General Response Actions
- 2.4 Identification and Screening of Technology Types and Process Options

### 2.2 REMEDIAL ACTION OBJECTIVE

The remedial action objective for the river areas is as follows:

- Minimize public access, either through removal, containment, or institutional controls, to areas with unacceptably high sediment arsenic concentrations, particularly the exposed former sediments in the Blackwater Branch floodplain.

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This objective was developed after considering all of the data from the RI and the risk assessment as discussed below.

### 2.2.1 Contaminants of Interest

As discussed in Subsection 6.1.1.1 of the River Areas RI (Ebasco, 1989c), a number of organic and inorganic contaminants were detected in the Blackwater Branch and the upper Maurice River. Inorganics included arsenic, lead, and mercury. Organics included TCE and the pesticides Endosulfan sulfate, DDT, and Gamma-BHC.

Arsenic was determined to be the main contaminant of concern. The calculated health risks from the other contaminants were found to be minimal with the possible exception of mercury. Therefore, arsenic contamination is the focus of this FS.

### 2.2.2 Allowable Exposure Based on Risk Assessment

The risk assessment identified a number of pathways whereby the public could be exposed to the water, sediments, and fish. The contaminants of concern were evaluated within each of these pathways to determine the overall health risks. The findings of the evaluation are summarized in Subsection 1.3.4.

The risk assessment considered worst-case exposure scenarios and most plausible exposure scenarios. Maximum contaminant concentrations were used to calculate risks for the worst-case exposure scenario, while mean contaminant concentrations were used to calculate risks for the most plausible exposure scenario. The end result of the risk assessment was the development of a series of calculations that showed, for both the worst-case and most plausible exposure scenarios, the total risk from recreational use of the river, the risk from recreational exposure to various media in the river (sediment, surface water, fish), and the risks from different types of exposure to each medium (dermal contact, ingestion, inhalation).

The risks from exposure to the sediments were the focus of this FS. Potential increased health risks were calculated for incidental ingestion of river water and for ingesting fish from the river. However, remedial alternatives for these two media were not included in this FS for the following reasons:

Water

- The mean flow rate of the Maurice River is at least 168 CFS, which is the mean flow of the Maurice River at the Norma gaging station approximately 4 miles upstream from the lake. It would be impractical to divert and treat part or all of this flow.

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- The groundwater discharge of the ViChem plant, which is the source of arsenic in the Maurice River, should be eliminated prior to considering any remedial alternatives for the downstream water, including the water in the Maurice River and the water in Union Lake.

Fish

- There are no practical remedial alternatives to reduce arsenic concentrations already found in fish.

- The risk assessment assumed that the arsenic detected in the fish was a combination of As (III) and As (V) in the same proportion as was found in the studies used to determine the Cancer Potency Factor (CPF) for arsenic. In fact, other studies suggest that the arsenic found in the fish would be an organic form that is relatively nontoxic. The form of arsenic found in the fish samples was not determined, but may be determined in further studies by the USEPA.

- The concentration of arsenic in the fish samples, approximately 1 mg/kg, is within normal background levels for fish and shellfish.

Allowable concentrations of arsenic in both the submerged and exposed sediments, considering human recreational exposure, were calculated from the risk assessment. The most plausible exposure pathway models were used to back calculate the health risks that would be produced at various arsenic concentrations. Then a target risk level was established, and the sediment arsenic concentration corresponding to the target risk level became the basis for the sediment remedial alternatives.

Three sediment exposure pathways were considered: inhalation, dermal contact, and accidental ingestion. The most plausible risks calculated for each of these pathways are summarized below:

- Inhalation - This pathway is most valid for the exposed sediments of the Blackwater Branch. The most plausible risk from this pathway, which corresponds to the cancer risk, is approximately $1x10^{-5}$, or one incident of cancer per one hundred thousand exposed persons.

- Dermal Contact - This pathway is valid for both submerged and exposed sediments. The most plausible risk from this pathway in the Blackwater Branch is $6x10^{-5}$, or six incidents of cancer per one hundred thousand people. The most probable risk from dermal contact of sediment in the Upper Maurice River is $3x10^{-7}$, or three incidents of cancer per ten million exposed persons. These potential risks were considered

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to be too low to warrant consideration of remedial alternatives for this pathway.

- Ingestion - This pathway comprises the majority of the risk from the sediment exposure pathways. Using the mean arsenic concentration in the submerged sediments, the present most probable risk calculates to $6x10^{-6}$. Using the most probable pathway models, a submerged sediment arsenic concentration of 120 mg/kg corresponds to a risk of $1x10^{-5}$, or one incident of cancer per one hundred thousand people exposed to the sediments. Similarly, the present risk from the exposed Blackwater Branch sediments, corresponding to worst-case scenario risk levels, calculates to $2x10^{-3}$. Back-calculating from the worst-case pathway models, a sediment arsenic concentration of 20 mg/kg corresponds to a risk of $1x10^{-5}$ from these exposed sediments.

After reviewing these data, the USEPA, in conference with the NJDEP, determined that the sediment cleanup level should be 120 mg/kg arsenic in the submerged sediment, and 20 mg/kg arsenic in the exposed sediments in the Blackwater Branch. These correspond to a risk of $1x10^{-5}$. A cleanup level of 120 mg/kg is acceptable for the submerged sediments; however, in order to provide an extra measure of protection of human health, a cleanup level of 20 mg/kg was established for the submerged sediments in the more accessible areas of the river including Almond Road Beach and the areas within 100 feet of either side of a river crossing. A cleanup level of 20 mg/kg in the more accessible river areas corresponds to a risk of $2x10^{-6}$, or two incidents of cancer per one million people exposed to the sediments. These are the sediment cleanup levels that the USEPA directed be used for this FS.

The risks associated with the target cleanup level of 120 mg/kg for submerged sediments and the target cleanup level of 20 mg/kg for the exposed floodplain sediments and the more accessible river sediments are within the USEPA guidance range for remediation. These risks are between $1x10^{-4}$ and $1x10^{-7}$.

### 2.2.3 Allowable Exposure-Based on ARARs

River Water

The following ARARs established a 50 ug/l total arsenic concentration as the criteria/standards for drinking water, groundwater or surface water quality:

- Safe Drinking Water Act MCLs;
- New Jersey Water Standards (NJAC 7:9-6.6) Groundwater Quality Criteria;



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- New Jersey Water Standards (NJAC 7:9-4.14C) Surface Water Quality Criteria for FW2 Waters; and

- New Jersey Pollution Discharge Elimination System (NJAC 7:14A-6.15) Maximum Concentration of Constituents for Groundwater Protection.

In addition, the Clean Water Act Water Quality Criteria for Protection of Human Health established a 2.2 ng/l arsenic level for water and fish ingestion, which was later adjusted to 25 ng/l for water ingestion only.

As shown in Figure 1-10, although the river water contains total arsenic exceeding ARAR criteria/standards, the dissolved arsenic concentrations of the river water are very close to the 0.05 mg/l limit.

River Sediments

No federal or state ARARs exist that establish a cleanup action level for contaminated soils and sediments. The NJDEP has a department guidance value for arsenic in soils. The federal government, through the RCRA program, has established certain criteria by which a soil or sediment may be considered hazardous or nonhazardous.

The NJDEP's department guidance value for arsenic in soils is 20 mg/kg. However, the NJDEP stresses that this is a guidance value only.

The RCRA program has also established certain criteria by which a soil may be considered hazardous or nonhazardous. In the case of soils contaminated with arsenic, if the leachable arsenic concentration following a RCRA Part 261 Extraction Procedure (EP) Toxicity Test or Part 268 Toxicity Characteristic Leaching Procedure (TCLP) test exceeds 5 mg/l, the soil may be considered hazardous because it is "characteristic". Also, if a soil has been contaminated with arsenic as a result of contact with a listed hazardous waste, the soil is also considered a listed hazardous waste. In the case of the river area sediments, the elevated arsenic concentrations are a result of the sediments being contacted by water containing arsenic derived from the listed hazardous waste K 031. As a result of this, personnel from USEPA's Site Policy and Guidance Branch, Hazardous Site Control Division (HSCD), have determined that the contaminated sediments shall also be considered a listed hazardous waste for the purposes of disposal. This designation does not, however, establish a cleanup level based on the arsenic concentration.

In summary, no state or federal ARARs exist to establish a cleanup level for the arsenic-contaminated sediments in the Maurice River and the Blackwater Branch. The cleanup levels and



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the areas requiring remediation were established as discussed above under risk-based cleanup levels.

### 2.2.4 Development of Remedial Action Objectives

Any remedial actions in the Blackwater Branch and the upper Maurice River must consider that these water bodies and associated sediments are a part of a dynamic system. The source of arsenic into this system is the groundwater discharge off the ViChem plant. This source must be eliminated prior to initiating any downstream remedial action. Eliminating this source was the focus of the Plant Site FS (Ebasco, 1989b).

Exposure to the river water was shown to pose potential health risks. However, the River Areas RI concluded that the river system was behaving as a conduit, transferring the arsenic downstream. Therefore, by eliminating the source of arsenic, the arsenic concentration in the river water should decrease. Since this was the focus of the Plant Site FS, remedial alternatives for the river water are not considered in this FS.

Ingestion of fish from the upper Maurice River was shown to pose possible health risks. No remedial alternatives were considered for the fish because the detected arsenic concentrations were within normal background levels and the form of arsenic in the fish may be relatively nontoxic.

Exposure to the sediments in the Blackwater Branch and the upper Maurice River were shown to pose a potential health risk. No federal or state ARARs exist establishing a cleanup level for contaminated sediments. The risk assessment determined also that exposure to the exposed sediments in the Blackwater Branch with arsenic concentrations greater than 20 mg/kg would yield elevated cancer risks greater than $1x10^{-5}$. The risk assessment determined also that exposure to submerged sediments containing 120 mg/kg arsenic would produce cancer risks of approximately $1x10^{-5}$, or one incident of cancer per one hundred thousand exposed persons. In addition, the risk assessment established that an action level of 20 mg/kg would provide an increased measure of health protection for exposure to submerged sediments.

If the human health risks, as well as the elevated concentrations of arsenic found in the sediments of the Maurice River and the Blackwater Branch, are to be reduced to acceptable levels, remedial actions must be developed to address the following objective:

- Minimize public access, either through containment, removal, or institutional controls, to areas with unacceptably high sediment arsenic concentrations, particularly the exposed former sediments in the Blackwater Branch floodplain.



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The focus of this FS is the determination of remedial alternatives for the submerged and exposed sediments having arsenic concentrations greater than 20 mg/kg in the Blackwater Branch floodplain and in the more accessible areas of the river, and greater than 120 mg/kg in the less accessible areas of the river.

## 2.3 GENERAL RESPONSE ACTIONS

### 2.3.1 Criteria for Initial Screening of General Response Technologies

The number of general response actions and associated remedial technologies that were potentially applicable to the River Areas were quite extensive. The technologies on this list were screened based upon their ability to address the remedial action objective. The screening process was based upon a set of criteria relevant to the protection of public health and the environment as well as to site-specific conditions and the contaminants.

Guidance provided in the National Oil and Hazardous Substances Contingency Plan as revised November 20, 1985; USEPA Guidance on Feasibility Studies under CERCLA, USEPA Interim Guidance on Superfund Selection of Remedy (December 1986); USEPA Interim Guidance for FY87 ROD's (July 1987); and USEPA Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA (March 1988) were utilized along with the professional judgement of engineers performing the Feasibility Study.

### 2.3.2 Identification of General Response Actions

Based on the established remedial action objective, site conditions, and waste characteristics, a preliminary screening of potential general response actions was conducted. A list of general response actions typically considered for cleanup of hazardous waste sites is presented in Table 2-1. General response actions such as pumping and collecting contaminated groundwater, storing hazardous materials, providing an alternate water supply for the community, and relocating residents were judged as not applicable for this site.

The no action category involves activities that restrict public access (e.g., fencing) to contaminated areas and includes monitoring of contaminant migration (e.g., monitoring wells). Continued monitoring of a contaminated medium over time will enable the determination of natural restoration rates occurring through natural attenuation brought about by advective transport and biodegradation. Monitoring will be designed to determine the amount of arsenic transported out of the system.



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TABLE 2-1

POTENTIAL GENERAL RESPONSE ACTIONS

1. No Action
2. Containment
3. Treatment and Disposal
   - Complete Removal (Contaminated Sediment)
   - Partial Removal (Contaminated Sediment)
   - On-Site Treatment (Sediment and Wastewater)
   - Off-Site Treatment (Sediment and Wastewater)
   - In Situ Treatment (Sediment and Wastewater)
   - Storage (Contaminated Sediment)
   - On-Site Disposal (Contaminated Sediment)
   - Off-Site Disposal (Sediment and Wastewater)

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Containment actions include technologies that involve little or no treatment, but provide protection to human health and the environment by reducing the mobility of contaminants and risks to exposure. Examples of containment actions are covering waste deposits and controlling groundwater movement by using low permeability barriers or containment walls.

Treatment actions include solids treatment and associated wastewater treatment technologies that act to reduce the volume, mobility, and/or toxicity of contaminants. There are many soil treatment technologies that are effective for metals, including thermal vaporization/oxidation, extraction and fixation. Wastewater treatment technologies include physical, chemical and biological treatment.

### 2.3.3 Additional Considerations in the Development of General Response Actions

Three other factors should be taken into account in terms of the response actions in the Blackwater Branch and the Maurice River. These are: (1) the source of contamination into the basin; (2) the location of the contaminated sediments; and (3) the potential for natural sediment migration.

The source of arsenic into the basin is the groundwater discharge off of the ViChem site. This source should be eliminated prior to remediating the sediments in the Blackwater Branch or the Maurice River. If the source is not eliminated, inflowing arsenic could recontaminate the sediments.

The sediments in the Blackwater Branch floodplain are exposed. They will not be subject to redistribution by flowing water, except possibly for a thin veneer of surface sediments subject to surface runoff and periodic flood flows. Therefore, if remediation of these sediments is desired, they would have to be mechanically removed. Remediation should not begin until the source of arsenic has been eliminated.

The Maurice River sediments are under water and may be subject to redistribution by flowing water. It is possible that, once the source of arsenic into the basin has been eliminated, these contaminated sediments may be naturally flushed from the system. Therefore it may be prudent to wait a certain period of time after the source has been eliminated (e.g., 3 years) to see if the contaminated sediments have flushed from the system. If the sediments have not flushed, a remedial action can be taken to remove them. If the sediments have flushed, then the remedial action for the submerged sediments would not be necessary.

Remedial alternatives for both the Blackwater Branch and the Maurice River are presented in this FS, however the timing of the enactment of the alternatives is discretionary to the USEPA. It

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may be prudent to consider that the Blackwater Branch floodplain remediation, if desired, could begin after the source of arsenic was eliminated, while Maurice River remediation could begin after a waiting period to determine the effectiveness of the river's natural flushing mechanisms.

## 2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

### 2.4.1 Identification, Screening and Evaluation of Technologies

The next step in the FS process consists of (1) identifying the categories of remedial technologies associated with each response action that are applicable to the River Areas and (2) determining the feasibility of achieving the remedial objective by using those technologies.

The remedial technology categories that are selected for initial screening are presented in Table 2-2.

The screening of remedial technologies is based on the remedial action objective, site-specific conditions, waste characterization and the extent of contamination. Waste characteristics include physical properties such as volatility, solubility and density; specific chemical constituents such as total organic carbon and metals; and properties that affect the performance of a technology. Site characteristics gathered during the RI are reviewed to identify conditions that may limit or favor the use of certain remedial technologies. Technologies whose uses are clearly precluded by waste or site characteristics are eliminated from further consideration.

Several sources were used during the initial screening of technologies, including the following:

- Remedial Action At Waste Disposal Site Handbook, USEPA, June 1982.
- Handbook For Evaluating Remedial Action Technology Plans, USEPA, August 1983.
- Review Of In-Place Treatment Techniques For Contaminated Surface Soils, Volume 1: Technical Evaluation, USEPA, September 1984.
- Technologies Applicable To Hazardous Waste, USEPA, May 1985.
- RCRA/CERCLA Alternative Treatment Technology Seminar, USEPA, May 1986.

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TABLE 2-2

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

| SARA Remedial Categories | General Response Actions | Remedial Technologies |
|---|---|---|
| 1. No Action | Monitoring | - Monitor and analyze sediment, fish and lake water |
| | Migration Assessment | - Sediment transport modeling |
| | Restricted Access/ Use | - Fence access areas<br>- Prohibit fishing, crabbing, swimming and water sports<br>- Prohibit irrigation |
| | Public Awareness | - Post warning signs<br>- Inform local officials and residents<br>- Hold public meeting |
| 2. Containment | Capping | - Clay cap<br>- Synthetic membranes<br>- Chemical sealants |
| | Covering | - Sand<br>- Stone/gravel<br>- Filter fabric |
| | Barriers | - Silt curtains<br>- Dikes/piers<br>- Sheet piling |
| 3. Treatment and Disposal | | |
| a. Sediment | Complete or Partial Removal | - Excavation (backhoe, bulldozer, front-end loader, dragline)<br>- Mechanical dredging (clam shell, bucket loader, dipper, Souerman dredge, terra marine scoop) |



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TABLE 2-2 (Cont'd)

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

| SARA Remedial Categories | General Response Actions | Remedial Technologies |
|---|---|---|
| 3. Treatment and Disposal a. Sediment (Cont'd) | Complete or Partial Removal | - Hydraulic dredging (suction/ dustpan, cutterhead, hopper dredge, horizontal auger-cutter dredge)<br>- Pneumatic dredging (Airlift, Nametech, Oozer, Pneuma) |
| | On-Site or Off-Site Treatment | - Incineration<br>- Wet oxidation<br>- Acidification/Alkalization<br>- Extraction<br>- Chemical fixation<br>- Hydroclones<br>- Drying beds<br>- Gravity thickeners<br>- Sedimentation basins/ lagoons<br>- Dehydro drying beds<br>- Ultrasonic dewatering<br>- Centrifuge<br>- Filter press<br>- Vacuum filter<br>- Belt filter press |
| | In Situ Treatment | - Extraction<br>- Grout Injection<br>- Vitrification |
| | On-Site or Off-Site Disposal | - Construct On-Site RCRA Landfill<br>- Construct Off-Site RCRA Landfill<br>- Existing RCRA Landfill<br>- Construct On-Site Nonhazardous Landfill<br>- Construct Off-Site Nonhazardous Landfill<br>- Existing Off-Site |



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TABLE 2-2 (Cont'd)

FEASIBLE GENERAL RESPONSE ACTIONS AND ASSOCIATED REMEDIAL TECHNOLOGIES

| SARA Remedial Categories | General Response Actions | Remedial Technologies |
|---|---|---|
| 3. Treatment and Disposal (cont'd) | | |
| | | Nonhazardous Landfill<br>- Ocean Disposal<br>- Floodplain Deposition<br>- Plant Site Deposition<br>- Construction Aggregate |
| b. Wastewater | On-Site Treatment | - Coagulation/Flocculation/Precipitation<br>- Biodegradation<br>- Oxidation<br>- Neutralization/pH adjustment<br>- Clarification<br>- Filtration<br>- Ion Exchange<br>- Adsorption<br>- Reverse osmosis |
| | Off-Site Treatment | - POTW and Industrial Wastewater Treatment Plant |
| | On-Site Wastewater Disposal | - Surface Water Discharge |
| 4. Transportation Technologies | | - Truck<br>- Pipeline |



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- Handbook For Stabilization/Solidification Of Hazardous Wastes, USEPA, June 1986.

- Mobile Treatment Technologies For Superfund Wastes, USEPA, September 1986.

In addition to these references, the annual proceedings of hazardous waste research symposia/conferences were used as sources of information (e.g., "Proceeding of Annual Research Symposia" published by USEPA; and the "Conference on Management Hazardous Materials Control Research Institute").

2.4.1.1 No Action

Description: No action is not a category of technologies but a group of activities that can be used to address the contamination problem when no remediation measures will be implemented. The activities mentioned below will be used to construct a No Action alternative later in this report, as required by the Superfund Amendments and Reauthorization Act (SARA) and the National Contingency Plan (NCP). The no action approach includes the following activities:

- Increase public awareness through public meetings, presentations in local schools, press releases, and posting warning signs;

- Restrict access to river for recreational activities; and

- Monitor fish, sediment, river water and floodplain soils to assess contaminant migration periodically.

Initial Screening: The no action approach is included through the detailed evaluation of alternatives as a baseline for comparison with other remedial alternatives.

2.4.1.2 Containment

Isolation of the contaminated sediments from the surrounding environment would eliminate public exposure. The containment technologies evaluated below either provide some degree of isolation or can be functionally associated with each other or another technology to obtain segregation from contaminated media. Containment of contaminated sediments would consist of capping, covering and barriers.

Capping

Capping technologies isolate the sediments by installing a cover that contains the sediments in place and, with varying levels of effectiveness, eliminates direct contact, particulate resuspension and dust generation. Capping of contaminated sediments

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could be achieved by utilizing any one or a combination of clay cap, synthetic membranes, or chemical sealants. The cap is normally intended to be used as a temporary measure, but could be permanent where extensive subsurface contamination at the site precludes excavation and removal of wastes because of the potential hazards and/or unrealistic costs.

- Clay Cap

  Description: Clay layers are commonly used as cover for landfills that contain both hazardous and nonhazardous wastes. Bentonite, a natural clay with high swelling properties, is often transported to a site and mixed with on-site soil and water to produce a low permeability layer. An impermeable clay cap would not only physically isolate the contaminated sediments, but also prevent interaction between the sediments and the overlying water. An impermeable clay cap would also minimize the leaching of contaminants to river water by creating an impermeable barrier.

  Initial Screening: The installation of a clay cap on the sediments under river water would require extensive dewatering and construction of a stable subbase, which are almost infeasible techniques. Clay caps are susceptible to cracking, settling and ponding of liquids, particularly when oversaturated with water, thus resulting in a loss of impermeability and fine material suspension. A clay cap within a river would be subject to erosion. In addition, while in place, a clay barrier would adversely impact benthic life. Because of low implementability and low reliability, the technology of clay capping for sediment is eliminated from further evaluation. However, clay capping is feasible and effective for landfill construction.

- Synthetic Membranes

  Description: Flexible synthetic membranes are made of polyvinyl chloride (PVC), chlorinated polyethylene (CPE), ethylene propylene rubber, butyl rubber, Hypalon and neoprene (synthetic rubbers), or elasticized polyolefin (USEPA, 1985b). Recent applications have seen the use of synthetic materials as both liners and caps in landfills and other waste facilities. Thin sheets are available in sections of variable width. The sheets are overlain and spliced in the field. Special adhesives and sealants are used to ensure linear integrity.

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Initial Screening: The installation of a synthetic membrane on the sediments under river water would require extensive dewatering and a stable subbase that has the same infeasibility as that of a clay cap. Adverse impacts to benthic life mentioned for clay barriers would apply to a synthetic liner as well. The integrity of synthetic liners can be damaged by uneven settling. Synthetic liners under water would require an overlaying anchor layer to minimize damage and to prevent the liner from floating. Synthetic liners are labor-intensive, since sealing requires special field installation methods, particularly for submerged installations. Due to the low implementability and low reliability, this technology is eliminated from further consideration. However, synthetic membranes will be retained for consideration as part of a multimedia cap for landfill facilities.

- Chemical Sealants

Description: Chemical stabilizers and cements can be added to relatively small amounts of soils to create stronger and less permeable surface sealants. Portland cement or bitumen (emulsified asphalt or tar) is suitable for mixing with sandy soils to stabilize and waterproof them. Other soil additives include chemical dispersants and swell reducers. Soluble salts such as sodium chloride, tetrasodium pyrophosphate, and sodium polyphosphate are added primarily to fine-grained soils with clay to deflocculate the soils, increase their density, reduce permeability, and facilitate compaction.

Initial Screening: Extensive dewatering, mixing, spreading and compaction are required to achieve a low permeability cap. Strict moisture control and a stable subbase for chemical sealant formation are not likely to be provided by silty sediments. Some of these sealant-sediment mixtures would not prevent biota from growing or burrowing through to the sediment underneath the seal. In addition, river scouring may damage the cap and cause it to be unstable. This technology is still in a developmental stage and very little information is available on the implementability of chemical sealants in a water environment, such as the effects on water quality and resistance to water forces. Based on the unique site conditions, difficulty in implementation and low reliability, this technology is eliminated from further consideration.

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Covering

- Coarse Sand

  Description: Covering contaminated sediments with a layer of coarse sand is an established practice to provide a positive effect in reducing public health risks from direct contact and the possible ingestion of contaminants. The sand blanket would also reduce the environmental impact by reducing the potential for bioaccumulation and erosion under normal weather conditions. The high-density coarse sand would to some extent resist severe erosion during a storm.

  Initial Screening: The river's velocity was measured at between 0.75 and 2 ft/sec in the RI. During storm events, the stream velocity may increase to the point where it would potentially disturb the sand covering and cause it to become unstable. In addition, the sand layer would not provide a reliable barrier to biota growing in the river or arsenic leaching from the underlying sediments. For these reasons this technology is considered ineffective and unreliable, and is thus eliminated from further consideration.

- Stone/Gravel

  Description: A layer of crushed stone and/or gravel could be placed directly over the sediment. The rough surface of larger particles has greater resistance to movement than the finer sediments underneath. This is a common engineering practice, which is used to control erosion of materials in a water environment.

  Initial Screening: The two major disadvantages of this material are that the river flow could transport the stone/gravel, thus removing it from the contaminated areas, and that a significant portion of the stone/gravel could immediately sink down into the soft sediment and thus allow the contaminated material to work its way up to the surface. The stone/gravel layer is highly permeable and it would not prevent the leaching of arsenic or sediment resuspension. The layer would form a barrier to the growth of plants that may presently balance the river ecosystem. For these reasons this technology is eliminated from further consideration.

- Filter Fabric

  Description: Filter fabric is a woven material that comes in various pore sizes. It can be designed to allow water and gases formed by biological activity to

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escape while preventing the passage of most particulates. Therefore filter fabric was considered to eliminate the redistribution of bottom sediments. Filter fabric has a limited life expectancy, but is commonly used in landfill caps and has had some applications in water environments.

Initial Screening: Some type of anchor or heavy material (e.g., sand, gravel) must be placed over the filter fabric to keep it in place on top of the sediments. In addition, the growing or burrowing of biota into the filter fabric cannot be prevented, thus creating maintenance problems. For these reasons filter fabric is considered ineffective and unreliable, and is eliminated from further consideration as an individual technology.

Barriers (Sediment Dispersion Control)

The following technologies provide for temporary or permanent barriers to isolate the contaminated sediments to minimize agitation and resuspension.

- Silt Curtains

  Description: Silt curtains constructed from filter fabric are used to reduce the transport of contaminated sediments. Suspended from floats or staked into the bottom sediments, the curtain is extended around the work area. The performance of this technique is sensitive to surface water disturbances that may tear or overtop the fabric. The technology is well developed for erosion control on land, but has not been thoroughly tested in projects where highly contaminated sediments are suspended in water, especially in the case where the contaminant is associated with the very fine-sized particles. However, the filtration effectiveness of this technology can be increased by using two curtains in parallel to provide a buffer zone between them to further control the suspended particles and turbidity.

  Initial Screening: Silt curtains would be effective in minimizing resuspended particle migration during sediment removal activities. Optimum use of silt curtains would result from surface water modeling and dye studies, which would enable proper selection of locations for the barriers. This technology is retained for further evaluation.

- Dikes/Piers

  Description: Earth and rockfill structures can be used to cordon off the areas to be cleaned and isolate them



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from uncontaminated areas, thus creating a safe area for public use. Piers can provide an effective barrier to direct the suspended sediment away from uncontaminated areas. Isolating an area within an enclosed dike will allow surface water to be pumped from this area, providing a semi-dry condition for excavation.

Initial Screening: Piers/dikes would have significant adverse impacts on the river hydraulically because they could cause backwater flooding and scouring. In addition, because the river is narrow, the installation of a pier/dike would prevent the recreational use of the river during construction. This technology is eliminated from further consideration.

- Sheet Piling

Description: Sheet piling driven into the sediments can be used as a barrier to limit the spread of contaminants outside of a work area. An enclosure constructed of interlocking sheet piles could substantially reduce the movement of contaminated water and suspended sediments to areas outside the piles. This technique could also be extended such that water within the enclosure is pumped out and work could proceed within a semi-dry state. The use of sheet piling is a commonly applied technology.

Initial Screening: In situ dewatering would not be required for contaminated sediment removal since the dewatering of dredged sediments would be more cost-effective. In addition, this technology may have an adverse impact on the river hydraulics. This technology is eliminated from further consideration.

2.4.1.3 Treatment and Disposal

Complete or Partial Removal

Figure 1-11 presents the sediment arsenic concentrations in the Blackwater Branch and the upper Maurice River. Appendix C presents arsenic concentrations from core samples taken at the river stations shown in Figure 1-11. Figure 4-3 presents the area of the Blackwater Branch requiring remediation. Appendix C presents the methods used to calculate the volumes of sediment above the cleanup level of 20 mg/kg and 120 mg/kg.

The total volume of exposed and submerged sediment in the Blackwater Branch floodplain with arsenic concentrations greater than 20 mg/kg are 56,200 cu yd and 6,400 cu yd, respectively. The total volume of submerged sediment in the Blackwater Branch downstream of North Mill Road and the upper Maurice River with

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an arsenic concentration of 120 mg/kg is 14,300 cu yd. Additionally, 1,100 cu yd of submerged sediment with an arsenic concentration greater than 20 mg/kg is located in the more accessible areas of the river. Excavation concerns for the sediments under water, 21,800 cu yd, would be different than for the exposed former sediments in the Blackwater Branch floodplain, 56,200 cu yd. Treatment and disposal technologies are applicable to all of these sediments.

- Excavation

  Description: This category of removal technologies refers to construction equipment that is typically used on land to excavate and handle solid materials. The equipment includes backhoes, bulldozers, front-end loaders and draglines. Large backhoes have production rates up to approximately 150 cubic yards per hour (cy/hr). Smaller models with low ground pressures are capable of working on soft soils.

  Bulldozers and front-end loaders have average excavation rates between 50 and 100 cy/hr and 70 and 180 cy/hr, respectively. They cannot load sediment that is not close to the shoreline. Draglines are suitable for excavating large land areas to depths ranging from 12 to 30 feet deep with boom lengths ranging from 30 to 200 feet.

  Initial Screening: A low ground pressure backhoe may be appropriate for excavation in the Blackwater Branch floodplain. Both bulldozers and front-end loaders cannot be used to load sediment that is not close to the shoreline, but could be used in support activities. Draglines would require the installation of an extensive network of access roads to reach all sections of the rivers. In addition, the drag buckets dig deep when they are dropped from the boom. Since the deepest areas to be excavated do not exceed 6 feet, deep excavation is not required.

  Based on the above considerations, a low ground pressure backhoe might be used in certain areas of the site as a primary means of removing the contaminated sediments. In addition, one or more of these types of equipment would be used for other construction support activities. Excavation is feasible and is retained for further evaluation.

- Mechanical Dredging

  Description: Mechanical dredging refers to the use of excavation equipment such as clamshells and bucket loaders that are usually mounted on barges. The main



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advantage of mechanical dredging is the removal of sediments at nearly in situ densities by not adding any water, therefore maximizing solids content and minimizing the scale of facilities required for dredged material transport, treatment and disposal. On the other hand, because mechanical dredging removes bottom sediment through the direct application of mechanical force to dislodge the material, sediment resuspension and turbidity is often high. In addition, this method of sediment removal has a characteristically low production rate (USEPA, 1985b).

Initial Screening: Most barge-mounted dredges require 5 to 6 feet of draft. Very few sections of the Maurice River are under this much water. These access restrictions, combined with the high resuspension of sediments associated with mechanical dredging, provide adequate reasons for eliminating mechanical dredging technologies from further consideration.

- Hydraulic Dredging

Description: Hydraulic dredging utilizes water as the medium for transporting sediments from their in-place location to a discharge point. Slurries of 10 to 20 percent solids by weight are common in standard hydraulic dredging operations. The operations are usually barge-mounted and have high production rates. The four different types of hydraulic dredges commercially available are suction/dustpan, cutterhead, hopper dredge and horizontal auger-cutter dredges.

The suction dredge relies solely on suction to dislodge, capture and transport the excavated slurry. The dustpan dredge is a modified suction dredge. It features a wide flared dredging head and utilizes high-pressure water jets to loosen and agitate sediment, then captures the sediment in the dustpan. Both suction and dustpan dredges are effective in removing relatively free flowing sediments.

A cutterhead suction dredge utilizes circular cutter blades, which rotate at the bottom of a suction pipe. This dredge is suitable for dredging both fine (silt and clay) and coarse (gravel and loose rock) materials.

The hopper dredge is basically a self-contained ship that uses a suction to draw sediments into hopper compartments within it. After all hoppers are full, the dredge is moved to a transfer location where th materials are pumped out. This dredge requir extensive maneuvering space and is used for oce operations.

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The horizontal auger-cutter dredge utilizes a hydraulically operated boom to raise and lower an auger/cutter/suction assembly to the sediments. The sediments initially loosened by the auger/cutter assembly are then transported by suction as a slurry through a floating pipeline or transfer barge to the treatment/disposal location. Smaller versions of this dredge can remove a maximum depth of sediment of approximately 1.5 feet with each pass, and can be transported to relatively isolated (in terms of navigation) water bodies such as inland rivers. A series of tests are presently being performed on the most commonly used portable dredge, the Mud Cat*.

Preliminary results indicate that sediment resuspension is negligible, even in riverine environments. Reduced resuspension would have to be obtained by sacrificing optimization of the dredging operation. This would be accomplished by increasing the amount of water taken in by the dredge during operation.

Initial Screening: Suction/dustpan dredges are usually large vessels geared for the maintenance dredging of major waterways. Due to their size and draft they would not be accessible to the upper Maurice River. In addition, underwater plants and debris could block the suction lines. Therefore the suction and dustpan dredges are not considered implementable and are eliminated from further evaluation.

Cutterhead dredges are usually designed for large production projects and are mounted on large barges. Therefore, due to their size and 5 to 6 foot draft requirements, they would not be accessible to the site and are eliminated from further evaluation.

Hopper dredges require extensive maneuvering to operate. Under the anticipated site conditions and nominal water depths, they are not considered appropriate for the upper Maurice River. They are therefore removed from further consideration.

Portable horizontal auger-cutter dredges are in wide use, particularly in shallow waters such as small reservoirs, streams and lagoons. They also characteristically have low depths of vessel draft (many less than

*In this report, any mention of trade names of commercial products and processes does not constitute endorsement or recommendation for use.

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2 feet) allowing them to be used inshallow-water applications. Because of the accessibility to the site and low sediment resuspension, this type of hydraulic dredge is retained for further evaluation.

- Pneumatic Dredging

  Description: Pneumatic dredges use compressed air and hydrostatic pressure to draw sediments to the collection head and through the transport piping. Four types of pneumatic dredges, including Airlift, Nametech, Oozer and Pneuma, are commercially available. Pneumatic dredges can yield denser slurries than conventional hydraulic dredges with lower levels of turbidity and suspended solids, but they are capable of only modest production rates. These dredges can be relatively easily dismantled and transported by truck, but have limited availability in the United States.

  Initial Screening: Some pneumatic dredges may not be suitable for shallow deposits because they require a minimum depth to build up enough air pressure for operation. The minimum depth required would be greater than what is available in the Maurice River. Some of these dredges are being evaluated by the USEPA for removing contaminated sediments; however, operational data is limited (USEPA, 1985b). Because of the limited availability, minimum depth requirements, and the lack of operational data, this category of dredges is eliminated from further evaluation.

On-Site or Off-Site Treatment Technologies

Although the same remedial technologies are applicable for the on-site or off-site treatment of sediments removed from the rivers, on-site treatment should be considered first to minimize transportation and handling costs. Even when on-site treatment is not completely possible, steps should be taken on-site to reduce the sediment water content and volume to minimize transportation costs. Such steps would be applicable to waste sludges generated by remedial treatment processes as well. The applicability of complete or partial on-site treatment will depend primarily on the availability of land upon which to construct facilities. It appears that sufficient land is available adjacent to the Maurice River for sediment handling and treatment. Table 2-2 presented a list of the on-site and off-site treatment technologies that will be screened relative to their potential applicability and feasibility to cleanup the contaminated sediments from the Maurice River and the Blackwater Branch.

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Thermal Treatment-Sediment

This category of technologies includes the use of incineration units and wet oxidation units to treat the arsenic-contaminated sediments.

Arsenic compounds can be vaporized in the range of 100°C to 450°C and can be oxidized to form an $As_2O_3$ emission. The vapor-phase arsenic emissions should be treated in an air pollution control device such as a water scrubbing system.

- Incineration

  Description: Incineration involves the thermal oxidation or destruction of organic matter. Incineration units such as multiple hearth, rotary kiln or infrared systems would evaporate water from the sediment slurry and decompose any organic matter. Therefore they could be used for sediment drying and volume reduction. Incineration would only vaporize arsenic from the sediments into the scrubbed water. Subsequent and suitable treatment would be required to remove arsenic from the scrubbed water prior to discharge to the river. There is currently no established incineration technology that will destroy arsenic. Incineration will only vaporize, sublime, or melt the arsenic. Both portable and stationary equipment are available for on-site and off-site incineration. To be useful in either case, the processing capacity of the incinerator should be consistent with the rate of sediment generated by the dredging and excavation operations.

  Initial Screening: The vaporization of arsenic would not require the high temperatures generated by an incinerator. Incineration requires very high capital, and operating and maintenance costs. The costs of removing arsenic from the scrubbed water are estimated to be very high. Incineration may melt a certain amount of arsenic to ash, and the disposal of the potentially hazardous ash would still remain a problem. For all of these reasons, this technology is considered ineffective, and is eliminated from further evaluation.

- Wet Oxidation

  Description: Wet air oxidation or wet supercritical water oxidation uses elevated temperature (500°F to 600°F) and pressure (100 to 500 atm) to oxidize contaminants. This process was developed mainly for treating pumpable aqueous and sludge wastes, which are

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too dilute (less than 15% organics) to treat economically by incineration. There is currently no established wet oxidation technology that would destroy arsenic. This technology would only vaporize and oxidize arsenic.

Initial Screening: The wet oxidation products containing arsenic oxides would remain dissolved and suspended in the liquid. The off-gas would contain dissolved arsenic oxides and hydrocarbons from the organic matters in the sediments. It would be very difficult to separate the arsenic-contaminated suspended solids and the inert fine silt. This technology category has not been demonstrated feasible for arsenic removal in a pilot-scale test or a full-scale operation. Therefore wet oxidation technologies are eliminated from further evaluation.

Chemical Treatment - Sediment

Chemical treatment can be used to remove arsenic from both the excavated and dredged sediment and the associated liquid wastes. Sediments can be treated chemically using acidification/alkalization, extraction and fixation.

- Acidification/Alkalization

Description: Acidification and alkalization consist of the addition of an acid or an alkali to the sediments to solubilize and leach arsenic into solution so that it can be removed from the sediments. Hydrochloric acid and sodium hydroxide are the most commonly used acid and alkali for this type of treatment.

Initial Screening: Both acidification and alkalization were tested in the bench-scale treatability studies (Section 7.0 of RI report) to determine the feasibility of this technology to leach arsenic from the sediments. The test results demonstrated a low efficiency for leaching at a low pH value (i.e., 3.0), but a high efficiency of leaching at an extremely high pH value (i.e., 12.0). The alkali-treated sediments contained 14 mg/kg of total arsenic, which is below the treatment criterion of 20 mg/kg. However, alkalization resulted in an unstable process and generated a large amount of fine silt, which was very difficult to settle out. Other chemical extraction solutions such as sodium citrate demonstrated better results. Therefore both acidification and alkalization were eliminated from further evaluation.

VIN 002 1281

o Extraction

Description: This technology would involve the extraction of the arsenic from the dredged sediments using water, a solvent, a wetting agent or any combination of the three. The supernatant solvent (extractant) containing the arsenic would then be further treated for arsenic removal prior to discharge to the river. The sediment, after washing with water for solvent recovery, would be disposed of as nonhazardous material.

Initial Screening: Extraction was evaluated in the bench-scale treatability studies (Section 7.0 of the RI Report) to determine the feasibility of this technology to extract arsenic from the sediments. The tests involved using extracting media such as water, sodium citrate, sodium oxalate and ethylenediaminetetra-acetate (EDTA), all commonly used extracting agents.

The treatability test result showed that the resultant coarse sand after a one-stage water wash contained 34 mg/kg arsenic, compared with an initial sediment (sand plus fine silt) concentration of 2,780 mg/kg. It is expected that a two-stage water wash would further reduce the arsenic contamination to below the more stringent action level of 20 mg/kg. If during final design, it is discovered, that a two-stage water wash would not sufficiently reduce the arsenic concentration to below 20 mg/kg extraction of arsenic using sodium citrate could be implemented. The treatability studies indicated that sodium citrate would extract arsenic from the sediment to a concentration of 21 mg/kg. This process could be optimized to achieve the action level of 20 mg/kg.

Based on the treatability test and on other information gathered in the RI, it was assumed that the leachate from the coarse washed sand would contain a low enough arsenic concentration to enable the coarse sand to meet the substantive delisting requirements and be disposed as nonhazardous material. The separated water and fine particles containing arsenic could then be treated with subsequent technologies to remove/fixate the arsenic. Because of its effectiveness in lowering the arsenic concentration in the washed sediments, this technology is retained for further evaluation. The delisting criteria for these sediments will be explained in detail in Section 3.0.

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o Fixation

Description: Fixation is a chemical process whereby contaminated sediments are converted into a stable cement type matrix containing minimal free water. Cement, lime, fly ash, sodium silicate, organic polymers, pozzolan, and asphalt can be used to bind or hydrate the free water available in the dredged sediments. Commercial proprietary agents are available for both organic and inorganic contaminant fixation. The contaminated sediment treated with any of these agents develops properties ranging from a loose sand or gravel to a weak concrete. The stable end product does not leach appreciable amounts of arsenic and can be classified as a nonhazardous material if it meets substantive delisting requirements.

Initial Screening: Bench-scale fixation tests were performed on sediment samples using a commercial silicated blend known as K-20/LSC (manufactured by Lopat Enterprises). Carbon powder, Portland cement and fly ash were also tested as fixation agents. The fixation formulations used were designed to produce fixated solids with leachates (produced from an EP Toxicity Test) of less than 5 mg/l of total arsenic. The tests achieved a level of approximately 1 mg/l arsenic in the leachate, much lower than the target level. The tests were not optimized to achieve a further reduced leachate concentration, although the vendor indicated that a more optimized leachate could be achieved.

Delisting criteria for classification of solids as RCRA nonhazardous material require that a leachate from an EP Toxicity Test have a contaminant concentration less than that computed from the USEPA's VHS model (1986d). For the sediment under consideration the leachate must be less than 0.32 mg/l arsenic. The treatability tests achieved a leachate of 0.800 mg/l arsenic using a 1:1 formulation ratio (chemicals : sediment). By modifying the formulation ratio it is believed the sediments could be fixated to produce an EP Toxicity extract with less than 0.32 mg/l. Therefore this technology is retained for further consideration. Additional treatability tests would be needed to confirm/optimize the formulation ratio. The delisting requirements are discussed in detail in Section 3.0.

Physical Treatment - Sediment

Physical treatment processes are applicable for handling sediments from dredging operations both to thicken and dewater them for subsequent treatment and disposal. Physical treatment

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processes evaluated for handling sediments include: hydroclones, drying beds, gravity thickeners, sedimentation basins, lagoons, dehydro drying beds, ultrasonic dewatering, centrifuges, filter presses, belt filter presses, and vacuum filters.

- Hydroclones

  Description: Hydroclones can be used to separate heavy (i.e., large diameter) particles from fines (i.e., small diameter particles) that are present in the sediments. The sediment is diluted with water to produce a slurry of approximately 20 percent solids. The slurry is pumped, under moderate pressures of 10 to 20 psig into the hydroclone at a tangential angle. The high rotational flow in the hydroclone causes all the particles to move towards the wall by centrifugal forces and downward to the apex. Proper selection of the size and operating pressure can induce the concentration of large (i.e., sand) particles in the underflow while the fines would concentrate only slightly in the underflow (i.e., pounds fines/pounds water in underflow is only slightly greater than the pounds fines/pounds water in the feed). The underflow is high in solids (i.e., 40% to 50%) and has a much lower water flow than the overflow. Therefore most of the fines leave the hydroclone in the overflow stream.

  Initial Screening: Hydroclones are a feasible technology for separating fines from larger particles in slurry streams. Based on the data collected in this RI/FS, it is believed that the fines in the sediments contain the majority of the arsenic, while little arsenic is contained in the coarse size fraction. This process is therefore retained for further consideration.

- Drying beds

  Description: Drying beds could be utilized to gravity-drain free liquids from sediments through a permeable layer. Sediment drying can be accomplished at a relatively low cost and in a reasonable amount of time using, for example, sand beds. The sand drying beds consist of an upper layer of sand and a lower layer with an underdrain system. Local climate such as temperature, precipitation, sunshine and humidity will affect the drying efficiency. It is possible to obtain 45% solids content or more in two weeks.

  Initial Screening: Sediment dewatering using drying beds is labor intensive and requires a significant land area. Since the feasible sediment treatment technologies for the site, such as extraction and fixation,

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would not require a high degree of dewatering, drying beds are considered not practical relative to other available dewatering and thickening technologies. Therefore drying beds are eliminated from further consideration.

- Gravity Thickeners

Description: Gravity thickeners are similar to conventional circular clarifiers except that they have a greater slope and are constructed with a heavier raking and pumping mechanism. The dredged sediment slurry would enter the center of the thickener unit and the solids would settle into a sump at the bottom. The solids would be removed for treatment or disposal, and the supernatant would be removed from the overflow weir system for treatment.

Initial Screening: Gravity thickeners are a feasible technology for thickening the sediment prior to extraction or fixation treatment as demonstrated in the bench-scale tests. This process is implementable and effective and is therefore retained for further evaluation.

- Sedimentation Basins/Lagoons

Description: Sedimentation basins and lagoons are two of the oldest and simplest processes for dewatering solids. Common design practices would use a two-lagoon or sedimentation basin system; as one is being filled, the other is being emptied. The side slopes and bottoms of the basins would be lined to prevent leakage. Sediments would be retained in the basins while the supernatant would be decanted and pumped away for treatment. The solids would be collected for further treatment and disposal.

Initial Screening: Sedimentation basins and dewatering lagoons are not practical for sediment dewatering due to the site-specific conditions. Dredging will be performed over an 8 mile distance, therefore a mobile type facility (such as a gravity thickener) is preferred. A permanent station (basin) would require an additional booster pump to pump the sediment from the dredge barge to the station. Therefore these technologies are not considered implementable and are eliminated from further consideration.

- Dehydro Drying Beds

Description: This technology is similar to a regular dry bed except that a flocculant is added to the dredged



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sediment slurry and the water is then filtered through a permeable mat by means of a vacuum system. The settling of dredged sediments can be accelerated by using this process. This method requires that the contaminated sediment and associated dredge slurry be evenly distributed over the permeable mats. The water is then drawn through the bed aided by a vacuum. The supernatant is collected in a sump and removed or stored for eventual treatment. Approximately 90% of the water in the dredged material can be removed by this process. Dehydro drying beds are a relatively new concept utilizing conventional technical practices.

Initial Screening: Dehydro drying beds perform a high degree of dewatering and can improve drying bed dewatering efficiency. However, based on the same reasons for conventional drying beds, dehydro drying beds are considered unimplementable for this site relative to other available dewatering and thickening technologies. Therefore this modified drying bed technology is eliminated from further evaluation.

- Ultrasonic Dewatering

Description: This system uses ultrasonic vibrations to remove water from solids. This is a new technology, which has limited documented success. Its applicability to dewatering sediments that have a high organic content is not known; however, this technology has been used in the mining and processing industry.

Initial Screening: Because of the unknown applicability to sediments with high organic content, and the limited availability of the technology, it is eliminated from further consideration.

- Centrifuge

Description: Centrifugal dewatering is a process that uses the force developed by fast rotation of a cylindrical drum or bowl to separate solids and liquids according to their density differences under the influence of centrifugal force. Centrifuges can be used to dewater or concentrate soils and sediments ranging in size from fine gravel down to silt. Effectiveness of centrifugation depends upon the particle size and shapes, and the solids concentration, among other factors.

Initial Screening: Centrifugation is a feasible technology for thickening and dewatering dredged sediments and excavated soils. It may also be applicable for

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separating fine and coarse particles in the sediments by operating the centrifuge in a manner that results only in the capture of coarse solids. This technology is retained for further consideration.

- Filter Press (Plate and Frame)

  Description: Filter presses may be used to dewater sediments by forcing sediments under pressure into a series of plates and chambers fitted with a fine filter cloth. Water is forced through the filter cloth into a collection system, and the plates are then separated and the solids removed for treatment and/or disposal. The system is operated on a batch basis.

  Initial Screening: This dewatering technology is labor intensive and not practical for dewatering sediments at the site due to relatively high operation and maintenance costs, as well as very limited unit capacity. Therefore, this technology is not retained for further evaluation.

- Vacuum Filter

  Description: Vacuum filters are commonly used to dewater sludges from wastewater treatment systems. Vacuum filters utilize a rotating cylinder with an internal vacuum to draw water through the filter medium while leaving solids as a layer on the filter cloth. The dewatered solids are continuously scraped off the rotating filter medium to a conveyor system.

  Initial Screening: Vacuum filtering is a feasible technology for dewatering sludges generated from the supernatant or extractant treatment system. This technology is retained for further evaluation.

- Belt Filter Press

  Description: A belt filter press uses two vertically or horizontally moving belts to squeeze water from solids. Belt filters have been commonly used for sludge dewatering, which requires preconditioning such as adding a coagulant and/or a polymer. Sludges containing fine particles would require preconditioning to improve dewatering efficiency.

  Initial Screening: Belt filter presses accomplish the same goals as vacuum filters, however, vacuum filters are more efficient for nonfiber or high viscosity sludge. Therefore this technology is eliminated from further consideration.

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In Situ Treatment Technologies

The following chemical and physical in situ treatment technologies were screened relative to their potential applicability and feasibility to the cleanup of contaminated sediments. These technologies were identified in Table 2-2.

In Situ Chemical Treatment

The in situ chemical treatment technologies considered involve the introduction of an agent that either removes the arsenic from the in place sediments or binds it to the sediments in such a way that the arsenic is no longer available or capable of being leached and resuspended.

- Extraction

  Description: The sediment is washed with some appropriate acid, alkali, or other solvent to dissolve or solubilize the arsenic. The area to be treated must be isolated by a cofferdam and dewatered with pumps. This enclosure is then flooded with a solvent using hydraulic sprayers. The sediment and solvent are then mixed using adequate agitators. The elutriate (solvent containing the arsenic) is then collected from the isolated area and is pumped to a treatment system.

  Initial Screening: Most of the sediments in the Maurice River and the Blackwater Branch are composed of organic silts. The in situ water extraction process would resuspend these fine particles and would result in pumping a large quantity of sediment with the elutriate to the treatment system. The treatability studies showed that these fines were not easily removed from the extractant solution. This site-specific condition would make in situ extraction no more attractive than on-site extraction. It would be very difficult to implement this technology in the river. Thus construction costs would be higher and construction duration would be longer. Therefore in situ extraction is considered unimplementable and was eliminated from further evaluation.

- Grout Injection

  Description: The contaminated sediments are solidified by injecting a mixture of Portland cement, fly ash, activated carbon and proprietary chemicals. The mixture traps the sediments into an insoluble matrix. The mixture can either be injected into closely spaced holes in the sediment to create vertical columns of solidified material or injected into the top layer of the sediment,

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while simultaneously being mixed in with rotary tillers to form a whipped layer of solidified material. The areas to be treated are isolated by a cofferdam and dewatered with pumps, thus the moisture of sediments can be controlled within an effective range. In general, in situ fixation is more difficult than on-site removal/fixation, particularly for sediments under water.

Initial Screening: Due to the difficulty in obtaining moisture control for this process, it is difficult to assess how effectively the grout will penetrate the sediment and how long the grout will remain intact. Also, because of the high organic content of the sediment and the dynamic water environment, the long-term stability of grout-injected sediment is unknown. Due to the uncertainties and technical problems with this technology, it was eliminated from further evaluation.

In Situ Physical Treatment

There was only one in situ physical treatment technology selected for initial screening.

- Vitrification

Description: In situ vitrification (ISV) is a thermal treatment process to stabilize chemically contaminated soils in-place. ISV destroys organic contaminants by pyrolysis and incorporates inorganic contaminants into a glass-like material that essentially renders these contaminants immobile. ISV involves placing electrodes and a graphite/glass mixture in a cross pattern in the sediment, then heating the sediment to molten temperatures by applying a voltage to the electrodes. As the surrounding sediment melts, it becomes electrically conductive. The resulting vitrified solid mass should be very leach-resistant and durable. This process is quite costly and thus has been restricted to the treatment of radioactive or very highly toxic wastes.

Initial Screening: In situ vitrification is still an emerging technology, but it is known that if the materials to be treated have a high water content, the effectiveness is reduced and the costs significantly increase. It is unlikely that ISV can be used to treat the sediments under water. Also, the study area is very long (approximately 8 miles), which is not what the ISV system is designed for. The technology is considered unimplementable and unreliable and is thus eliminated from further consideration.



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## On-Site or Off-Site Disposal Technologies

If one or more of the removal technologies are incorporated into potential alternatives, then disposal of the removed sediments and any by-product sludges must also be addressed. The requirements for disposal can be divided into two categories, depending on whether the sediments are still hazardous or have been treated so as to be delisted as nonhazardous materials. Nonhazardous materials can be further categorized as either wastes or useful and marketable materials. There are two general locations for disposal, on-site or off-site. The RCRA Land Disposal Restrictions for RCRA characteristic and listed wastes will become effective May 8, 1990. RCRA landfilling of treated sediment that still fails the EP Toxicity Test (or TCLP when enacted) for arsenic may not be feasible after that date without further treatment. The following technologies identified in Table 2-2 represent various combinations of these waste classifications and possible disposal locations.

## Hazardous Waste Disposal

Under this category, three different locations are discussed for the ultimate deposition of the contaminated sediments whose arsenic concentrations qualify them as a hazardous waste.

- Construct On-Site RCRA Landfill

  Description: A new RCRA Subtitle C containment facility could be constructed somewhere within the site boundaries to receive the treated sediments that are not delistable. Although permitting requirements under the laws are not required under fund-financed actions under CERCLA (USEPA, 1985a), the landfill would have to be designed with a double liner system, a groundwater monitoring system, and two leachate detection, collection, and removal systems, according to applicable RCRA requirements (USEPA, 1985b).

  According to an interpretation of the "site boundaries" given to USEPA Region II by USEPA Site Policy and Guidance Branch personnel, the "site" consists of the ViChem Plant property and possibly areas immediately adjacent to the plant. While the Blackwater Branch and the Maurice River are considered part of the ViChem Superfund site, a landfill adjacent to either of these areas would not be considered "on-site", since lands adjacent to them are not within the "area of contamination". Therefore an "on-site" landfill would consist of a landfill constructed at the ViChem Plant site itself.

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Initial Screening: Although landfilling hazardous waste was and still is widely used as a management practice, it is now being discouraged by USEPA, which makes obtaining approval for constructing a new facility very difficult. In addition, treatment before landfilling would have to be explored based on the recent land disposal regulations. The disposal facility would be designed to satisfy all the applicable regulations. The ViChem plant site is a viable location for on-site RCRA disposal. Although acquisition of site properties may be difficult, this technology is retained for further consideration.

- Construct Off-Site RCRA Landfill

Description: The construction of a RCRA Subtitle C facility could be undertaken at some location in Salem, Cumberland or Putnam Counties. A site in one of these counties would minimize hauling distances while still allowing an adequate siting area in which to define the optimum location of the facility. However, since it would not be located within the CERCLA site, federal and state permits would have to be obtained.

Initial Screening: The permitting process requires extensive investigations and acceptance by numerous agencies. Important factors affecting the regulatory acceptance would be the definition of site conditions, design, construction, operation, public concerns, closure, and post-closure monitoring. The land-ban disposal restriction regulations prohibit off-site landfilling without treatment after November 1988, thus this technology may not be feasible without treating the sediment. Because of the difficult administrative efforts, this technology is eliminated from further evaluation.

- Existing RCRA Landfill

Description: The waste material could be hauled to an existing RCRA Subtitle C landfill facility already permitted to accept treated material that is not delistable. This provides a straightforward solution to the disposal problem, but unit costs are high due to transport distance and disposal fee structure. In addition, volume limitations at a facility may put a limit on the quantity of waste that can be disposed of in this fashion.

Initial Screening: Off-site disposal in an existing RCRA facility would have minimal long-term public health and environmental impacts. The land ban disposal

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restriction regulations prohibit off-site landfilling without treatment after November 1988, thus this technology is not feasible without treatment of the sediment. This technology is therefore retained for consideration in combination with treatment on-site or off-site.

Nonhazardous Disposal Options

If the arsenic-contaminated sediment can be treated by one of the previously evaluated technologies to be delistable as nonhazardous, then its disposal would no longer be limited to just a RCRA Subtitle C Facility. Two methods for the disposal of nonhazardous sediments are discussed in this category. These methods address the final deposition of the treated sediments, based on their being classified either as waste or as marketable materials.

Disposal of Waste Materials

Treated sediments determined by the NJDEP as being ID 27 wastes (nonhazardous) can be disposed of by the following landfill and ocean dumping options:

- Construct On-Site Nonhazardous Landfill

  Description: As discussed in the previous category, a location within the boundaries of the Vineland Chemical Site would be considered "on-site". Because this landfill would only be accepting what is considered to be nonhazardous waste, the design and operation requirements would be similar to that of a municipal sanitary landfill.

  Initial Screening: Construction of a sanitary landfill with the associated reduction in hazardous properties of the toxic wastes may be acceptable to regulatory agencies and the community if the treated material is delistable. Data from the River Areas RI suggest that the treated (fixated or water wash extracted) material could meet substantive delisting requirements. This option is retained for further evaluation as a potential disposal alternative.

- Construct Off-Site Nonhazardous Landfill

  Description: Somewhere within Salem, Cumberland or Putnam Counties, a new landfill could be sited, designed, constructed, and operated to receive the treated sediments. After being filled, it would be



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closed and monitored. Since the waste is not hazardous, requirements for the landfill would be less stringent. However, because it would not be located within the CERCLA site, federal and state permits would have to be obtained.

Initial Screening: Because of the permitting, siting studies, and the public's reluctance to have a landfill sited nearby, this technology is not retained for additional evaluation.

- Existing Off-Site Nonhazardous Landfill

Description: An existing licensed landfill could be used for the disposal of nonhazardous wastes. There would only be disposal costs associated with this technology, and no costs to the remediation associated with the design, operation and maintenance, closure, or monitoring of a new facility. It is assumed that there would be no problems with using an existing landfill facility. The nearby landfills that have been contacted have the capacity to accept the treated material, and would possibly be willing to use it as daily cover.

Initial Screening: Treated materials may be disposed of in nonhazardous landfills and even used as cover material, depending upon the delisting classification. Preliminary investigations into the availability of a local landfill willing to accept the treated sediments are encouraging. Therefore this technology is retained for further consideration.

- Ocean Disposal

Description: The disposal of nontoxic, treated sediments in the Atlantic Ocean can be considered. Barges would haul the material to an acceptable disposal location in the Atlantic Ocean and deposit them there. Permits and the assessment of environmental impacts are important considerations for this technology.

Initial Screening: The current regulations in 40 CFR 220-227 require a long and involved testing process in order to acquire a permit to dispose of the sediments in the Ocean. Ocean disposal would require ocean-going barges and barge loading facilities to be constructed at or near the site. This would be impractical for the upper Maurice River and the Blackwater Branch. The treated sediments would be transported by barge down the lower Maurice River to the Delaware Bay. Local citizen groups have protested other barge traffic planned for the lower Maurice River. Therefore ocean disposal is eliminated from further consideration.

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Disposal of Usable Materials

Treated sediments not classified by the NJDEP as ID 27 wastes can be considered marketable materials with the following disposal options:

- Floodplain Deposition

  Description: Floodplain deposition of the treated sediments is a cost-effective disposal alternative. Trucks would haul treated sediments to the Blackwater Branch floodplain and deposit the materials in areas requiring fill after remediation. Bulldozers and graders would compact and grade the treated sediment.

  Initial Screening: This disposal activity would invoke RCRA requirements, including upcoming land disposal restrictions. Therefore any material to be deposited in the floodplain would require delisting. Data from the River Areas RI suggest that the treated material may be delistable. Following delisting and the determination that the treated sediments are not ID 27 waste, deposition would take place. Since the treated sediments would be consolidated into predefined areas, i.e., the floodplain from which they were initially excavated, control measures could be instituted to monitor the effectiveness of the treatment. As previously discussed, the effectiveness of this alternative is expected to be high, thus this technology is retained for further evaluation.

- Plant Site Deposition

  Description: Plant site deposition of the treated sediments is a cost-effective disposal alternative. The treated sediments would be deposited in undeveloped areas of the site. Trucks would haul the treated sediments to locations within the approximate 17-acre available land area. Bulldozers and graders would compact and grade the treated sediment.

  Initial Screening: This disposal activity would also invoke RCRA requirements, including upcoming land disposal restrictions. As discussed previously, any material to be deposited on the site would require delisting and a determination that the treated sediments are not ID 27 waste. Control measures would be instituted to monitor the effectiveness of the treatment. The effectiveness of this disposal option is expected to be high, thus it is retained for further evaluation.

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- Construction Aggregate

  Description: Treated sediments would be hauled to nearby construction material vendors and used as aggregate in suitable applications. These applications could range from fill for highway construction to bed material for lagoons. The physical characteristics of the material following treatment and the vendor's ability to render it suitable to a specific need would dictate the effectiveness of this option.

  Initial Screening: This option would be facilitated by delisting treated sediments and subsequently identifying beneficial uses for them. This option would be similar to floodplain deposition, except that the materials would not be consolidated in one area where they could be monitored. Since a substantial cost saving could be realized by implementing this alternative for utilization of the treated material, it is retained as a process option to floodplain deposition when evaluating remedial alternatives.

Chemical Treatment - Water

The supernatant water associated with the sediments that would be removed by dredging was chemically analyzed in the RI. It was shown to require arsenic and suspended solids removal before discharge back into the Maurice River. In addition, the extractant generated from the water extraction process also required arsenic and suspended solids removal. Suspended solids removal would also remove the arsenic associated with the suspended solids. Arsenic and suspended solids removal can be achieved by chemical coagulation/flocculation/precipitation. Other technologies screened include biodegradation and oxidation.

- Coagulation/Flocculation/Precipitation

  Description: Chemical coagulation/flocculation/precipitation is the addition of chemicals such as ferric chloride, lime, sulfide and polymers to precipitate metals and suspended solids from solution. Flocculation is the gentle agitation of the coagulated solids to promote the growth of floc particles to increase precipitation rates and removal.

  Initial Screening: This process is used primarily in conventional wastewater treatment systems to remove arsenic, iron and suspended solids. Ferric chloride precipitation is the key unit operation for arsenic removal at the existing ViChem wastewater treatment plant. Therefore chemical coagulation/flocculation/precipitation is retained for further evaluation.

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- Biodegradation

  Description: Biodegradation utilizes bacteria or other microbes to biologically oxidize or reduce contaminants by converting the organics to carbon dioxide, water, methane, and new cellular biomass. Proper control of the treatment environment (pH, nutrients, temperature, and oxygen) is critical to the reproduction and growth of the microbes. However, bacteria and microbes used for one contaminant may be inhibited by the presence of another contaminant.

  Initial Screening: The bench-scale treatability tests for the sediment arsenic extraction indicated that the extractant contained a large amount of very fine suspensions high in organic content. It is believed that these fine particles can be settled out of solution by a combination of coagulation/flocculation/precipitation. The extracting solution will be water only with no other additives. Therefore there is no reason to biologically treat the extractant solution containing the fines, thus eliminating biodegradation from further consideration.

- Oxidation

  Description: Chemical oxidation is utilized to change the chemical form of a hazardous material to render it less toxic, or to change its solubility, stability, separability or otherwise change it for handling or disposal purposes. Oxidizing agents include hydrogen peroxide, potassium permanganate, ozone, sodium hypochlorite and calcium hydrochlorite.

  Oxidation processes can be used to treat diluted wastewater containing oxidizable organics and can also be used as an effective process for pretreating wastes prior to biological treatment.

  Initial Screening: The ViChem wastewater treatment plant has utilized potassium permanganate oxidation to oxidize organic arsenic (mainly monomethyl arsenic acid and dimethyl arsenic acid) to arsenate. Oxidation also converts most of arsenite into arsenate. Arsenate is the form of arsenic most effectively removed by chemical coagulation, flocculation and precipitation. Chemical oxidation is effective and implementable, and is therefore retained for further evaluation.

- Neutralization/pH Adjustment

  Description: Neutralization is a process used to adjust



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the pH (acidity or alkalinity) of a waste stream to an acceptable level for discharge, usually between 6.0 to 9.0 pH units. Neutralization may also be used as a pre- or post-treatment step with other treatment processes i.e., chemical precipitation. Adjustment of pH is done by adding acidic reagents to alkaline streams and vice versa.

- Initial Screening: Neutralization is a conventional and widely demonstrated means of adjusting the pH of a waste before and/or after chemical oxidation and precipitation. For this reason, neutralization is retained for further evaluation, if required as part of a chemical treatment system.

Physical Treatment - Water

Physical treatment processes that were screened for the liquid wastes generated from thickening, dewatering, or extraction processes include clarification, filtration, ion exchange, reverse osmosis and adsorption.

- Clarification

  Description: The primary function of clarification is to remove settleable suspended solids to produce a clear waste stream. The clarifier is equipped with a solids removal device to facilitate clarification on a continuous basis, resulting in a lower solids content for the effluent. Clarifier performance is based on the settling characteristics of the sediment and the design criteria of the units.

  Initial Screening: Clarification, which is a sedimentation process, has been shown in the bench-scale studies to be applicable for removing suspended solids in the dredged supernatant. This technology is therefore retained for further evaluation.

- Filtration

  Description: Filtration is used to remove organics and solids that are not settleable. The use of different media is possible, the most common being sand filtration or mixed media filters, which include sand and anthracite. Sand filtration is typically used after clarification to remove nonsettleable solids. A mixed media filtration system consists of a layer of anthracite and a layer of sand to effect the filtration and adsorption of fine particles. This type of filter media would selectively remove the insoluble particles that are present in the suspended solids of the supernatant.

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Initial Screening: Filtration is applicable to the removal of nonsettleable suspended solids and is retained for further evaluation.

- Ion Exchange

Description: Ion exchange is a process whereby toxic ions are removed from the aqueous phase by electrostatic exchange with relatively harmless ions that are held by ion exchange resins. Ion exchange is used to remove metallic cations and anions, inorganic anions, organic acids and organic amines. Fixed bed and countercurrent systems are the most widely used ion exchange systems. The continuous countercurrent systems are suitable for high flows. The strong base anion exchange resins are the most effective resins for arsenic removal.

Initial Screening: Bench-scale tests indicated that the strong base anion exchange resins in chloride form (Amberlite IRA-400 and Dowex AG-I-X8) removed arsenic from groundwater to below the discharge limit level of 0.05 mg/l. The ion exchange process is feasible to be used as a polishing unit for further arsenic removal following the physical-chemical precipitation process. However, the need for a polishing process unit is not anticipated due to the high solids and subsequent arsenic removal provided by clarification. Thus ion exchange is eliminated from further evaluation.

- Adsorption

Description: The process of adsorption involves contacting a waste stream with an adsorbent, usually by flow through a series of packed bed reactors. Adsorption efficiency depends on the strength of the molecular attraction between the adsorbent and the adsorbate, molecular weight, type and characteristics of adsorbent, electrokinetic charge, pH and surface area. Activated carbon has been demonstrated to be an ineffective adsorbent for arsenic removal from aqueous wastes (Lee, 1982), whereas activated alumina has been shown to be an effective adsorbent for arsenic-contaminated wastewater.

Initial Screening: The bench-scale treatability studies performed in the RI indicated that activate alumina adsorption displayed a much better arsen removal efficiency than activated carbon adsorptio Activated alumina adsorption could be used as polishing process for physical-chemical treatment fo the water extractant solution, but as discussed unde

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ion exchange, the need for a polishing unit is not anticipated. Therefore activated alumina adsorption is eliminated from further consideration.

- Reverse Osmosis

Description: Reverse osmosis is the application of sufficient pressure to a concentrated solution to overcome the osmotic pressure and force the net flow of water through the membrane toward a dilute phase. This allows the concentration of solute (impurities) to be built up in a circulating system on one side of the membrane, while relatively pure water is transported through the membrane. Ions and small molecular compounds in true solution can be separated from water by this technique. The basic components of a reverse osmosis unit are the membrane, a membrane support structure, a containing vessel, and a high pressure pump. The semipermeable membrane can be flat or tubular, but regardless of its shape, it can act like a filter due to the pressure-driving force.

Initial Screening: The bench-scale treatability studies indicated that reverse osmosis could be used to remove arsenic from the contaminated supernatant and to produce an effluent with total arsenic concentration below the target level of 0.05 mg/l. However, this process generated an extremely high volume of reject stream and required a very high operating pressure. In addition, the waste stream must be compatible with the waste stream's chemical and physical characteristics. Suspended solids and some organics would clog the membrane material, and low-solubility salts could precipitate onto the membrane surface. For these reasons, reverse osmosis is not a practical and economical technology for the liquid extractant treatment and is eliminated from further consideration.

Off-Site Wastewater Treatment

- POTW and Industrial Waste Treatment Plant

Description: Under this technology, the sediment supernatant or water wash extractant would be piped to a publicly owned treatment works (POTW) or industrial facility for treatment and discharge. At present, hookup to the local POTW or an industrial treatmen plant does not exist. A new piping system would hav to be constructed to transport the wastewater to th sewer system in the area or directly to an industria treatment plant.

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Initial Screening: The City of Vineland Sewage Treatment System near Union Lake was contacted with regard to accepting the wastewater. They indicated that their works do not have the extra capacity and adequate treatment processes to handle the large quantity of arsenic-contaminated wastewater. Therefore the off-site POTW technology is infeasible and is eliminated from further evaluation.

The only nearby industrial waste treatment plant is the ViChem wastewater treatment plant. This plant would not have the extra capacity to handle the supernatant or extractant flow. In addition, the existing ViChem wastewater treatment plant occasionally does not produce an effluent with arsenic below the discharge limit of 0.05 mg/l. Therefore this technology is eliminated from further consideration.

On-Site Wastewater Disposal

- Surface Water Discharge

Description: Surface water discharge entails the pumping of treated effluent into a nearby body of water. Discharge is accomplished by means of a pipe jutting into the water body with a diffusing section at its end to ensure adequate mixing with the receiving waters.

Initial Screening: Surface water discharge is a proven means of effluent disposal and is applicable to the River Areas. A well-engineered treatment process and diffuser section should meet all regulatory requirements for this technology, thus enabling it to be retained for additional consideration.

2.4.1.4 Transportation Technologies

In association with the optional off-site disposal technologies screened in Subsection 2.4.1.3, complementary modes of transportation must also be considered. The following methods of transportation were selected for this screening process.

- Truck

Description: There is limited road access to the Blackwater Branch and the upper Maurice River. Trucks would probably be used to bring in equipment and materials for remediation. In addition, watertight trucks or tanker trailers could be used to haul and

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transport sediment and sludge generated from treatment. Trucks would be properly decontaminated, weighed, and manifested before leaving the site. Stringent regulations and special permits for hauling hazardous materials and oversized and heavy loads over public highways would have to be taken into consideration.

Initial Screening: This is the most acceptable mode of transportation. The operation is flexible, because the number of trucks can be increased or decreased depending upon the requirements. The mode of transportation does not require special loading facilities at the project site or unloading facilities at the disposal site. Trucks are retained for further evaluation.

- Pipeline

Description: A pipeline system consisting of pipes or tubing could be used to convey materials. It can be used to handle both liquids and solids; however, the solids must be in a slurry form with a high water content. Hydraulic dredging technologies produce such a slurry, requiring a pipeline to carry the sediments to a dewatering basin. A pipeline can be a very costly system, especially if booster pump stations are required to overcome steep changes in elevations and distances.

Initial Screening: A pipeline to the disposal site only for the duration of the construction period would be extremely expensive. In addition, routing of this pipeline through various towns and along the roads would require numerous permits. This technology is eliminated for the disposal option. However, pipelines that are an integral part of a remediation process for conveying dredged/treated material from one unit to another unit will be considered.

### 2.4.2 Selection of Representative Technologies

Table 2-3 presents the results of the evaluation of various technologies performed in this section and the selection of representative technologies. This table identifies those technologies that are not feasible and have been eliminated from further evaluation. The table also identifies the technologies that will be combined into remedial alternatives and further evaluated in Section 3.0.

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# TABLE 2-3
# SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

| RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTIONS | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|---|
| NO ACTION | NONE | NOT APPLICABLE | NO ACTION | REQUIRED FOR CONSIDERATION |
| CONTAINMENT OF SEDIMENT | CAP | CLAY | COMPACTED CLAY OVER AREAS OF CONTAMINATION | NOT FEASIBLE UNDER RIVER BUT IS SUITABLE FOR LANDFILL |
| | | SYNTHETIC MEMBRANE | SYNTHETIC MEMBRANE OVER AREAS OF CONTAMINATION | POTENTIALLY APPLICABLE FOR USE W/MULTILAYER CAP |
| | | CHEMICAL SEALANTS | CHEMICALS OR CEMENT FORM STRONGER AND LESS PERMEABLE SURFACE | SUBJECT TO RIVER EROSION AND CRACKING. ALSO APPLICABILITY IN WATER IS UNKNOWN |
| | COVERING | COARSE SAND | COARSE SAND COVER PLACED OVER CONTAMINATED SEDIMENTS | SUBJECT TO RIVER EROSION AND ATTACK BY BIOTA, AND DOES NOT PREVENT ARSENIC LEACHING |
| | | STONE/GRAVEL | STONE OR GRAVEL PLACED OVER CONTAMINATED SEDIMENTS | SUBJECT TO RIVER EROSION, MAY NOT PREVENT PLANT GROWTH, AND DOES NOT PREVENT ARSENIC LEACHING |
| | | FABRIC FILTER | WOVEN MATERIAL PLACED OVER SEDIMENTS TO LIMIT MOVEMENT | NOT FEASIBLE BECAUSE IT IS SUBJECT TO BIOTA ATTACK AND REQUIRES CONTINUAL MAINTENANCE |
| | BARRIER | SILT CURTAIN | MADE FROM FABRIC FILTER AND SUSPENDED BY FLOATS OR STAKED INTO SEDIMENT TO REDUCE TRANSPORT | WOULD BE EFFECTIVE IN MINIMIZING RESUSPENDED PARTICLE MIGRATION |
| | | DIKES/PIERS | EARTH AND ROCKFILLED STRUCTURES USED TO ISOLATE AREAS FROM CONTAMINATION | ADVERSELY IMPACTS THE RIVER HYDRAULICALLY AND MAY CAUSE BACK-WATER FLOODING AND SCOURING |
| | | SHEET PILING | DRIVE SHEET PILE AROUND AREAS OF CONTAMINATION | NOT REQUIRED SINCE SEDIMENTS CAN BE REMOVED BY DREDGING |



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# TABLE 2-3 (CONTINUED)
# SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

| RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTIONS | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|---|
| TREATMENT OF SEDIMENT | COMPLETE OR PARTIAL REMOVAL | EXCAVATION | EXCAVATION OF SEDIMENTS IN FLOODPLAIN AND ALONG SHORELINES | A LOW GROUND PRESSURE BACKHOE CAN EXCAVATE FLOODPLAIN SEDIMENTS, AND BULLDOZERS AND FRONT-END LOADERS CAN PROVIDE SUPPORT |
| | | MECHANICAL DREDGING | CLAMSHELL OR BUCKET LOADERS MOUNTED ON BARGES EXCAVATE SEDIMENTS IN-PLACE | REQUIRES WATER DEPTH OF AT LEAST FIVE FEET AND CAUSES RESUSPENSION OF SEDIMENTS |
| | | HYDRAULIC DREDGING | UTILIZES WATER TO TRANSPORT IN-PLACE SEDIMENTS AS A 10 TO 20% WEIGHT SLURRY. FOUR TYPES OF HYDRAULIC DREDGES ARE COMMERCIALLY AVAILABLE | SUCTION/DUSTPAN, CUTTERHEAD AND HOPPER DREDGES CANNOT OPERATE IN THE SHALLOW MAURICE RIVER. PORTABLE HORIZONTAL AUGER CUTTER DREDGES ARE SUITABLE FOR USE |
| | | PNEUMATIC DREDGING | USES COMPRESSED AIR AND HYDROSTATIC PRESSURE TO DRAW SEDIMENTS TO A COLLECTION HEAD AND THROUGH A TRANSPORT PIPE | SOME UNITS REQUIRE A MINIMUM DEPTH AND ARE CURRENTLY BEING EVALUATED |
| | THERMAL TREATMENT | INCINERATION | TREATMENT WILL EVAPORATE WATER, DESTROY ORGANIC MATTER, AND VAPORIZE VOLATILE METALS | NOT FEASIBLE DUE TO INORGANIC ARSENIC CONTAMINATION |
| | | WET OXIDATION | ELEVATED TEMPERATURE AND PRESSURE ARE USED TO OXIDIZE ORGANIC COMPOUNDS | NOT APPLICABLE TO SOLIDS AND INORGANIC CONTAMINANTS |
| | CHEMICAL TREATMENT | ACIDIFICATION/ ALKALIZATION | AN ACID OR AN ALKALI ARE MIXED WITH SEDIMENT TO SOLUBILIZE AND LEACH ARSENIC INTO SOLUTION | TREATABILITY TESTS SHOWED THIS TECHNOLOGY WAS NOT FEASIBLE |
| | | EXTRACTION | EXTRACTION OF CONTAMINANT USING WATER, SOLVENT, WETTING AGENT, OR ANY COMBINATION OF THE THREE | TREATABILITY TESTS SHOWED THIS TECHNOLOGY TO BE FEASIBLE |
| | | FIXATION | CHEMICAL PROCESS THAT CONVERTS CONTAMINATED SEDIMENT INTO A CEMENT MATRIX WITH MINIMAL FREE, UNLEACHABLE WATER | TREATABILITY TESTS SHOWED THIS TECHNOLOGY TO BE POTENTIALLY FEASIBLE |



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# TABLE 2-3 (CONTINUED)
# SUMMARY OF REMEDIAL TECHNOLOGY SCREENING

| RESPONSE ACTION | REMEDIAL TECHNOLOGY | PROCESS OPTIONS | DESCRIPTION | SCREENING COMMENTS |
|---|---|---|---|---|
| TREATMENT OF SEDIMENT | PHYSICAL TREATMENT | HYDROCLONES | SLURRIES ARE PUMPED TANGENTIALLY INTO THE HYDROCLONE CAUSING MOST LARGE PARTICLES TO BE TRANSPORTED TO THE WALL AND OUT THE BOTTOM. MOST OF THE WATER AND FINES LEAVE AT THE TOP | FEASIBLE FOR SEPARATING FINES CONTAINING HIGH ARSENIC CONTENT FROM THE LARGE SANDY MATERIAL IN THE SEDIMENTS |
| | | DRYING BEDS | LIQUIDS ARE SEPARATED FROM THE SEDIMENTS BY GRAVITY DRAINING THROUGH A PERMEABLE LAYER | REQUIRES A LARGE LAND AREA AND IS LABOR INTENSIVE. OTHER TECHNOLOGIES ARE MORE SUITABLE |
| | | GRAVITY THICKENERS | SIMILAR TO CIRCULAR CLARIFIERS BUT HAVE A STEEPER SLOPE AND HEAVIER RAKING AND PUMPING MECHANISM | CAN BE USED TO THICKEN SEDIMENTS PRIOR TO EXTRACTION OR FIXATION |
| | | SEDIMENTATION BASINS/LAGOONS | A LINED BASIN/LAGOON IS FILLED WITH SEDIMENT/SLURRY AND AFTER SUFFICIENT TIME THE SUPERNATANT IS PUMPED OUT | THIS IS IMPRACTICAL TO IMPLEMENT BECAUSE THE EXCAVATION IS OVER A DISTANCE OF 8 MILES |
| | | DEHYDRO DRYING BEDS | SIMILAR TO REGULAR DRYING BEDS BUT A FLOCCULANT MIXER WITH SEDIMENT SLURRY AND A VACUUM IS USED TO PULL THE WATER THROUGH A PERMEABLE MAT | REQUIRES A LARGE LAND AREA AND IS LABOR INTENSIVE. OTHER TECHNOLOGIES ARE MORE SUITABLE |
| | | ULTRASONIC DEWATERING | ULTRASONIC VIBRATIONS ARE USED TO REMOVE WATER FROM SOLIDS | THE APPLICABILITY OF THIS TECHNOLOGY TO SEDIMENTS WITH A HIGH ORGANIC CONTENT IS UNKNOWN |
| | | CENTRIFUGE | CENTRIFUGAL FORCE SEPARATES SOLIDS FROM LIQUIDS BY DENSITY DIFFERENCES | FEASIBLE FOR SEPARATING FINES CONTAINING HIGH ARSENIC CONTENT FROM THE LARGE SANDY MATERIAL IN THE SEDIMENTS |
| | | FILTER PRESS | SEDIMENTS ARE FORCED UNDER PRESSURE AGAINST A FINE CLOTH THAT PERMITS THE WATER TO PASS THROUGH | THIS TECHNOLOGY IS VERY LABOR INTENSIVE AND HAS A LIMITED CAPACITY |
| | | VACUUM FILTER | A ROTATING CYLINDER WITH AN INTERNAL VACUUM PULLS WATER THROUGH A FILTER CLOTH LEAVING THE SOLIDS ON THE OUTSIDE | FEASIBLE TECHNOLOGY FOR DEWATERING SEDIMENTS |
| | | BELT FILTER PRESS | A HORIZONTALLY OR VERTICALLY MOVING BELT USES VACUUM AND/OR ROLLERS TO PULL WATER THROUGH THE BELT | THIS ACCOMPLISHES THE SAME RESULT AS THE VACUUM FILTER BUT IS MORE COSTLY |



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## 3.0 DEVELOPMENT AND SCREENING OF REMEDIAL ALTERNATIVES

In this section, the technically feasible remedial technologies identified in Section 2.0 are grouped into potential remedial action alternatives. These alternatives are screened based on effectiveness, implementability and cost considerations. The purpose of the screening step is to identify those alternatives of sufficient merit to undergo detailed evaluation.

The purpose of the initial screening is to narrow the number of potential remedial alternatives for detailed analysis while preserving a range of options. The discussions and evaluations comprising this screening are not intended as a substitute for or a supplement to the detailed analysis of the alternatives conducted in the next section of this report.

### 3.1 DEVELOPMENT OF REMEDIAL ALTERNATIVES

The contamination within the Maurice River and the Blackwater Branch presents a potential for human risk to exposed populations through contact with sediments that were contaminated with arsenic. The target cleanup levels for arsenic in sediments have been established in Section 2.2.

The Maurice River also presents a potential human risk to exposed populations through ingestion of surface water and fish contaminated with arsenic. However, as discussed previously, only sediment remedial alternatives are considered in this FS. It is expected that the water's arsenic contamination can be reduced through remedial actions at the ViChem plant, which are presented in the Plant Site FS. If, after further USEPA review, it is determined that the fish ingestion risks are unacceptable, remedial alternatives for this problem can be addressed at that time.

The remedial objective established for the contaminated sediments in the Maurice River, Blackwater Branch and the Blackwater Branch floodplain is:

- Minimize public access, either through containment, treatment, or institutional controls, to areas with unacceptably high sediment arsenic concentrations, particularly the exposed former sediments in the Blackwater Branch floodplain.

Remedial alternatives that may achieve this objective and are suitable for initial screening are developed by a three-step process. First, response criteria are established to evaluate the acceptability and the anticipated performance of each alternative with respect to environmental and public health impacts. This step establishes the applicable or relevant and appropriate requirements (ARARs) and other criteria as



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appropriate to define potential human health risks associated with the remedial action, and establishes performance requirements which must be met by the remedial action. Next, potentially applicable technologies identified in Section 2.0 are used to develop comprehensive remedial alternatives on the bases of operation and performance, compatibility, and the use of acceptable engineering practice. Finally, the alternatives are evaluated in a general sense with respect to effectiveness, implementability and cost criteria. The following is a description of each step of the process.

### 3.1.1 Development of Remedial Response Criteria

This subsection describes the use of applicable or relevant and appropriate requirements (ARARs) in evaluating remedial alternatives during feasibility studies, and identifies the ARARs used to evaluate remedial alternatives for the River Areas.

#### 3.1.1.1 Use of ARARs in Remedial Alternative Evaluation

CERCLA did not provide specific guidance on standards that should be utilized to manage uncontrolled hazardous substance sites. USEPA subsequently developed the ARAR concept to govern Superfund program compliance with other environmental and public health statutes in remedial actions.

Before enactment of the Superfund Amendment and Reauthorization Act (SARA), USEPA's ARAR guidance was contained in the National Contingency Plan (NCP) and the "Memorandum on CERCLA Compliance with Other Environmental Laws" (the Compliance Policy), which was published as an appendix to the NCP. Section 121 of SARA incorporated the ARAR concept but made several changes. Most importantly, Section 121 designated state requirements as ARARs whenever they are promulgated and identified in a timely manner, and are as strict or stricter than equivalent federal ARARs. SARA also required the attainment of Water Quality Criteria or Maximum Contaminant Levels if they are "relevant and appropriate". On August 27, 1987, USEPA issued an Interim Guidance document addressing the new ARAR provisions (52 Fed. Reg. 32496).

The role of ARARs in the Feasibility Study process involves the evaluation of a remedial alternative to characterize the performance level it is capable of achieving. Each remedial alternative must be assessed to evaluate whether it attains or exceeds federal and state ARARs.

Two types of ARARs exist: "applicable" and "relevant and appropriate" requirements of federal and state laws. An applicable requirement is any standard or limitation that is legally binding on a CERCLA site based on the contaminant, remedial action, or location of the site. In other words,

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applicable requirements are requirements that would apply to response actions even if actions were not taken pursuant to CERCLA. A "relevant and appropriate" requirement is any standard or limitation that, while not applicable to the hazardous substance, action, or location at a CERCLA site, does address problems or situations sufficiently similar to those encountered at the CERCLA site that its use is suited. When establishing performance goals for remedial alternative selection, relevant and appropriate requirements are given equal weight and consideration as applicable requirements.

If no ARAR exists for a CERCLA site situation, other federal and state criteria, advisories, guidances, or proposed rules may be considered for developing remedial alternative performance goals. These "To Be Considered" materials are not legally binding, but may provide useful information or recommended procedures that explain or amplify the content of ARARs. If no ARAR addresses a particular situation, or if existing ARARs do not ensure protection of human health and the environment at a particular site, "To Be Considered" material (TBCs) should be evaluated for use.

Each type of ARAR can be characterized further as (1) contaminant-specific; (2) action-specific; and (3) location-specific. A contaminant-specific ARAR sets health and risk-based concentration limits in various environmental media for specific hazardous substances or contaminants. An action-specific ARAR sets performance, design, or other similar action-specific controls on particular remedial activities. A location-specific ARAR sets restrictions on the conduct of activities in particular locations, such as wetlands, flood-plains, national historic districts, and others.

3.1.1.2 Identification of ARARs for the River Areas

This section presents a listing and general discussion of the federal and New Jersey ARARs and "To Be Considered" (TBCs) material utilized in this Feasibility Study.

3.1.1.2.1 Listing of ARARs and TBCs

This listing is organized into the categories described above.

- <u>Contaminant-Specific</u>

  - Federal and New Jersey Drinking Water Maximum Contaminant Levels (MCLs)

  - Federal Clean Water Act Water Quality Criteria

  - New Jersey Surface Water Quality Standards

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- New Jersey Department of Environmental Protection: citation found under New Jersey Environmental Cleanup Responsibility Act (ECRA) - New Jersey Soil Cleanup TBC for Arsenic

o <u>Location-Specific</u>

- Wild and Scenic Rivers Act
- U.S. Fish and Wildlife Coordination Act
- National Endangered Species Act
- Federal Floodplain and Wetlands Executive Order
- Federal Floodplains and Wetlands Policy
- New Jersey Coastal Area Facility Review Act (CAFRA) Permit Requirements
- New Jersey Wetlands (Coastal and Fresh Water) Permit Requirements
- River and Harbor Act Section 10/Clean Water Act Section 404 Standards
- New Jersey Soil Erosion and Sediment Control Requirements
- New Jersey Stream Encroachment Act Standards

o <u>Action-Specific</u>

- Federal and New Jersey Hazardous Waste (Resource Conservation and Recovery Act) Treatment/Storage/ Disposal Facility Requirements
- Federal Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions
- Federal and New Jersey Nonhazardous Waste Landfill Facility Criteria
- Clean Water Act NJPDES Discharge to Surface Water Requirements
- Occupational Safety and Health Act Requirements for Hazardous Responses
- RCRA Characteristic Testing for Hazardous Waste Identification



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- Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste

- New Jersey Toxic Substance Air Pollution Standards

- New Jersey Ambient Air Quality Standards

- National Historic Preservation Act

3.1.1.2.2 General Discussions of Key ARARs and TBCs

This subsection presents general discussions of those ARARs and TBCs that are the key requirements in remedial alternative evaluation and comparison. The focus of these discussions is on distinguishing between alternatives based upon ARAR/TBC attainment, rather than providing an exhaustive description of the ARARs/TBCs themselves.

o <u>New Jersey Surface Water Quality Standards and NJPDES Discharge Requirements</u>

New Jersey surface water quality standards furnish ambient levels that provide for the protection of freshwater systems that may be used for recreational, domestic, potable, and/or agricultural uses (after treatment). The NJPDES effluent limits are set to prevent exceedance of standards following discharge in and mixing with surface waters. To ensure that surface water discharges at the ViChem River Areas do not exceed the ambient levels, the surface water quality standards are used as a conservative approach. These standards establish the design and operation goals for water treatment systems.

o <u>New Jersey Department of Environmental Protection: Citation found under New Jersey Environmental Cleanup Responsibility Act (ECRA) - New Jersey Soil Cleanup Standards</u>

New Jersey soil cleanup standards are not promulgated, but are so-called "To Be Considered" standards. These standards are found in Attachment 6 of an NJDEP ARAR submission to USEPA Region II dated February 19, 1987. This document sets so-called surrogate or alarm levels, which encompass the contaminants (e.g., arsenic) contained in the exposed Blackwater Branch floodplain sediments.

The cleanup level for arsenic contaminated soil is 20 mg/kg. This standard was developed based on anticipated background levels. New Jersey established this level to achieve their goals of preventing direct contact and protecting groundwater and surface water. Given the reasons behind the New Jersey TBCs, remedial alternatives that either contain or remove the

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contaminated sediments would attain these clean-up levels, since both remedial approaches will eliminate the pathways that create a human health risk.

o National Historic Preservation Act

This calls for a Stage IA survey to be performed during the design phase if a remedial action is taken. The Stage IA survey requires a literature search to identify areas of historical significance which should be protected during a remedial action. The Stage IA survey does not call for field surveys for areas of historical significance. The USEPA Region II was informed of this requirement by personnel from the USEPA's Environmental Impacts Branch (EIB).

o RCRA Regulations

Sediments contaminated with arsenic are considered a "RCRA Characteristic" hazardous waste (40 CFR 261.24, USEPA Hazardous Waste #0004), if the arsenic concentration levels in an extract produced by the EP Toxicity Test from a representative sediment sample exceed the EP Toxicity Test threshold level of 5.0 mg/l. Soils containing by-product salts from the production of monosodium methanoarsenate (MSMA) (RCRA listed waste K 031) and sediments contaminated by K 031 are considered a listed hazardous waste because they were derived from a listed waste (40 CFR 261.32).

MSMA by-product salt improperly stored on-site is believed to be the source of the arsenic contamination detected in sampling to date. Throughout this FS Report, ViChem arsenic-contaminated soils and sediments are considered a RCRA listed hazardous waste derived from the by-product salt waste, K 031. Arsenic is the listed hazardous constituent of concern for K 031 (see 40 CFR 261 Appendix VII). Guidance on this classification was received from USEPA Region II RCRA Branch and USEPA Headquarters Site Policy Guidance Branch personnel (SPGB).

o RCRA Land Disposal Restrictions (LDRs)

RCRA LDRs were enacted to prohibit the disposal of untreated hazardous wastes in landfills, surface impoundments, injection wells and other forms of land disposal facilities. The LDRs establish Best Demonstrated Available Technology (BDAT) treatment standards for hazardous wastes prior to land disposal. RCRA characteristic wastes and RCRA listed hazardous wastes are subject to RCRA LDRs.

The RCRA characteristic wastes are part of the so called "Third-Third" of RCRA wastes, which will be subject to LDR requirements after May 8, 1990. Proposed LDR standards for these wastes are not yet developed. The RCRA listed waste K 031

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(by-product salts from the production of MSMA) is part of the "First-Third" of RCRA waste that is subject to the LDR "soft hammer" requirements as of August 1, 1988. The "soft hammer" provision limits disposal of K 031 wastes for which no treatment standard has been established. Until May 8, 1990, such waste may be placed in a landfill that meets minimum technology requirements (MTR) under two conditions: (1) the generator demonstrates and certifies to the USEPA that either no treatment technology is practically available; or (2) the waste has been treated to reduce meaningfully the long-term hazard of the waste when it is placed in the landfill. If the USEPA has not established a BDAT standard by May 8, 1990, land disposal of the listed waste is prohibited.

Delisting

As discussed above, the river sediments are a RCRA listed hazardous waste based on their derivation from K 031. According to RCRA SPGB, this waste could be declared nonhazardous and excluded from the protective management restraints of RCRA Subtitle C through a delisting procedure. In USEPA practice, a delisting exclusion on a "generator-specific" basis may be applied to waste already generated or anticipated for generation as part of an industrial process. In this CERCLA case, in comparison, arsenic-contaminated sediments are present on a Superfund site and will be treated and disposed of as part of the remedial action selected for the site.

Delisting can be done in three ways: (1) by a rulemaking petition to the Administrator of USEPA; (2) by a rulemaking petition to the state of New Jersey which was delegated delisting authority, 53 Federal Register 30054 (August 10, 1988) or (3) by a determination of the Regional Administrator of USEPA Region II in the ROD based on compliance with the delisting standards. A delisting petition submitted under 40 CFR 260.20, or the equivalent New Jersey regulation, allows any person to petition, to modify or to revoke any provisions of Parts 260 through 268, 124, 270 and 271 of Title 40 of the CFR - Code of Federal Regulations and 40 CFR 260.22, or the equivalent New Jersey regulations, which specifically provide generators the opportunity to exclude a waste on a "generator-specific" basis from the hazardous waste lists.

A petitioner must show that a waste generated at its facility does not meet any of the criteria under which the waste was listed (see 40 CFR 260.22 (a)). In addition the Hazardous and Solid Waste Amendments (HSWA) require USEPA to consider factors, including additional constituents, other than those for which the waste was listed, if there is a reasonable basis to believe that such additional factors could cause the waste to be hazardous. Accordingly, a petitioner must demonstrate also that the waste does not exhibit any of the hazardous waste

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characteristics, (i.e., ignitability, reactivity, corrosivity and EP Toxicity) and present sufficient information for USEPA, or NJDEP, to determine whether the waste contains any other toxicants at hazardous levels (see 40 CFR 260.22, 42 U.S.C. 6921(f) and USEPA's background documents for listed wastes). Although wastes which are "delisted" (i.e., excluded) have been evaluated to determine whether or not they exhibit any of the characteristics of hazardous waste, generators remain obligated to determine whether their waste remains nonhazardous based on the hazardous waste characteristics.

Delisting requires demonstrating that the material no longer exhibits the characteristic for which it was initially listed, and that no hazardous constituents of concern are present in the material. Factors considered for delisting include the nature of the waste, the concentration of the contaminant in the waste, the potential for contaminant migration, the quantity of the waste disposed, and the presence of other hazardous constituents potentially mixed in with the waste. Selection of the appropriate delisting procedure depends on the ultimate disposal selected for the treated waste, as discussed in the following section.

For off-site nonhazardous disposal, a petition followed by a public comment period would enable the Administrator of USEPA, or the state of New Jersey with equivalent regulations, to exclude a waste from regulation as a hazardous waste. On-site nonhazardous disposal permits the Regional Administrator to delist a waste in the ROD, with public comment on the ROD, but without all the procedural steps of a formal rulemaking.

The USEPA and NJDEP generally utilize the VHS model for evaluating delisting petitions. The VHS model predicts groundwater contamination potential for wastes disposed in a Subtitle D landfill. This environmental fate and transport model simulates contaminant transport through an aquifer that underlies a landfill. Under a landfill disposal scenario, the major exposure route of concern for hazardous constituents would be ingestion of contaminated groundwater. The VHS model reflects a reasonable worst-case disposal scenario that is appropriate when evaluating whether treated wastes could be disposed of as nonhazardous in a Subtitle D landfill. Details on the VHS model are given in 50 FR 7882 (February 26, 1985) and 50 FR 48896 (November 22, 1985).

Parameters of the VHS include contaminant concentration in the leachate, penetration depth of leachate in the aquifer, distance from the disposal site to the compliance point, length of the disposal site, lateral dispersivity and vertical dispersivity. With the exception of the contaminant concentration in the leachate, determined by the EP Toxicity Test, and the length of the disposal site, dictated by the volume of waste, all of the

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values for the model's parameters have been fixed by the USEPA. The VHS model outputs hypothetical hazardous constituent concentrations at a groundwater receptor 500 feet from the disposal site.

In the event that the treated waste is deemed appropriate for commercial use by NJDEP, alternate exposure routes such as air or surface water are relevant for delisting. Therefore, in addition to the VHS model, a risk assessment, which has already been performed for the sediments, would be utilized to demonstrate that the treated waste represents an acceptable risk which USEPA has determined is protective of human health and the environment.

Substantive Delisting Demonstration

In order to meet substantive delisting requirements, the EP Toxicity extract for total arsenic must be less than that computed by the VHS model. Utilizing 78,000 cubic yards as the total volume of contaminated sediments, the VHS model was used to "back-calculate" a maximum EP Toxicity concentration in the disposed waste which would correspond to a receptor well concentration of 0.05 mg/l of arsenic, the MCL. MCLs are used by the delisting program as the levels of regulatory concern. If delisting is performed by the Regional Administrator, the ROD would need to solicit comment on the appropriateness of utilizing the VHS model to evaluate the waste. For the river area sediments, the EP Toxicity extract must be less than 0.32 mg/l to meet a hypothetical "at the well" concentration of 0.05 mg/l. Based on the treatability studies, other information gathered during the RI, and with USEPA Region II concurrence, it is assumed that the treated material (fixated or extracted) will achieve an EP Toxicity extract concentration that will meet the level of regulatory concern, as predicted by the VHS model.

The EP Toxicity Tests conducted in the fixation treatability studies achieved an arsenic concentration in the extract of approximately 1 mg/l. At the time the tests were performed, the target delisting criterion was believed to be an EP Toxicity extract arsenic concentration of 5 mg/l, which the original treatability tests clearly achieved. Different formulations to optimize additive addition rates were not tried, nor were additional mixtures tried to determine the lowest arsenic concentration that could be achieved in the EP Toxicity extract, since the target arsenic concentration (less than 5 mg/l) was achieved.

The vendors who performed the fixation tests indicated that it would be feasible to achieve a leachate concentration lower than 1 mg/l total arsenic by increasing the amount of proprietary agent added to the fixation formulation (Falk and Gironda - Telephone Communication, 1988). As the sediment has a high



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organic content, the amount of powdered activated carbon added to the formulation would also be increased. Therefore, based on confirmation by the vendor, it is assumed, with USEPA Region II concurrence, that the contaminated sediment could be fixated to achieve an EP Toxicity concentration of less than 0.32 mg/l total arsenic. This would enable the fixated materials to meet substantive delisting requirements based on utilization of the VHS model to evaluate the waste.

It is also believed that the arsenic concentration in the separated coarse sands could be reduced, as a result of extraction, to levels complying with the VHS calculated delisting level. Extraction was evaluated in the bench-scale treatability studies to determine the feasibility of this technology to extract arsenic from the sediments. It was unclear from the tests whether the water wash simply separated the fine sediment containing arsenic from the coarse sediments that contain little arsenic, or whether the water actually solubilized the arsenic contained in the sediment. It is believed, based on the treatability study and other data collected during the RI, that the water wash separated the fine sediments that contained most of the arsenic from the coarse sediments. The elutriate solution, containing both fine sediments and water, contained a majority of the arsenic while the washed sediments contained very little arsenic (36 mg/kg). Therefore a water "extraction" is deemed feasible to separate the coarse from the fine sediments, which in effect substantially reduces the arsenic concentration in the coarse sediments. It is believed that these course sediments could meet the substantive delisting requirements and thus be disposed of by nonhazardous methods.

These hypotheses are further supported by the fact that all the EP Toxicity Tests conducted on <u>untreated</u> sediment achieved an extract of less than 0.32 mg/l total arsenic. For this FS, it is thus assumed that the treated sediments can meet the substantive delisting requirements and can be disposed of as nonhazardous materials. This assumption is made with USEPA Region II concurrence. However, in order to ensure that only nonhazardous wastes are removed from Subtitle C control, an extensive verification testing program would be conducted for the sediments. Due to the heterogeneous nature of contaminated sediments, it is not feasible to test in advance every variation of material which would require treatment. Therefore, during design, verification testing would be conducted along with bench- and pilot-scale testing on the optimized treatment systems. Verification testing would also be performed on representative batches treated during the remedial action. Representative testing would be done to ensure that all treated materials complied with the VHS-calculated delisting level.



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The authority for delisting the treated waste would rest with USEPA Headquarters, NJDEP, or the USEPA Region II Regional Administrator, depending on the location chosen for final disposal of the treated sediments. On-site disposal of the treated sediments would permit delisting by the Regional Administrator in the ROD based upon the treated waste meeting the delisting criteria. Off-site disposal of the treated sediment in New Jersey would require a delisting petition to be reviewed by NJDEP. In the event that the treated sediments are disposed of in a state other than New Jersey or Georgia, delisting would be performed by the USEPA Administrator.

The USEPA permits "upfront delisting" i.e., delisting petitions granted prior to the generation of waste, which without upfront exclusions, would unnecessarily be considered hazardous. With respect to this CERCLA action, the arsenic-contaminated sediment waste exists, but the intent to delist would be incorporated in the ROD.

Conditional delisting would be permitted based on a program of treatment, sampling and analysis of the treated sediments to demonstrate that they have been treated to levels that are nonhazardous. The actual delisting of the waste would occur after the waste was treated.

During final design, the chosen treatment process would be optimized to assure that the treated waste would meet the delisting requirements with a considerable degree of certainty. The treated sediments would meet the substantive delisting criteria established by the VHS model and also the more stringent cleanup level established in the risk assessment for this material. It should be noted that arsenic is the hazardous substance of concern in the listed waste K 031. The assurance that the treated material consistently achieves the substantive delisting level of the VHS model and the level in the risk assessment would be established from bench-scale studies conducted during the design phase. In addition, verification testing conducted throughout the remedial action would assure that the substantive standards of the delisting program are met and that only nonhazardous wastes are removed from Subtitle C control.

Management of Delisted Materials

After the treated sediments have met the delisting requirements, they would no longer fall under RCRA Subtitle C control and a method of final disposition would be determined. This method is dependent upon whether or not the material is classified as a waste. If a material is classified by NJDEP as ID 27 waste, it would be disposed of in an on-site or off-site nonhazardous solid waste landfill. However, if a beneficial use can be identified, and if the sediments are treated to below the more



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stringent action level of 20 mg/kg arsenic, the NJDEP may not consider the material as a waste. For treated sediments designated by NJDEP as suitable for the commercial market, the potential exists for use as a construction aggregate. Material vendors in the region have expressed interest in acquiring the sandy sediments treated by both extraction and fixation for a number of construction applications. The treated sediment could also be used as "clean fill" to restore the excavated areas of the Blackwater Branch floodplain. These methods of final disposition of the treated sediments would be environmentally sound and would also result in substantially reduced costs compared to disposal in a nonhazardous waste Subtitle D landfill.

If, during final design, it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting agent would be required. Treatability tests indicated that sodium citrate would reduce the sediment arsenic concentration to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediments.

Subtitle C Landfill Disposal

If the treated sediments are not delistable, USEPA Headquarters SPGB personnel have provided guidance on the criteria to allow for their disposal in a hazardous waste RCRA Subtitle C landfill. Since no BDAT is presently available for K 031 listed hazardous waste, a "treatability variance" could be applied for if the treated sediments do not meet the 0.32 mg/l arsenic leachate concentration established through the application of the VHS model. For the treated river sediments, this treatability variance is 1 mg/l arsenic concentration in an EP Toxicity Test according to USEPA Headquarters SPGB personnel. Achieving this level would allow the treated sediments to be disposed of in a RCRA Subtitle C hazardous waste landfill.

If a BDAT standard for the listed waste K 031 is not established by May 8, 1990, and the treated sediments are not delistable, land disposal of the sediments would be prohibited. In contrast, once the waste meets the delisting criteria, the treated material is no longer subject to RCRA LDRs because the material is no longer a listed waste.

Summary

Figure 3-1 presents a flow chart showing the impact of RCRA LDRs on the river sediments. To summarize the discussion above, BDAT levels for the RCRA listed hazardous waste K 031 have not yet been established. The river sediments containing elevated arsenic concentrations are considered K 031 waste because the contamination was derived from K 031 wastes generated and improperly stored at the ViChem site.



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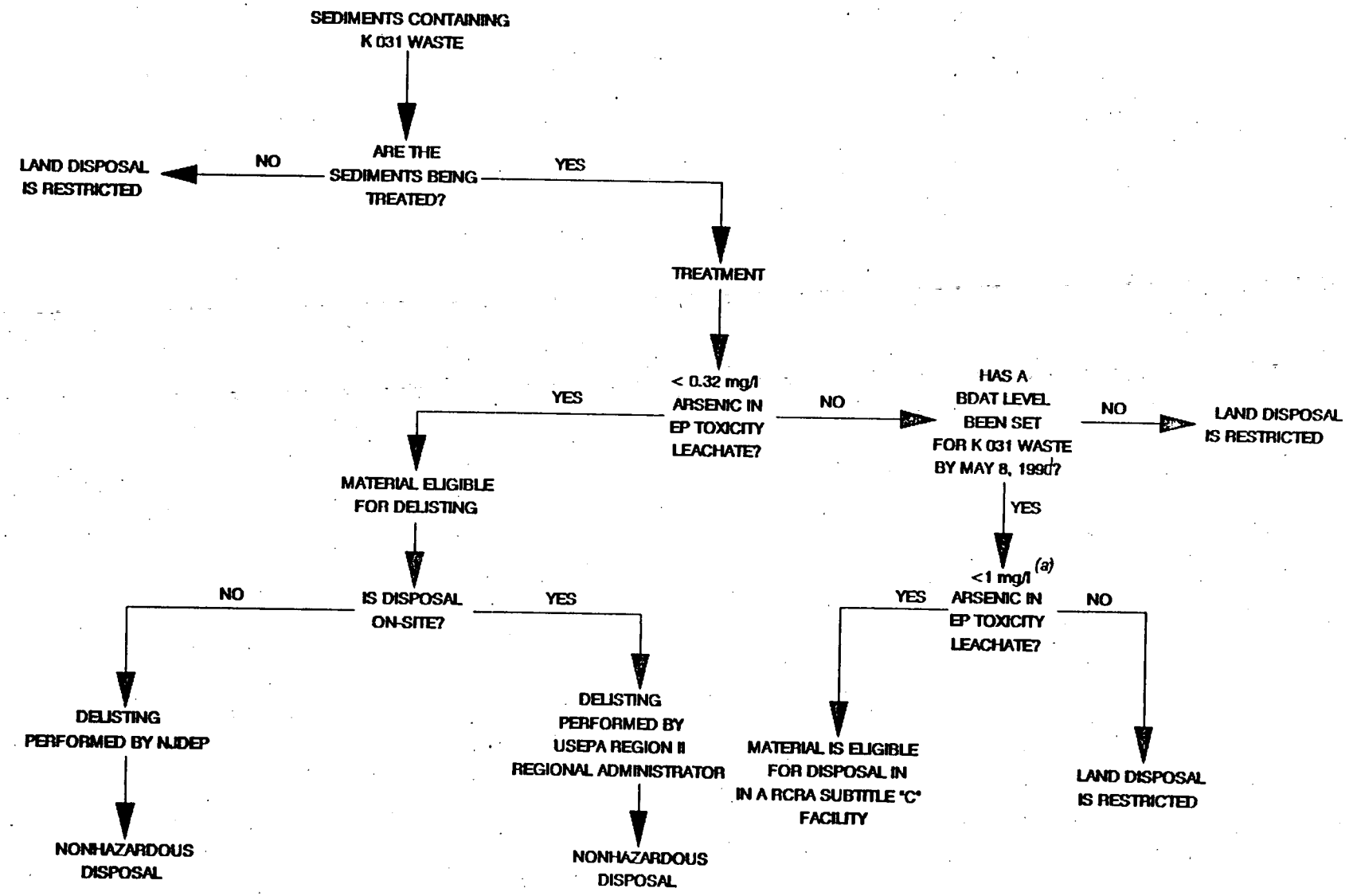
# FIGURE 3-1

## RCRA DISPOSAL CONSIDERATIONS




*REATABILITY VARIANCE" AND APPLIES REGARDLESS OF WHAT RIA ARE ESTABLISHED FOR THE K 031 WASTE*

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If BDAT standards governing the disposal of the K 031 wastes are not established by May 8, 1990, these wastes cannot be disposed of on the land. However, since BDAT standards are not presently established, USEPA Headquarters SPGB personnel have given the following guidance to USEPA Region II regarding the disposal options for the treated river sediments.

- If, after treatment, the sediments meet the substantive delisting requirement of 0.32 mg/l in the EP Toxicity extract, they can be delisted. This will remove the sediments from RCRA Subtitle C management control and is not contingent on there being a BDAT standard in effect at the time of remediation. Region II may utilize delisting in the ROD for the treated sediments for on-site nonhazardous disposal. A delisting petition to the Administrator of USEPA or to NJDEP would be required for off-site nonhazardous disposal. The delisted sediments could also potentially be reused for a beneficial purpose based on a risk assessment and prior State approval.

- If, after treatment, the treated sediments do not comply with the VHS model criterion of 0.32 mg/l in the EP Toxicity extract, then they cannot be considered nonhazardous material. A treatability variance of 1 mg/l arsenic in the EP Toxicity leachate could be applied for. If the treated sediments can meet this level, but cannot meet the 0.32 mg/l criterion, then the treated sediments can be disposed of only as hazardous waste in RCRA Subtitle C landfill. This option applies only if a BDAT standard is in affect (i.e., the "hard hammer" provisions are not in effect), and applies regardless of what the BDAT standards for wastes are.

- If, after treatment, the treated sediments do not comply with the 1 mg/l treatability variance EP Toxicity criterion, they cannot be disposed of in any type of landfill. An alternate remedial technology would have to be chosen that would achieve this minimum level, or a different remediation strategy would be required.

- If, after May 8, 1990, a BDAT standard for the listed waste K 031 has not been established, and the sediments fail to meet the delisting criterion allowing their removal from RCRA Subtitle C control, they cannot be land disposed.

Based on the treatability studies, information collected during the RI, and on information supplied by vendors, it is assumed that both fixation and water wash extraction can be optimized and that the treated sediments from either process would meet the delisting requirements. Bench or pilot-scale treatability studies to achieve optimized treatment systems would be performed as part of the design to verify this assumption.



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Extensive testing would also be required during the remedial action to verify that all possible sediment types are treated to delistable levels.

Assuming the treated sediments meet the delisting requirements, a determination of whether or not the material can be classified as ID 27 waste would have to be made to facilitate the means of final disposition. If the material is classified as ID 27 waste by NJDEP, then the material may be disposed in an on-site or off-site Subtitle D landfill. If the material is not classified as ID 27 waste, it may be used as clean fill for the excavated areas of the site or introduced into the commercial market for use as a construction aggregate, substantially reducing remediation costs.

### 3.1.2 Combination of Applicable Technologies into Feasible Remedial Alternatives

An overview of the technology screening presented in Section 2.0 and Table 2-1 indicates that three basic remedial alternatives exist for the contaminated sediments:

1) No Action
2) Removal, Treatment and Disposal
3) Containment (RCRA Landfill)

A fourth alternative, in situ treatment, was eliminated from further consideration in Section 2.0.

The development of the source control alternatives was based on the identification and screening of technology types and process options as discussed in Section 2.4. Regulatory requirements require that a No Action Alternative be developed in order to serve as a baseline against which the other alternatives can be compared. Thus Alternative 1 was developed. The screening performed in Section 2.0 identified the arsenic-contaminated sediment to be treatable utilizing sediment fixation or water extraction with subsequent off-site or on-site disposal of the treated sediment. Alternatives 2A, 2B, 2C, 3A, 3B and 3C were developed considering these options. Off-site RCRA and on-site RCRA disposal options for the contaminated sediment passed the initial screening and are evaluated in Alternatives 4A and 4B.

Based on the requirements of the remedial responsive objectives and their associated feasible remedial technologies, the following combined remedial alternatives are thus identified:

Alternative 1 - No Action
Alternative 2A - Dredging/Excavation/Thickening/Fixation/Off-Site Nonhazardous Landfill
Alternative 2B - Dredging/Excavation/Thickening/Fixation/On-Site Nonhazardous Landfill



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Alternative 2C - Dredging/Excavation/Thickening/Fixation/ Floodplain Deposition of Exposed Sediments/ Plant Site Deposition of River Sediments

Alternative 3A - Dredging/Excavation/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Alternative 3B - Dredging/Excavation/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Alternative 3C - Dredging/Excavation/Extraction/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/Off-Site Hazardous Sludge Disposal

Alternative 4A - Dredging/Excavation/Dewatering/Off-Site RCRA Landfill

Alternative 4B - Dredging/Excavation/Dewatering/On-Site RCRA Landfill

The potential remedial alternatives listed above are described and evaluated in Section 3.2.

### 3.1.3 Evaluation Criteria and Approach

The factors considered in the three evaluation criteria (i.e., Effectiveness, Implementability and Cost) are discussed in the USEPA's October 1988 Interim Final Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA. A brief description of these factors follows.

#### Effectiveness Evaluation

The effectiveness evaluation considers the capability of each remedial alternative to protect human health and the environment and to achieve the target cleanup concentrations. The target arsenic cleanup level for submerged and exposed sediments in the Blackwater Branch floodplain and the more accessible submerged sediments in the river is 20 mg/kg and the target cleanup level for the sediments in the less accessible areas is 120 mg/kg. In order to satisfy requirements for disposal disposed in a nonhazardous landfill, the treated sediments must have an EP Toxicity leachate concentration less than 0.32 mg/l of arsenic. Each alternative is evaluated as to the protection it would provide, and the reductions in toxicity, mobility or volume it would achieve.

#### Implementability Evaluation

The implementability evaluation is used to measure both the technical and administrative feasibility of constructing, operating and maintaining a remedial action alternative. In addition, the availability of the technologies involved in a remedial alternative is also considered.



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Cost Evaluation

Costs may be used in the screening process to discriminate between treatment alternatives, but not between treatment and nontreatment alternatives. Cost evaluation includes estimates of capital cost, annual operation and maintenance (O&M) costs, and present worth analysis. These conceptual cost estimates are order-of-magnitude estimates, and have been prepared based on:

- Preliminary conceptual engineering for major construction components;
- Unit costs of capital investment and general annual operation and maintenance costs available from USEPA documents (USEPA 1985b and USEPA 1985c) and from Ebasco in-house files.

Present worth costs are used for comparisons among the remedial alternatives, and they are estimated based on a designated discount rate and a system life. It should be noted that treatment and nontreatment alternatives (i.e., containment and no action) are not compared with respect to cost, as they inherently do not provide similar degrees of remediation.

As a result of the screening process, effectiveness, implementability, and present worth costs are then used to compare the alternatives, especially alternatives that are very similar. As a result of this comparison, the least favorable remedial alternatives are ruled out from further consideration or detailed evaluation. The alternatives that pass this screening are taken into detailed evaluation in Section 4.0.

## 3.2 DESCRIPTION AND SCREENING OF REMEDIAL ALTERNATIVES

The purpose of this section is to describe and screen the remedial action alternatives developed in Subsection 3.1.2 to ultimately narrow the number of potential alternatives for detailed analysis while preserving a range of technical options. The screening criteria conform with the remedial requirements set forth in CERCLA as amended, Section 121, and in the NCP (40 CFR 300.68 (g)).

### 3.2.1 Alternative 1 - No Action

Description: The No Action Alternative provides the baseline against which other responses can be compared. It would result in leaving the arsenic-contaminated sediments intact. This alternative would consist of environmental monitoring a security measures. In addition, education programs would implemented to inform the public about potential hazards.

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A long-term monitoring program would include sediment sampling and river water sampling in both the Maurice River and the Blackwater Branch. In addition, ecological surveys would be performed with the sampling. Site security measures would include posting warning signs along the perimeter of the river areas. Because this alternative would result in wastes remaining on-site, 1986 CERCLA amendments would require that the site be reviewed every five years.

Effectiveness: This alternative would reduce the potential for direct human contact (through the institutional controls); however, access restriction measures can be violated. This alternative would not meet the remedial action objective and would not achieve any reduction in the volume, toxicity or mobility of contaminants. It would not attain any ARARs since this response does not address the threat of the off-site migration of contaminants. Contaminants would continue to migrate off-site by leaching or the resuspension of particles into river water with subsequent transport to Union Lake.

Implementability: From a technical perspective, this alternative would be easy to implement (posting warning signs), but extensive site monitoring would require attention to long-term administrative considerations. Some administrative efforts would also be required to obtain institutional controls. These institutional controls would include public education programs to heighten public awareness concerning the restricted use of the river. Monitoring technologies are reliable and are readily available.

Cost: No action would be the least expensive alternative under consideration. It is estimated that this alternative would require a capital cost of approximately $44,000 and an annual operation and maintenance cost of approximately $41,000 (per year for 30 years). The present worth for this alternative, including six five-year reviews, would be $674,000, based on a 5% discount rate after inflation for a 30-year period.

Conclusion: The No Action Alternative will be retained for detailed evaluation as it serves primarily, but not always, as a baseline for comparison to other remedial alternatives. It may be acceptable if the river areas are not used in the future.

### 3.2.2 Alternative 2A - Dredging/Excavation/Thickening/Fixation/Off-Site Nonhazardous Landfill

Description: Hydraulic dredging was identified in the initial screening as the only practicable method for removing contaminated sediments from the Blackwater Branch and the upper Maurice River. A Mud Cat hydraulic dredging unit or an equivalent would be used to dredge an average of 2.25 ft of sediment and to pump the dredged sediment to an on-site fixation



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plant for subsequent treatment and disposal. The volume of contaminated sediments to be dredged is estimated to be 21,800 cy. Figure 3-2 shows a flow diagram of all of the treatment systems. Figure 4-1 shows a schematic of the treatment system.

Hydraulic dredging is the only practical method for removing contaminated sediments that are underwater. However, there is also an area of the Blackwater Branch floodplain that is contaminated. This area, which is dry, would be excavated using a low ground pressure backhoe. The volume of contaminated sediments to be excavated from this area is estimated to be 56,200 cy.

The volumes that have been presented are based upon 1987 and 1988 data. Due to the inherent dynamics of the river system, it is assumed that a sampling program will be implemented in the final design phase to update these quantities.

A treatment plant for treating all of the contaminated sediment and supernatant would be a mobile unit, which would be constructed at the site along the riverbanks or near Union Lake. This unit could be used for the remediation of the River Areas and possibly for remediating the ViChem site and Union Lake. The hydraulically dredged sediment would be pumped to thickeners to allow the separation of water and solids and thickening of the settled sediment. The sediment excavated from the Blackwater Branch floodplain would contain little water and therefore could be taken directly to a fixation unit, where it would be mixed with water and additives. Chemicals would be added to the contaminated sediment in the fixation unit to chemically stabilize/immobilize the arsenic. After curing for more than 48 hours, the fixated sediments would be trucked to a nearby nonhazardous landfill site for disposal.

The supernatant from the thickeners would be discharged to clarifiers for the removal of total suspended solids (TSS). Alum, ferric chloride and polymer would be added as coagulants in this clarification and precipitation process. After the removal of TSS and arsenic, the levels of other associated parameters such as iron would also be significantly reduced to a level no greater than what is in the ambient water. The sludge would be combined with the sediment to be fixated. The treated effluent would then be discharged to the Blackwater Branch or the Maurice River.

The feasibility of sediment fixation and supernatant treatment was evaluated during bench-scale studies as discussed in Section 7.0 of the RI report.

Reviews would be required every five years and a long-term monitoring program would be required to measure the



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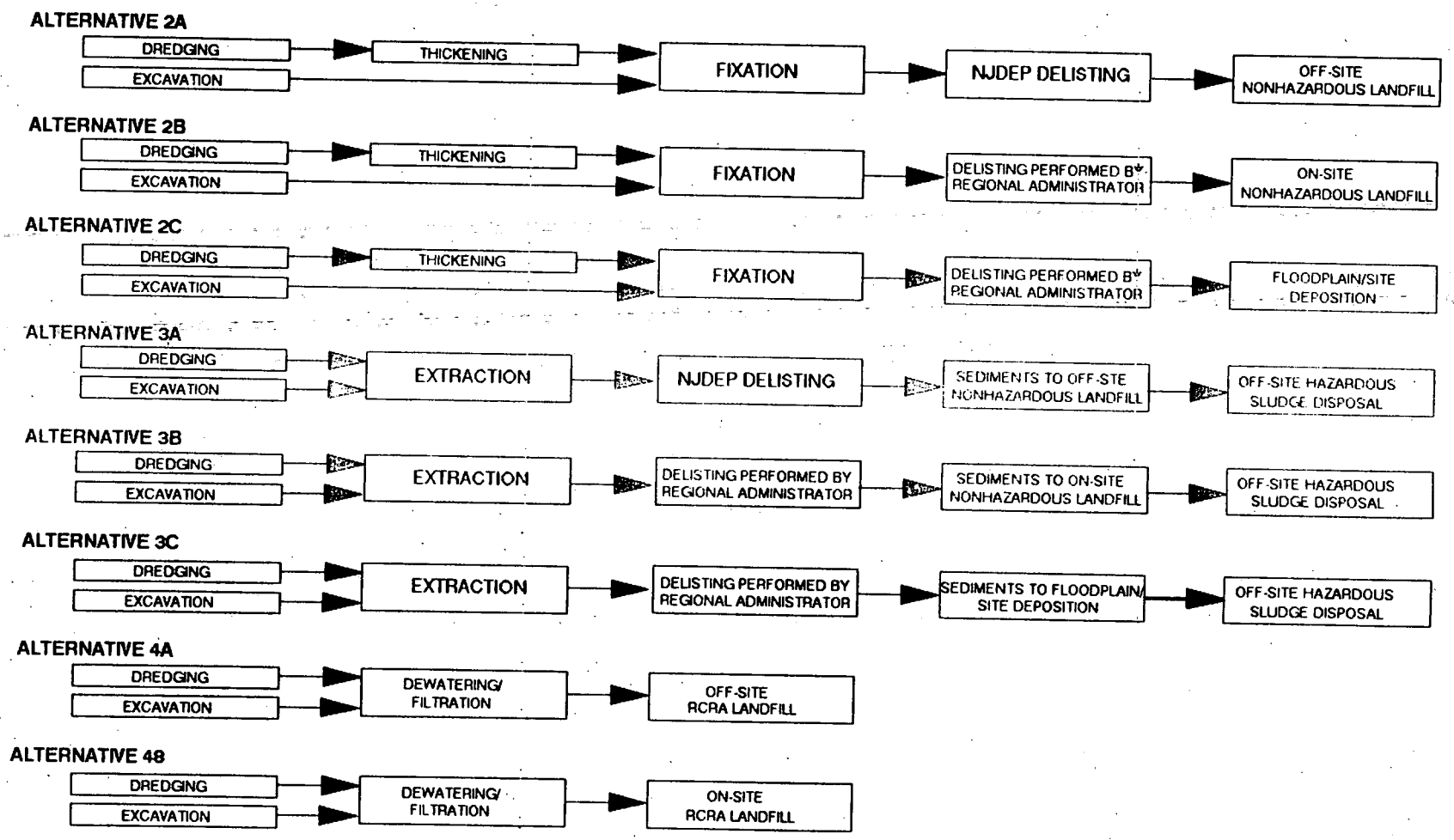
# FIGURE 3-2
# FLOW DIAGRAMS OF SOURCE CONTROL TREATMENT ALTERNATIVES



effectiveness of this alternative in reducing the arsenic contaminants in the river areas.

Effectiveness: This alternative would achieve the target cleanup level for the contaminated sediments in the river areas. Chemical fixation would achieve a permanent remedy for the sediments by immobilizing arsenic contaminants and would minimize the potential of leachate generation. Migration of contaminated surface water from resuspension of sediments that pose a health risk would be minimized after removal and treatment are completed. This assumes that the source of contamination from the aquifer underlying the ViChem plant site is conjunctively controlled.

Very few adverse effects are anticipated with implementation of this remedial alternative. Trucks would be used for transporting fixated sediments to nearby nonhazardous landfill sites. Additional traffic would cause noise and air pollution and a possible increase in accidents in the areas surrounding the site. These potential adverse impacts can be minimized by appropriate preventive measures, such as covering and stabilizing wastes decontaminating trucks, and implementing a traffic control plan.

This remedial action would be an effective treatment and would adequately protect human health and the environment. The ARARs and appropriate criteria would be attained under this remedial alternative.

Implementability: Chemical fixation is a well-developed and reliable technology. The chemical additives for fixation and immobilization are commercially available, and the process equipment can be assembled using conventional off-the-shelf hardware. The fixation system could be designed and constructed for specific use at the site. It is assumed that the fixated material would meet the delisting requirements and could be disposed of in an off-site nonhazardous landfill facility as discussed in Subsection 3.1.1.2.2. Therefore this alternative would not trigger the LDR. Annual monitoring and five-year review programs would require administrative attention.

Cost: Capital costs for this alternative are estimated to be $52,075,000. Operation and maintenance costs are estimated at $40,000 (per year for 30 years). The present worth cost, calculated at a discount rate of 5 percent after inflation, is estimated to be $52,690,000.

Conclusion: Chemical fixation of the wastes addresses the current statutory preference for permanent remedies designed to reduce the mobility and toxicity of wastes. This alternative would remove contamination from the site. Thus this alternative is retained for detailed evaluation.

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### 3.2.3 Alternative 2B: Dredging/Excavation/Thickening/Fixation/On-Site Nonhazardous Landfill

Description: The operations involved in this alternative would be the same as those of Alternative 2A except that the fixated sediments would be disposed of at a newly constructed on-site landfill. In addition, reviews would be conducted every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative. Figure 3-2 shows a flow diagram of the treatment system. Figure 4-1 depicts a schematic diagram of the treatment system.

As discussed in Alternative 2A, it is believed that the fixated sediments would meet the delisting requirements and be disposed of in a nonhazardous landfill, according to regulatory requirements. Delisting by NJDEP would not be required since deposition is on-site. The USEPA's Region II Regional Administrator could choose nonhazardous disposal based on the sediments meeting the delisting requirements. The on-site landfill would be constructed and operated according to the requirements specified in the New Jersey Solids and Hazardous Wastes Management Regulations.

An interpretation of the term "on-site" given to USEPA Region II by USEPA Headquarters SPGB personnel states that a landfill would be considered "on-site" only if it were constructed at the ViChem plant site. A landfill constructed along the Maurice River would be considered off-site. In this report an on-site landfill refers to one that would be constructed at the ViChem Plant site itself.

Effectiveness: The same effectiveness screening concerns with implementing Alternative 2A can be applied to this alternative, except that additional environmental and public health impacts may be associated with the construction of the on-site nonhazardous landfill.

The ViChem plant site is not a sensitive ecosystem area such as a wetland area. Landfilling treated sediments on-site would pose little risk to groundwater and surface water qualities due to the low mobility of fixated sediments and the effectiveness of the landfill system. The long-term hazard from the failure of the landfill system is unlikely. Therefore there are no appreciable environmental impacts for this landfill site.

Implementability: The same implementability concerns in Alternative 2A can be applied to this alternative. In addition, constructibility and reliability concerns associated with the construction of an on-site nonhazardous landfill are include here. The construction techniques for the cap, liner, drainag and leachate collection systems are conventional and relativel simple. As the ViChem site is a CERCLA site, the permittin

requirements are waived. The land is assumed to be available, but it may not meet the local zoning regulatory requirements. Administrative efforts would be required to coordinate activities between state and local agencies.

It is assumed that the treated material could meet the delisting requirements and be disposed of in a nonhazardous landfill. Since the material would be considered nonhazardous, land disposal restrictions would not apply.

USEPA Headquarters SPGB informed USEPA Region II that since the landfill would be on-site, a delisting petition to USEPA Headquarters would not be necessary. The Region II Regional Administrator could choose this alternative based on information indicating that the treated sediments could meet the delisting requirements.

An annual monitoring program would be implemented to assess sediment migration within the River Areas. Five-year reviews would have to be performed as well.

Cost: The capital cost for this alternative is estimated to be $41,835,000. Annual operation and maintenance costs are $124,000 (per year for 30 years). The present worth cost, calculated at a discount rate of 5 percent after inflation, is $43,741,000.

Conclusion: This alternative would provide the same permanent remedies as Alternative 2A. On-site nonhazardous landfilling of treated sediments is viable and enables this alternative to be retained for detailed evaluation.

### 3.2.4 Alternative 2C: Dredging/Excavation/Thickening/Fixation/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments

Description: The operations involved in this alternative would be the same as those of Alternative 2A except that the fixated floodplain sediments would be disposed of in the Blackwater Branch floodplain where contaminated sediments were removed previously and the fixated river sediments would be deposited on the plant site. Figure 3-2 shows a flow diagram of the treatment system. A schematic of the treatment system is presented in Figure 4-1.

The product of the sediment fixation is a physically stable solid with a rock-like appearance. The fixated product would be transported by truck to either a previously excavated area of the floodplain and deposited, or to the plant site and deposited in the undeveloped areas of the site. Clean fill material would be brought on-site to provide natural cover for the treated sediments.

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Long-term monitoring would be required to measure the effectiveness of this alternative.

Effectiveness: The same effectiveness concerns with implementing Alternative 2A can be applied to this alternative, except that additional environmental impacts may be associated with the deposition of the fixated sediments on the floodplain and on the plant site. Fixation of the sediments would significantly reduce the mobility of the arsenic. The long-term hazard from the failure of the fixation process is unlikely. However, in the event that it did fail, the floodplain would have to be reexcavated at a substantial cost. Also, any surface remediation work which would have been undertaken to restore the floodplain would have to be repeated. This is in contrast to the landfill disposal options, where if a failure did occur, leachate could be controlled and the entire remedial effort would not have to be repeated.

Implementability: The same implementability concerns in Alternative 2A can be applied to this alternative. In addition, the concerns associated with floodplain deposition and site deposition are included. Floodplain deposition and site deposition are only allowable if the NJDEP views the treated sediments as clean fill and not as ID 27 waste. Transporting the fixated sediments by truck to the Blackwater Branch floodplain or to the plant site would be relatively simple. The increase in volume associated with the fixation process may present problems when depositing the treated sediments on the floodplain. Grading and compaction of fixated materials may be impractical due to the physical characteristics of the treated sediment and the underlying water-bearing sediments. The ability for the growth of vegetation may be hindered by the presence of the rocky materials. Approximately 17 acres of land are available for deposition of the fixated material on the plant site. A one foot layer of topsoil would be utilized to restore the topography.

Cost: The capital cost and annual operation and maintenance cost are estimated at $36,535,000 and $40,000, respectively. The present worth cost, calculated at a discount rate of 5 percent after inflation, is $37,150,000.

Conclusion: Floodplain deposition and plant site deposition of the treated sediments is eliminated from further evaluation. In the event that the fixation system were to fail, the entire Blackwater Branch floodplain would have to be reexcavated at a substantial cost, disturbing the floodplain restoration which would have occurred after the initial deposition.

### 3.2.5 Alternative 3A: Dredging/Excavation/Extraction/ Sediments to Off-Site Nonhazardous Landfill/ Off-Site Hazardous Sludge Disposal

Description: Arsenic-contaminated sediments would either be excavated or hydraulically dredged. Two-stage mechanical soil washing with water would be provided to remove arsenic from the sediments. The extracted sediments would be placed on trucks and transported to an off-site nonhazardous landfill. Clean fill and topsoil would be brought on-site and deposited in the excavated areas of the floodplain. Reviews would be conducted every five years and a long-term monitoring program would be required to measure the effectiveness of this alternative.

The extractant from the soil washing process would be treated in a system that would include the unit operations of chemical oxidation, coagulation, clarification, sedimentation and dewatering.

It is estimated that 7,400 tons of arsenic-contaminated sludge would be generated. The arsenic-contaminated sludge would be transported to an off-site RCRA facility for treatment and disposal. Figure 3-2 shows a flow diagram of the treatment system. A schematic diagram of the treatment system is presented in Figure 4-7.

Effectiveness: This alternative achieves arsenic removal via two separate mechanisms in treating contaminated sediments with water in a reactor vessel. The process releases the small amounts of arsenic attached to coarse sands and also separates the fine organic matter with high concentrations of arsenic from the coarse sands. The effectiveness of this technology would depend on the extent to which arsenic is extracted from the sediments with the water. The treatability studies, using a single stage extraction, indicated that water would remove most of the arsenic from the sediment either by desorption or the separation of organic fines from coarse sands. A two-stage extraction is assumed in this FS to maximize extraction potential. A pilot-scale test would be required to confirm the effectiveness of this technology.

It is expected that the extracted sediment would meet the delisting requirements based on EP Toxicity Test results of untreated sediments and the VHS model as discussed in Section 3.0, and thus could be disposed of in a nonhazardous landfill facility. Since the material would be nonhazardous, land disposal restrictions would not apply. The wastewater containing the fine sediments would be treated to MCL levels and would also meet the substantive delisting requirements. The arsenic-contaminated sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility and treated according to BDAT requirements. The sludge would ultimately be disposed of in a RCRA Subtitle C Landfill in

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accordance with the land ban. It is assumed that the EP Toxicity concentration of the treated sludge would comply with the 1 mg/l arsenic leachate treatability variance but not the 0.32 mg/l level to allow for nonhazardous disposal of this material.

The concentration of the extracted arsenic dissolved in the wastewater would be reduced to below the MCL of 50 ug/l by chemical oxidation followed by coagulation/precipitation/ clarification. These processes would also separate fine organics containing arsenic from the solution. Upon meeting MCLs, the wastewater would be discharged to the Blackwater Branch or the Maurice River.

This remedial alternative would attain the health-based clean-up levels for both the exposed and submerged sediments at the site by reducing the toxicity, mobility and volume of the contaminated sediments. Potential leaching of arsenic from the sediments to the water column would also be eliminated. Long-term adverse impacts on public health and the environment should be reduced as a result of implementing this alternative. Short-term effects would stem from handling and hauling sediments during remediation.

Implementability: Sediment washing/extraction systems utilize available equipment from process industries, and the reliability is generally high from an operation and maintenance standpoint. Mobile sediment washing/extraction systems are currently commercially available. The USEPA operates a mobile sediment washing unit capable of processing 4 to 18 cubic yards of sediment per hour, depending on the sediment properties and the optimum period of reaction. Extraction systems are not complex and can be assembled using conventional off-the-shelf hardware. The system could be designed and constructed for specific use at the site.

Similarly, extractant treatment systems are conventional industrial wastewater physical-chemical treatment processes, which can be designed and constructed for specific uses, also utilizing conventional off-the-shelf hardware. These technologies are well-developed and are highly reliable.

Cost: The capital cost of this alternative is estimated to be $12,615,000. Operation and maintenance costs are estimated at $40,000 (per year for 30 years). The present worth cost, based on a discount rate of 5 percent after inflation, is $13,230,000.

Conclusion: Two-stage water extraction of wastes with off-site nonhazardous landfilling of treated materials provides a permanent remedy for removing arsenic contamination from the site. This alternative would reduce the toxicity and mobility of wastes and is retained for detailed evaluation.

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### 3.2.6 Alternative 3B: Dredging/Excavation/Extraction/ Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those of Alternative 3A, except the processed sediments would be disposed of in an on-site nonhazardous landfill since the treated sediments would be expected to comply with the delisting requirements. The on-site landfill facility would be constructed as described in Alternative 2B. Figure 3-2 shows a flow diagram of the treatment system. A schematic of the treatment system is presented in Figure 4-7.

Effectiveness: Both the effectiveness of two-stage water extraction as discussed in Alternative 3A and the effectiveness of an on-site nonhazardous landfill as discussed in Alternative 2B are applicable for this alternative. Two-stage water extraction would significantly reduce the level of arsenic contamination in the sediment to meet the substantive delisting criteria, so that the treated sediment could be safely deposited in an on-site nonhazardous landfill facility. The on-site nonhazardous landfill would not pose any appreciable environmental impacts to surface water, groundwater and the ecosystem at the site.

The extractant water would be treated utilizing conventional industrial wastewater treatment units as discussed in Alternative 3A. Arsenic concentrations in the wastewater would be reduced to meet MCLs. The arsenic-contaminated sludge would be transported to a RCRA treatment and disposal facility.

Implementability: As discussed in Alternative 3A, mobile sediment washing/extraction systems are currently commercially available. A large-scale extraction system can be designed and constructed for specific use at the site. The extractant treatment systems are conventional wastewater treatment processes and can be designed and constructed for site-specific applications.

The implementability of an on-site nonhazardous landfill facility discussed in Alternative 2B is applicable for this alternative. A long-term monitoring program would be required at the landfill site. Five-year reviews and annual monitoring, both highly implementable tasks, would be required for the site as well.

As discussed in Alternative 3A, the clean sediments would be expected to meet the delisting requirements and be disposed of in a nonhazardous landfill. RCRA land disposal restrictions would therefore not apply to this material. An on-site nonhazardous landfill would be constructed on the ViChem property adjacent to the plant. As this is a CERCLA site, the permit requirements would be waived. The extractant treatment

system would reduce the arsenic concentration in the water to levels below MCLs, enabling disposal back to the river. The arsenic-contaminated sludge would be transported to a RCRA treatment and disposal facility.

Cost: The capital cost of this alternative is estimated to be $8,305,000. An annual operation and maintenance cost is estimated at $143,000 (per year for 30 years). The present worth cost, calculated based on a discount rate of 5% after inflation, is $10,503,000.

Conclusion: This alternative would provide the same permanent remedies as Alternative 3A, however it would require the construction of an on-site landfill and the implementation of a long-term monitoring program. It is retained for further evaluation.

### 3.2.7 Alternative 3C: Dredging/Excavation/Extraction/ Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/Off-Site Hazardous Sludge Disposal

Description: The operations involved in this alternative would be the same as those of Alternative 3A, except the treated floodplain sediments would be deposited on the Blackwater Branch floodplain and the treated river sediments would be deposited on the plant site. A long-term management program would be required.

The product of the extraction process would be a clean sand. The sand would be transported by truck to the floodplain or the site, deposited, graded and compacted. Figure 3-2 shows a flow diagram of the treatment system. A schematic of the treatment system is presented in Figure 4-7.

Effectiveness: The effectiveness of two-stage water extraction of arsenic as discussed in Alternative 3A is applicable for this alternative. Two stage water extraction would significantly reduce the level of arsenic contamination in the sediment. Based on EP Toxicity Test results of untreated sediment and the results of the VHS model, previously discussed in Section 3.0, the treated sediment could meet the substantive delisting requirements and be safely deposited on the floodplain and the plant site.

Arsenic is actually removed from the coarse sediments via the extraction process. Therefore, the potential for leaching due to failure, as was noted for the fixation treatment, is reduced. This substantially reduces the possibility of having to re-excavate the sediments, since the arsenic is no longer present in significant quantities.

Implementability: As discussed in Alternative 3A, mobile soil washing/extraction systems are currently commercially available. Large-scale extraction systems could be designed and constructed for site-specific use. The extractant treatment system utilizes conventional industrial wastewater treatment processes that are well developed and highly reliable.

As discussed previously, it is assumed that the extracted sediments would meet the delisting requirements and be classified as clean fill for deposition on the Blackwater Branch floodplain and the plant site. The NJDEP would have to waive an ID 27 waste classification of the treated sediments to allow their use as clean fill. A substantive requirement for classification as non-ID 27 waste is a reduction in the sediment arsenic concentration to 20 mg/kg, the plant site action level for soils and the action level for the Blackwater Branch floodplain. If during final design, it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting media would be required. Treatability tests indicated that sodium citrate would reduce the sediment arsenic concentration to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediments. The material would blend well in the environment since treatment would not drastically alter its form. The sludge generated from the extraction process would be transported to a RCRA treatment and disposal facility.

Cost: The capital cost for this alternative is estimated to be $5,017,000. Annual operation and maintenance costs are estimated to be $40,000 (per year for 30 years). The present worth cost, calculated at a discount rate of 5 percent after inflation, is $5,632,000.

Conclusion: This alternative would provide a permanent remedy with minimal impact to the environment by removing arsenic contamination from the sediments identified as a public risk in the risk assessment. The potential for failure is low, since the arsenic will have been removed from the sediments. Therefore this alternative is retained for further evaluation.

### 3.2.8 Alternative 4A: Dredging/Excavation/Dewatering/Off-Site RCRA Landfill

Description: The tasks of sediment dredging and thickening (via the removal of dredged supernatant water), and the excavation of dry sediments involved in this alternative would be the same as those described in Alternative 2A, except the settled sediment from dredging would be withdrawn from the sediment thickeners to a vacuum filter for further dewatering. The dewatered dredged sediment would contain approximately 30% to 35% solids, which would be suitable for landfill deposition.

If necessary, the dewatered dredged sediment and the excavated sediment would be stabilized with an inert additive such as kiln dust. The supernatant from the thickening system and vacuum filters would be treated using the clarification and precipitation process units as described in Alternative 2A. Figure 3-2 shows a flow diagram of the treatment system.

Off-site RCRA landfilling would include containerizing and transporting the arsenic-contaminated sediment to a licensed RCRA hazardous landfill site.

Effectiveness: This alternative would consist of hydraulic dredging, backhoe excavation, dewatering, transporting and landfilling the sediments with treatment of the dredged supernatant and filtrate from the vacuum filters. The on-site dredging, excavation, and dewatering operations would include removal of the source materials with their subsequent consolidation into containers for off-site transport. A permitted RCRA disposal facility with the capacity and capability to handle this source material would have to be identified.

This alternative would be effective at eliminating waste sources, leachate generation and contaminant migration from the site. Long-term monitoring would be required to monitor sediment transport.

This alternative would attain the health-based cleanup target levels and would achieve a significant reduction in the toxicity, mobility, and volume of contaminants on-site. However, it would not reduce the toxicity or volume of contaminated sediments in the environment overall. The off-site RCRA landfill would reduce the mobility of the contaminants by containment. If the landfill should fail, the contaminants could be re-released into the environment. However, the RCRA land disposal restrictions regulation would require that the contaminated sediments be treated via the Best Demonstrated Available Technology (BDAT) prior to being placed in an off-site RCRA facility. ARARs pertaining to land disposal restrictions would not be attained since wastes would not be treated by the BDAT.

Implementability: This remedial alternative has been demonstrated at many small hazardous waste sites. There should be no special difficulties in removing and transporting the sediment and restoring the site. The major obstacles to implementing the alternative are identifying the disposal facilities capable of accepting the large volume of waste material and the associated cost of transport and disposal (i.e., RCRA landfill availability and capacity).

Implementation of this alternative would require administrative effort to secure an off-site RCRA landfill for disposal. With

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the implementation of the RCRA land ban (51 CFR 40572, November 7, 1988) this may be very difficult. Land disposal restriction regulations and DOT regulations for waste shipment would need to be met. Annual monitoring of the River Areas and five-year reviews would require additional administrative attention.

Off-site disposal of sediment from contaminated areas is a feasible option if an acceptable facility can be identified. The only currently recognized permanent land disposal facility is a double-lined landfill. There are very few commercial facilities with double liners in the eastern United States capable of receiving the large volumes of wastes that would be removed from the site. Implementation of this alternative would depend on the available capacity and the current laws that would prevail at the time of remediation.

Cost: The capital cost for this alternative is estimated at $30,765,000. Operation and maintenance costs are approximately $40,000 (per year for 30 years). The present worth cost for this alternative, calculated at a discount rate of 5 percent after inflation, is estimated to be $31,380,000.

Conclusion: The off-site disposal of contaminated soils without any treatment would not meet the land disposal restriction requirements. This alternative is therefore not feasible at this site.

### 3.2.9 Alternative 4B: Dredging/Excavation/Dewatering/On-Site RCRA Landfill

Description: The operations involved in this alternative would be the same as those of Alternative 4A except that the dredged and dewatered sediments and the excavated sediments would be disposed of at a newly constructed on-site RCRA landfill. A RCRA Subtitle C containment facility could be constructed at the ViChem plant site as described in Alternative 2B. As discussed previously, this potential landfill area is considered to be within the site study boundaries.

The RCRA landfill would have to be designed with a double liner system and have two leachate detection, collection and removal systems, according to applicable RCRA requirements. Figure 3-2 shows a flow diagram of the treatment system.

Effectiveness: Even though the landfilling of hazardous waste was widely used as a management practice for years, it is now being discouraged by the USEPA, which makes obtaining approval for constructing a new facility very difficult. The on-site RCRA landfill alternative would remove hazardous wastes from the area of contamination into another area within the Superfund site boundaries. This on-site landfill would constitute RCRA land disposal, thus land disposal restriction requirements would

be applicable for this alternative. As discussed in Alternative 4A, ARARs pertaining to land disposal restrictions would not be attained, since wastes would not be treated prior to being placed in a RCRA facility.

The RCRA landfill would provide only a long-term containment for the hazardous waste, but would not attain a permanent remedy designed to reduce the toxicity, mobility and volume of wastes.

Since the contaminated sediments would be removed from the river areas, leachate generation and contaminant migration from sediments to river water may be significantly reduced. This alternative would meet the remedial action objective established for this site. The on-site RCRA landfill would not pose any appreciable environmental impacts to surface water, groundwater and the ecosystem around the landfill site. A long-term operation and maintenance management plan including periodic groundwater monitoring would be required for the post-closure activities.

Implementability: The RCRA landfill facility could be designed to satisfy all the applicable requirements. The potential landfill site would not be within the 100-year floodplain. The construction of a landfill facility is a conventional and proven technology and would be commercially available. The possibility of failure of a new RCRA landfill system would be relatively low. The land is assumed to be available, however local zoning regulatory requirements may not be met.

Landfilling hazardous wastes without any treatment, in the immediate vicinity of an important water resource area, is unlikely to be acceptable. The permitting process requires extensive investigations and acceptance by regulatory agencies. Important factors affecting the regulatory acceptance would be the site conditions, design, construction, operation, public uneasiness, closure, and post-closure monitoring. Additional attention would have to be directed towards performing annual monitoring and five-year review programs.

Cost: The capital cost of this alternative is estimated at $11,175,000. An annual operation and maintenance cost of $228,000 (per year for 30 years) would be required. The present worth cost, calculated at a discount rate of 5 percent after inflation, is $14,680,000.

Conclusion: This alternative would not meet the land disposal restriction requirements and would not provide a permanent remedy. Therefore it is eliminated from further evaluation.

## 3.3 SUMMARY OF INITIAL SCREENING OF REMEDIAL ALTERNATIVES

Table 3-1 presents a summary of source control (contaminated sediments) remedial alternative screening in terms of effec-

tiveness, implementability and cost factors, as well as the conclusion of screening results with respect to detailed evaluation. Table 3-2 presents a summary of the cost breakdowns for these alternatives. Based on the results of the preliminary screening discussed above, Alternatives 2C, 4A and 4B have been eliminated from further consideration while the remaining Alternatives (1, 2A, 2B, 3A, 3B and 3C) have been retained for detailed evaluation in Section 4.0 of this report. General conclusions derived from the initial screening are listed below.

1) Extraction of arsenic contaminants from the sediments would reduce the volume, toxicity and mobility of contaminants, whereas fixation would only offer a reduction of mobility.

2) RCRA landfilling of the arsenic wastes would not provide a permanent remedy. Alternatives 4A and 4B are eliminated from detailed evaluation since no reduction in toxicity, mobility or volume would be achieved and RCRA LDRs would not be met.

3) Off-site nonhazardous landfilling of the treated sediment may be more implementable than on-site landfilling due to state and community approval required for construction of a landfill. However, a cost savings is realized in utilizing an on-site landfill for disposal.

4) Floodplain deposition of fixated sediments could cause adverse environmental impacts to the ecosystem in the event of failure. The remediation in the Blackwater Branch would have to be repeated if this occurred. Alternative 2C was eliminated for this reason, while Alternative 3C was retained for further consideration because no major physical changes arise from the deposition of solids which have been treated by the extraction process, and failure is unlikely.

TABLE 3-1

SUMMARY OF ALTERNATIVE SCREENING

| Source Control Alternatives | Cost (1989 Dollars) Capital | Annual O/M | Present Worth | Effectiveness | Implementability | Detailed Evaluation |
|---|---|---|---|---|---|---|
| NO ACTION | | | | | | |
| Alt. 1 - No Action | 43,500 | 41,000 | 673,750 | 1. Minimizes access to contaminated sediment source areas by signs and public education<br>2. Does not attain ARARs<br>3. No reduction in toxicity, mobility or volume<br>4. No treatment, natural attenuation | 1. Easy to implement<br>2. Monitoring technologies are reliable and available<br>3. State approval and community acceptance are questionable | Retained |
| TREATMENT | | | | | | |
| Alt. 2A - Dredging/Excavation/Thickening/Fixation/Off-Site Nonhazardous Landfill | 52,075,000 | 40,000 | 52,690,000 | 1. Achieves permanent remedy<br>2. Reduces mobility of contaminants<br>3. Reduces migration of arsenic leachate from the sediment to the river water<br>4. Does not attain all ARARs<br>5. Potential restoration of riverine areas for future use<br>6. Potential short-term public health and environmental impacts due to handling and transportation<br>7. Treated material is believed to be delistable | 1. Chemical fixation is a well-developed and reliable technology<br>2. Full-scale operation of fixation is commercially available<br>3. Treatability studies proved fixation is a feasible technology<br>4. Potential impacts on public health and environment can be minimized by providing health/safety protection measures<br>5. Off-site nonhazardous landfill facilities are commercially available<br>6. Long-term post-implementation management is required<br>7. NJDEP performs delisting | Retained |
| Alt. 2B - Dredging/Excavation/Thickening/Fixation/On-Site Nonhazardous Disposal | 41,835,000 | 124,000 | 43,741,000 | 1. Same as Items, 1, 2, 3, 4, 5 and 7 in Alt. 2A<br>2. Potential long-term environmental impacts should the landfill fail<br>3. Minimal transportation impacts on the environment | 1. Same as Items 1, 2, 3, 4, and 6 in Alt. 2A<br>2. Nonhazardous landfill technology is conventional and available.<br>3. State and community acceptance of on-site landfill is required<br>4. Delisting performed by USEPA Region II Regional Administrator | Retained |

TABLE 3-1 (Cont'd)

SUMMARY OF ALTERNATIVE SCREENING

| Source Control Alternatives | Cost (1989 Dollars) Capital | Annual O/M | Present Worth | Effectiveness | Implementability | Detailed Evaluation |
|---|---|---|---|---|---|---|
| Alt. 2C - Dredging/Excavation/Thickening/Fixation/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments | 36,535,000 | 40,000 | 37,150,000 | 1. Same as Items 1, 2, 3, 4, 5 and 7 in Alt. 2A<br>2. Long-term environmental impacts to the River Areas possible<br>3. Minimizes transportation through populated areas<br>4. Adverse impacts to floodplain and downstream ecosystem | 1. Same as Item 1, 2, 3, 4 and 6 in Alt. 2A<br>2. Deposition/compaction/grading may be difficult in water bearing sediment areas<br>3. Long-term post implementation management is required<br>4. Difficult to monitor effectiveness of fixation process<br>5. Materials cannot be classified as ID #27 waste<br>6. Delisting performed by USEPA Region II Regional Administrator | Eliminated |
| Alt. 3A - Dredging/Excavation/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal | 12,615,000 | 40,000 | 13,230,000 | 1. Achieves permanent remedy<br>2. Reduces toxicity, mobility and volume of contaminants in the river<br>3. Reduces migration of arsenic leachate from the sediment to the river water<br>4. Potential restoration of river water for future use<br>5. Potential short-term public health and environmental impacts due to handling and transportation<br>6. Treated sediments believed to be delistable<br>7. Requires pilot-scale study to confirm its effectiveness<br>8. Sludge generated from process requires secondary disposal considerations | 1. Extraction is a well-developed and reliable technology<br>2. Full-scale operation of extraction is commercially available<br>3. Extractant treatment process is a well-developed technology<br>4. The implementation facilities require considerable space<br>5. NJDEP performs delisting | Retained |
| Alt. 3B - Dredging/Excavation/Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal | 8,305,000 | 143,000 | 10,503,000 | 1. Same as Items, 1, 2, 3, 4, 6, 7 and 8 in Alt. 3A<br>2. Long-term environmental impacts in the landfill area would be possible<br>3. Minimal transportation impacts on the environment | 1. Same as Items 1, 2, 3, and 4 in Alt. 3A<br>2. Nonhazardous landfill technology is conventional and available<br>3. State and community acceptance of on-site landfill is required<br>4. Long-term monitoring of the site would be required<br>5. Delisting performed by USEPA Region II Regional Administrator | Retained |

TABLE 3-1 (Cont'd)

SUMMARY OF ALTERNATIVE SCREENING

| Source Control Alternatives | Cost (1989 Dollars) Capital | Annual O/M | Present Worth | Effectiveness | Implementability | Detailed Evaluation |
|---|---|---|---|---|---|---|
| CONTAINMENT | | | | | | |
| Alt. 3C - Dredging/Excavation/Extraction/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/ Off-Site Hazardous Sludge Disposal | 5,017,000 | 40,000 | 5,632,000 | 1. Same as Items 1, 2, 3, 4, 5, 6, 7, 8 and 9 in Alt. 3A<br>2. No long-term environmental impacts on floodplain due to deposition of the treated sediments.<br>3. Sediment characteristics slightly altered by treatment process<br>4. Ecosystem may experience alterations after application sediment | 1. Same as Items 1, 2, 3 and 4 in Alt. 3A<br>2. Floodplain deposition and plant site deposition would be a simple technology<br>3. Materials cannot be classified as ID #27 waste<br>4. Delisting performed by USEPA Region II Regional Administrator | Retained |
| Alt. 4A - Dredging/Excavation/Dewatering/Off-Site RCRA Landfill | 30,765,000 | 40,000 | 31,380,000 | 1. Alternative does not attain SARA preference for treatment that reduces toxicity, mobility or volume<br>2. Landfill without treatment does not meet RCRA land disposal restriction requirements<br>3. Reduces cancer risk level because all contaminants have been removed from site<br>4. Potential short-term public health and environmental impacts due to handling and transportation | 1. RCRA landfill is a demonstrated and proven technology<br>2. Commercial RCRA landfill facilities are limited and require intensive administrative efforts to secure usage<br>3. No long-term post-implementation management is required by USEPA<br>4. Dewatered sediments may require stabilization for off-site transportation and landfilling | Eliminated |
| Alt. 4B - Dredging/Excavation/Dewatering/On-Site RCRA Landfill | 11,175,000 | 228,000 | 14,680,000 | 1. Same as Items 1, 2, 3 in Alt. 4A<br>2. Potential long-term environmental impacts in the landfill areas would be possible<br>3. Minimizes transportation impacts on the environment | 1. Same as Item 1 in Alt. 4A<br>2. Long-term post-implementation management is required | Eliminated |



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TABLE 3-2

PRELIMINARY COST ESTIMATE OF POTENTIAL ALTERNATIVES

| Potential Alternatives | Major Remediation Components | Estimated Quantities | 1989 Dollars Unit Cost | Capital Cost | Annual O/M Cost |
|---|---|---|---|---|---|
| 1. Alternative 1 - No Action | 1. Warning Signs | 50 | $150 | $ 7,500 | |
| | 2. Quarterly Ecology, Water, Sediment Monitoring | 72 | $500 | $36,000 | $36,000 |
| | 3. Public Meetings | | | | $ 5,000 |
| | | | Total | $ 43,500 | $41,000 |
| 2. Alternative 2A - Dredging/Excavation Thickening/Fixation/Off-Site Nonhazardous Landfill | 1. Excavation | 56,170 cy | $ 13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Supernatant Water Treatment | 220 gpm | $2000/gpm | $ 440,000 | |
| | 5. Chemical Fixation | 167,000 cy | $ 200/cy | $33,400,000 | |
| | 6. Off-Site Transport | 185,000 ton | $ 40/ton | $ 7,400,000 | |
| | 7. Off-Site Nonhazardous Landfill | 185,000 ton | $ 50/ton | $ 9,250,000 | |
| | 8. Quarterly Monitoring | | | | $40,000 |
| | | | Total | $52,075,000 | $40,000 |
| 3. Alternative 2B - Dredging/Excavation Thickening/Fixation/On-Site Nonhazardous Landfill | 1. Excavation | 56,170 cy | $13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Supernatant Water Treatment | 220 gpm | $2000/gpm | $ 440,000 | |
| | 5. Chemical Fixation | 167,000 cy | $ 200/cy | $33,400,000 | |
| | 6. On-Site Nonhazardous Landfill | 101,000 cy | $ 60/cy | $ 6,060,000 | $76,000 |
| | 7. Land | 7 acres | $50,000/acre | $ 350,000 | |
| | 8. Post Landfill Monitoring | 16 | $500 | | $ 8,000 |
| | 9. Quarterly Monitoring | | | | $40,000 |
| | | | Total | $41,835,000 | $124,000 |
| 4. Alternative 2C - Dredging/Excavation/ Thickening/Fixation/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments | 1. Excavation | 56,170 cy | $ 13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Supernatant Water Treatment | 220 gpm | $2000/gpm | $ 440,000 | |
| | 5. Chemical Fixation | 167,000 cy | $ 200/cy | $33,400,000 | |
| | 6. Floodplain Deposition | 81,000 cy | $ 10/cy | $ 810,000 | |
| | 7. Plant Site Deposition | 20,000 cy | $ 15/cy | $ 300,000 | |
| | 8. Quarterly Monitoring | | | | $40,000 |
| | | | Total | $36,535,000 | $40,000 |

TABLE 3-2 (Cont'd)

PRELIMINARY COST ESTIMATE OF POTENTIAL ALTERNATIVES

| Potential Alternatives | Major Remediation Components | Estimated Quantities | 1989 Dollars Unit Cost | Capital Cost | Annual O/M Cost |
|---|---|---|---|---|---|
| 5. Alternative 3A - Dredging/Excavation Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal | 1. Excavation | 56,170 cy | $13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Extraction | 350 gpm | $3000/gpm | $ 1,050,000 | |
| | 5. Extractant Treatment | 500 gpm | $1000/gpm | $ 500,000 | |
| | 6. Off-Site Transport | 92,000 ton | $ 40/ton | $ 3,680,000 | |
| | 7. Off-Site Nonhazardous Landfill | 92,000 ton | $ 50/ton | $ 4,600,000 | |
| | 8. Sludge Disposal | 8,000 ton | $150/ton | $ 1,200,000 | |
| | 9. Quarterly Monitoring | | | | $40,000 |
| | | | Total | $12,615,000 | $40,000 |
| 6. Alternative 3B - Dredging/Excavation Extraction/Sediments to On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal | 1. Excavation | 56,170 cy | $13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Extraction | 350 gpm | $3000/gpm | $ 1,050,000 | |
| | 5. Extractant Treatment | 500 gpm | $1000/gpm | $ 500,000 | |
| | 6. On-Site Nonhazardous Landfill | 62,000 cy | $ 60/cy | $ 3,720,000 | $ 95,000 |
| | 7. Sludge Disposal | 8,000 ton | $150/ton | $ 1,200,000 | |
| | 8. Land | 5 acres | $ 50,000/acre | $ 250,000 | |
| | 9. Post Landfill Monitoring | 16 | $ 500 | | $ 8,000 |
| | 10. Quarterly Monitoring | | | | $ 40,000 |
| | | | Total | $ 8,305,000 | $143,000 |
| 7. Alternative 3C - Dredging/Excavation/ Extraction/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/Off-Site Hazardous Sludge Disposal | 1. Excavation | 56,170 cy | $13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Gravity Thickening | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Extraction | 350 gpm | $3000/gpm | $ 1,050,000 | |
| | 5. Extractant Treatment | 500 gpm | $1000/gpm | $ 500,000 | |
| | 6. Floodplain Deposition | 49,500 cy | $ 10/cy | $ 495,000 | |
| | 7. Plant Site Deposition | 12,500 cy | $ 15/cy | $ 187,500 | |
| | 8. Sludge Disposal | 8,000 ton | $ 150/ton | $ 1,200,000 | |
| | 9. Quarterly Monitoring | | | | $ 40,000 |
| | | | Total | $ 5,017,000 | $ 40,000 |



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TABLE 3-2 (Cont'd)

PRELIMINARY COST ESTIMATE OF POTENTIAL ALTERNATIVES

| Potential Alternatives | Major Remediation Components | Estimated Quantities | 1989 Dollars Unit Cost | Capital Cost | Annual O/M Cost |
|---|---|---|---|---|---|
| 8. Alternative 4A - Dredging/Excavation/ Dewatering/Off-Site RCRA Landfill | 1. Excavation | 56,170 cy | $13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Supernatant Water Treatment | 220 gpm | $1000/gpm | $ 220,000 | |
| | 5. Dewatering System (Vacuum Filters) | 26,000 cy | $ 10/cy | $ 260,000 | |
| | 6. Blending/Storage | 82,000 cy | $ 5/cy | $ 410,000 | |
| | 7. Off-Site Transportation | 123,000 ton | $ 80/ton | $ 9,840,000 | |
| | 8. Off-Site RCRA Landfill | 123,000 ton | $150/ton | $18,450,000 | |
| | 9. Quarterly Monitoring | | | | $40,000 |
| | | | Total | $30,765,000 | $40,000 |
| 9. Alternative 4B - Dredging/Excavation/ Dewatering/On-Site RCRA Landfill | 1. Excavation | 56,170 cy | $13.30/cy | $ 747,000 | |
| | 2. Hydraulic Dredging | 75,000 cy | $ 6.5/cy | $ 487,500 | |
| | 3. Sediment Thickening System | 350 gpm | $1000/gpm | $ 350,000 | |
| | 4. Supernatant Water Treatment | 220 gpm | $1000/gpm | $ 220,000 | |
| | 5. Dewatering System (Vacuum Filters) | 26,000 cy | $ 10/cy | $ 260,000 | |
| | 6. Blending/Storage | 82,000 cy | $ 5/cy | $ 410,000 | |
| | 7. On-Site RCRA Landfill | 82,000 cy | $ 100/cy | $ 8,200,000 | $180,000 |
| | 8. Land | 10 acres | $ 50,000/acre | $ 500,000 | |
| | 9. Post Landfill Monitoring | 16 | $ 500 | | $ 8,000 |
| | 10. Quarterly Monitoring | | | | $ 40,000 |
| | | | Total | $11,175,000 | $228,000 |

## 4.0 DETAILED DESCRIPTION AND ANALYSIS OF REMEDIAL ALTERNATIVES

This section presents a detailed description and evaluation of each remedial alternative that passed the initial screening in Section 3.0. Table 4-1 lists the alternatives to be analyzed. Section 4.1 discusses the evaluation process used and the nine criteria against which the alternatives were analyzed. The nine criteria are:

1. Short-Term Effectiveness
2. Long-Term Effectiveness
3. Reduction of Toxicity, Mobility or Volume
4. Implementability
5. Cost
6. Compliance with ARARs
7. Overall Protection of Human Health and the Environment
8. State Acceptance
9. Community Acceptance

Section 4.2 discusses the assessment of the remedial alternatives in which each alternative is described in detail and evaluated with respect to each of the nine criteria listed above.

### 4.1 EVALUATION PROCESS AND CRITERIA

The remedial alternatives are examined with respect to the requirements stipulated in CERCLA as amended, OSWER Directive No. 9355.0-19 (Interim "Guidance on Superfund Selection of Remedy", December 24, 1986), statutory factors described in OSWER Directive No. 9355.0-21 ("Additional Interim Guidance for FY'87 Records of Decision", July 24, 1987) and USEPA's "Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA" (USEPA, March 1988a). A detailed analysis of alternatives consists of the following components and processes:

- Further definitions of each alternative, if appropriate, with respect to the volumes or areas of contaminated media to be addressed, the technologies to be used, and any performance requirements associated with those technologies.
- Assessment and summary of each alternative against the nine criteria as defined by the OSWER Directive No. 9355.0-21.
- Comparative analysis among alternatives to assess the relative performance of each alternative with respect to each evaluation criterion.

Each remedial alternative is evaluated with respect to the nine criteria presented below. At the completion of all detailed analyses, a summary section is included, whereby the statutory factors and criteria described in OSWER Directive No. 9355.0-21 are compared for each alternative to assist in the remedy selection process.

TABLE 4-1

REMEDIAL ALTERNATIVES FOR DETAILED ANALYSIS

| | |
|---|---|
| Alternative 1: | No Action |
| Alternative 2A: | Dredging/Excavation/Thickening/ Fixation/Off-Site Nonhazardous Landfill |
| Alternative 2B: | Dredging/Excavation/Thickening/ Fixation/On-Site Nonhazardous Landfill |
| Alternative 3A: | Dredging/Excavation/Extraction/ Sediments to Off-Site Non-hazardous Landfill/Off-Site Hazardous Sludge Disposal |
| Alternative 3B: | Dredging/Excavation/Extraction/ Sediments to On-Site Non-hazardous Landfill/Off-Site Hazardous Sludge Disposal |
| Alternative 3C: | Dredging/Excavation/Extraction/ Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/ Off-Site Hazardous Sludge Disposal |

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Short-Term Effectiveness: This evaluation criterion addresses the impacts of the alternative during the construction and implementation phase until the remedial response objectives are met. Factors to be evaluated include protection of the community during the remedial actions, protection of workers during the remedial actions, environmental impacts resulting from the implementation of the remedial actions, and the time required to achieve protection.

Long-Term Effectiveness: This evaluation criterion addresses the results of the remedial action in terms of the risk remaining at the site after the response objectives have been met, particularly the effectiveness of the controls that will be applied to manage the risks posed by the residuals of the treatment process and/or untreated wastes. The components of this criterion include the magnitude of the remaining risks measured by numerical standards such as cancer risk levels; adequacy and suitability of controls used to manage treatment residuals or untreated wastes; and the long-term reliability of management controls for providing continued protection from residuals, i.e., the assessment of potential failure of the technical components.

The evaluation of the risks in this category will consider sediment exposure risks only. As discussed previously, there are existing increased health risks from exposure to the surface water and from ingesting fish. These risks will not necessarily be reduced through sediment remediation. However, the surface water risks may be reduced by stopping the source of arsenic entering the rivers, thereby reducing the water arsenic concentration. The fish ingestion risks may be reevaluated in the future. In either case, since sediment remediation is the focus of this FS, the risks associated with the sediments themselves will be the focus of the risk reduction for this evaluation criterion.

Reduction of Toxicity, Mobility or Volume: This evaluation criterion addresses the statutory preference that treatment is used to reduce the principal threats of the total mass of toxic contaminants, contaminant mobility, or the total volume of contaminated media. Factors of this criterion to be evaluated include the treatment process employed; the amount of hazardous material destroyed or treated; the degree of reduction in toxicity, mobility, or volume expected; and the type and quantity of treatment residuals.

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. Factors of technical feasibility include construction and operation difficulties, the reliability of the technology, the ease of undertaking additional remedial

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actions, and the ability to monitor the effectiveness of the remedy. The administrative feasibility includes the ability and time required for permit approval and for activities needed to coordinate with other agencies. Factors to evaluate the availability of services and materials include the availability of treatment, storage, and disposal services with the required capacities; the availability of equipment and specialists; and the availability of prospective technologies for competitive bids.

Cost: The types of costs that should be addressed include capital costs, operation and maintenance (O&M) costs, costs of five year reviews (where required), present value of capital and O&M costs, and potential future remedial action costs. Capital costs consist of direct and indirect costs. Direct costs include expenditures for the equipment, labor, and materials necessary to install the remedial actions. Indirect costs include expenditures for engineering, financial, and other services required to complete the installation of the remedial alternatives. Annual O&M costs include auxiliary materials and energy, disposal of residues, purchased services, administrative costs, insurance, taxes, and license costs; maintenance reserve and contingency funds, rehabilitation costs, and the costs of periodic site reviews.

This assessment evaluates the costs of remedial alternatives on the basis of present worth. Present worth analysis allows remedial alternatives to be compared on the basis of a single cost representing an amount that, if invested in the base year and disbursed as needed, would be sufficient to cover all costs associated with the remedial action over its planned life. A required operating performance period is assumed for present worth and is a function of the discount rate and time. An operating performance period of 30 years and a discount rate of 5 percent after inflation is assumed for base calculations in this FS. The "study estimate" costs provided for the alternatives are intended to reflect actual costs with an accuracy of -30 to +50 percent.

A cost sensitivity analysis assesses the effect that variations in specific assumptions associated with the design, implementation, operation, discount rate and effective life of an alternative have upon the alternative if there is sufficient uncertainty concerning the specific assumptions. Factors of a sensitivity analysis include risk based target levels, effective life span, O&M costs, duration of cleanup, volume of contaminated material, size of the treatment system and discount rate.

The cost sensitivity to the volume of contaminated sediments to be treated was performed in this FS. This was done by keeping the quantity of sediments to be removed from the Blackwater

Branch floodplain constant, while varying the quantity of submerged sediments remediated. This took into account some of the uncertainties in the data base.

In the Blackwater Branch, supplemental sediment sampling was performed in November, 1988 specifically to estimate the quantity of sediments for removal. Since this area is now exposed and not under water, there is little potential that these sediments will move prior to a remedial action being taken.

For the submerged sediments in the Blackwater Branch and the upper Maurice River, however, the data base is more tenuous. Even though over 200 sediment samples were taken from approximately 20 cross-sections along these rivers, a significant amount of extrapolation was necessary to estimate the submerged sediment volume above the action level. Also, since the submerged sediments are under water, they may redistribute between the time of the RI/FS sampling and the time of a remedial action. To account for these uncertainties, the cost sensitivity included remediating the exposed Blackwater Branch floodplain sediments only and remediating one-half, and two times the volume of submerged sediments, while keeping the quantity of sediments removed from the Blackwater Branch floodplain constant.

Compliance with ARARs: This evaluation criterion is used to determine how each alternative complies with applicable or relevant and appropriate Federal and State requirements as defined in CERCLA Section 121. Each alternative is evaluated in detail for:

- Compliance with contaminant-specific ARARs (e.g., MCLs);
- Compliance with action-specific ARARs;
- Compliance with location-specific ARARs; and
- Compliance with appropriate criteria, advisories, and guidances (e.g., "To Be Considered" material).

Table 4-2 presents a list of ARARs and "to be considered" (TBC) material that were used to evaluate the remedial alternatives. The table entries provide specific statutory or regulatory citations and their applications to the remedial alternatives evaluated in Section 4.2.

Overall Protection of Human Health and the Environment: This evaluation criterion provides an overall assessment of protection based on a composite of factors such as long-term and short-term effectiveness and compliance with ARARs. Evaluations of the overall protectiveness address:

TABLE 4-2

ARARS AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

| ARARs and "TBC" Material | Alternative Type Affected | Application |
|---|---|---|
| Contaminant-Specific: | | |
| o Federal Clean Water Act Quality Criteria | Source Control | Ambient Water Standards for Surface Water used by NJ to develop their own standards |
| o New Jersey Department of Environmental Protection Citation under the Environmental Cleanup Responsibility Act (ECRA) (ECRA-NJAC 7:103) New Jersey Soil Cleanup TBC for arsenic | Source Control | Soil cleanup action level |
| o NJ Surface Water Stds (NJAC 7:9-4, 14(c) and (d)) | Source Control | Ambient stds. for water treatment systems discharging to surface water |
| Action-Specific: | | |
| o Federal and NJ Hazardous Waste RCRA Treatment Storage and Disposal Facility Standards (40 CFR 264/265 and NJAC 7:26-9, 10 and 11) | Source Control | General stds. for groundwater monitoring, closure, and post-closure activities |
| o Clean Water Act NJPDES Discharge to Surface Water Requirements (NJAC 7:14A-1 *et seq*, Appendix F) | Source Control | Stds. for water treatment systems discharging to surface water |
| | | Design and operating stds. and closure and post-closure activities for specific treatment systems |

TABLE 4-2 (Cont'd)

ARARS AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

| ARARs and "TBC" Material | Alternative Type Affected | Application |
|---|---|---|
| Action-Specific (Cont'd) | | |
| o Clean Water Act (Cont'd) | | - Landfills<br>- "Miscellaneous" units such as soil leaching, extraction, ion exchange, fixation and other chemical, physical, and biological treatment systems |
| o Federal Resource Conservation and Recovery Act (RCRA) Land Disposal Restrictions | Source Control | BDAT required prior to land dispose of certain contaminated wastes |
| o Federal and NJ Non-hazardous (Sanitary) Landfill Stds. (40 CFR 257/258 and NJAC 7:26-2A and 2) | Source Control | Design and operating stds. for sanitary landfills |
| o Federal and NJ Transportation Requirements for Hazardous and Non-Hazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7) | Source Control | Off-site transport of treatment residues and excavated material |
| o OSHA Health and Safety Requirements for Hazardous Substance Responses (29 CFR 1910) | Source Control | Worker Protection stds. for all activities |
| o RCRA Characteristic Testing for Hazardous Waste Identification (40 CFR 261) | Source Control | EP Toxicity Test for determining whether a material is RCRA hazardous |



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TABLE 4-2 (Cont'd)

ARARS AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

| ARARs and "TBC" Material | Alternative Type Affected | Application |
|---|---|---|
| Action-Specific (Cont'd) | | |
| o DOT Transportation Requirements for Hazardous Waste (40 CFR 100 - 177) | Source Control | Manifest System for hazardous waste transport |
| o NJ Toxic Substances Air Pollution Stds (NJAC 7:27-17) | Source Control | General prohibition on discharge of pollutants to air from storage tanks |
| o NJ Ambient Air Quality Stds. (NJAC 7:27-13) | Source Control | Stds. for limiting discharge of certain particulates |
| o National Historic Preservation Act | Source Control | Requires Stage IA survey during remedial action |
| Location-Specific: | | |
| o NJ Soil Erosion and Sediment Control Act of 1975 (NJSA 4:24-42) and Guidance | Source Control | Vegetation and engineering stds. to control sedimentation and conserve soil |
| o Wild and Scenic Rivers Act | Source Control | Activities that affect or may affect rivers specifically designated in the Act |
| o National Endangered Species Act | Source Control | Activities that affect endangered species |
| o US Fish and Wildlife Coordination Act | Source Control | Activities that affect fish or wildlife in stream areas |

TABLE 4-2 (Cont'd)

ARARS AND "TBC" MATERIAL FOR REMEDIAL ALTERNATIVES UNDERGOING DETAILED EVALUATION

| ARARs and "TBC" Material | Alternative Type Affected | Application |
|---|---|---|
| Action-Specific (Cont'd) | | |
| o Federal Floodplain and Wetlands Executive Order and Policy (#11990 and 11988) (40 CFR 6, Appendix A) | Source Control | Activities that affect floodplains and wetlands |
| o New Jersey Coastal Area Facility Review Act (CAFRA) Permit Requirements (NJSA 13:19-1 et seq) | Source Control | Activities affecting coastal areas |
| o New Jersey Wetlands (Coastal and Fresh) Permit Requirements (NJSA 13:9A-1 et seq, and 13:9B-1 et seq) | Source Control | Activities affecting wetlands |
| o NJ Stream Encroachment Permit Standards (NJAC 7:8-3.15) | Source Control | Construction within 100-yr. floodplain areas |
| o Rivers and Harbors Act Section 10 Clean Water Act Section 404 Stds | Source Control | Excavation activities in riverine areas may fall within "navigable waters of the US" |

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- How a specific site alternative achieves protection over time;
- How site risks are reduced; and
- How each source of contamination is to be eliminated, reduced, or controlled for each alternative.

State Acceptance: This assessment evaluates the technical and administrative issues and concerns the State may have regarding each of the alternatives. The factors to be evaluated include features of alternatives that the State supports, has reservations about, and/or opposes.

Community Acceptance: This assessment incorporates public input into the analysis of alternatives. Factors of community acceptance to be discussed include features of the supportiveness, reservations and opposition of the community.

The State has reviewed the draft of this FS and has provided comments to it which are incorporated into the report. However, the public has not been provided with a formal opportunity to review the detailed analysis of the remedial alternatives. A brief synopsis of state comments has been provided, but the public comments are not available. It is anticipated that the formal comments from the State and the public will be provided during the 30-day public comment period for this FS report. These comments will then be addressed in the ROD and the Responsiveness Summary.

## 4.2 ASSESSMENT OF REMEDIAL ALTERNATIVES

The remedial alternatives listed in Table 4-1 are evaluated in detail in this section.

Alternative 1 (No Action) involves limiting access to the identified contaminated areas of the site, conducting public education programs and instituting site-use restrictions. This alternative has no provisions for the treatment of wastes. Alternatives 2A and 2B involve treatment of arsenic contaminated sediments on-site using chemical fixation. The treated sediments are to be landfilled as nonhazardous wastes off-site or on-site for Alternatives 2A and 2B, respectively. Alternatives 3A, 3B, and 3C involve on-site treatment of arsenic-contaminated sediments using water extraction. Landfilling of the treated sediments on-site or off-site is considered for Alternatives 3A and 3B, respectively. Deposition of treated sediments in the Blackwater Branch floodplain and on the Plant site are the means of final disposition for Alternative 3C.

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### 4.2.1 Alternative 1 - No Action

#### 4.2.1.1 Description

Under this alternative, a public education program would be provided and warning signs would be installed to minimize access to the site. Institutional administration would be established to limit the use of the river areas. Warning signs would be posted at 500-foot intervals around the river in open access areas. In closed access areas the warning signs would be placed at 2,000-foot intervals. In both areas the warning signs would be placed in prominent locations. It is estimated that 75 signs would be needed. Education programs, including public meetings and presentations, would be undertaken to increase public awareness.

Long-term monitoring of the site would be performed to evaluate the performance of this alternative. This would consist of annual inspections of the site, as well as sampling of sediments and river water every year for 30 years. Four sediment samples and associated river water samples would be collected yearly and analyzed for arsenic. In addition, an ecosystem survey and ecological sampling would be performed yearly. Because this alternative would result in contaminants remaining on-site, CERCLA as amended would require that the site be reviewed every five years.

#### 4.2.1.2 Assessment

- Short-Term Effectiveness: This alternative would only restrict site access and use. Very little construction would be involved in this remedial action. There are no short-term threats to neighboring communities and no significant impacts on the public health and the environment during implementation activities. On-site workers would be properly protected with personnel protection equipment against direct contact with and ingestion of contaminants in the sediments during the implementation of this alternative. Therefore the risks through direct contact and ingestion of sediments can be minimized. Education programs, including public meetings and presentations, would be instituted to increase public awareness.

- Long-Term Effectiveness: The No Action alternative would not reduce the level of sediment contamination in the river areas, therefore the target cleanup level would not be attained. Some years would probably be required before natural dilution and transport mechanisms would reduce the arsenic concentrations in the sediments to the target level.

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This alternative is designed to prevent ingestion and/or direct contact with the contaminated sediments by restricting access to the site. The long-term effectiveness of this alternative depends on its success in preventing access to the site and the use of the study area. The incremental lifetime cancer risks associated with exposure to the contaminated sediment range from $10^{-3}$ to $10^{-5}$. If the access restrictions are unsuccessful, these risk levels might not decrease for some years.

The contaminated sediments in the Blackwater Branch downstream of the North Mill Road Bridge and in the upper Maurice River are presently under water. The data in the River Areas RI showed that these sediments were probably subject to mixing and redeposition. Presumably, therefore, the contaminated sediments would eventually resuspend and travel downstream if the No Action Alternative is instituted. They would probably be deposited eventually in Union Lake, which was shown to be a sink for arsenic in the basin.

The contaminated sediments in the Blackwater Branch floodplain are presently exposed; this is the direct result of removing a beaver dam. Unlike the sediments mentioned above, these sediments are not under water. Their potential for being transported downstream is significantly less than the potential associated with sediments that are under water. If the No Action Alternative is instituted, this floodplain would pose a potential health risk for some years. These sediments would remain as a potential source of arsenic into the river system, either through leaching or possibly through direct transport during atypical and excessive flood events.

If a groundwater remediation system were installed on-site to prevent contaminated groundwater from discharging into the Blackwater Branch, the data indicate that the total arsenic concentration in the downstream surface waters would drop relatively quickly. This drop would be a function of the dissolved arsenic concentration dropping. The concentration of arsenic or suspended particulates in the water would not be affected, except that no further arsenic would be available to bind to the sediments. The arsenic-contaminated sediments that would remain in the rivers if the No Action Alternative were chosen could continue to supply a suspended arsenic load to the surface water. This could therefore reduce the effectiveness of the surface water cleanup, which would be accomplished by eliminating the groundwater contamination entering the Blackwater Branch.



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This alternative would not improve the river environment. The implementation of this alternative would not have any beneficial or adverse impacts on the environment compared to the existing conditions. There are no additional long-term threats to neighboring communities resulting from the implementation of this alternative.

- Reduction of Toxicity, Mobility or Volume: This alternative would not involve any containment, removal, treatment or disposal of the contaminated sediments. It would leave the contaminated sediments in place. Therefore, this alternative would not result in any reduction in the toxicity or mobility of contaminants. The river's natural dilution and transport mechanisms would resuspend, disperse, and possibly leach the sediments into the river water. Therefore, there may be a reduction in the volume of contaminated sediments in the river through time. However, assuming all future arsenic releases to the river areas are stopped, it would probably take some years for the natural movement of the river water to significantly reduce the volume of contaminated sediments (see River Areas RI Subsection 5.2.5).

- Implementability

  Technical Feasibility: Posting warning signs is a relatively simple task which could be performed by local contractors. The required equipment is readily available. The work could be completed within approximately three to four weeks.

  Once posted, warning signs would reduce site access. Routine inspection and the replacement of damaged and missing signs would be required. Direct monitoring of the effectiveness of the alternative may be difficult because it is impossible to determine if significant access restriction is achieved. Public awareness would increase the effectiveness of this alternative and regular public surveillance would deter access violations.

  Administrative Feasibility: Implementation of this alternative would require institutional controls to restrict river use. Considerable long-term institutional management would be associated with this alternative because wastes would remain on-site and review would be necessary every five years. Annual inspections, sampling and public education programs (e.g. public meetings and work shops) would demand administrative and regulatory attention.

- Cost: The capital cost for this alternative, as outlined in Table B-1, is $44,500. Annual operation and maintenance costs for this alternative, outlined in Table B-7, are

approximately $49,500 a year, for 30 years. The present worth, calculated at a discount rate of 5% after inflation, is $874,200. This cost represents all of the activities to post warning signs, implement institutional controls through public informing activities, and conduct six five-year reviews.

- Compliance with ARARs: Action-specific ARARs for the No Action Alternative apply to the posting of warning signs and the site monitoring activities. Requirements for these activities include OSHA Health and Safety Standards.

  This alternative would not remove contaminated material from the site nor would it provide containment of contaminated sediment. It would provide only minimal protection to human health and the environment. The potential for the contaminants to migrate from the sediments into the river water and the potential for human exposure to the contaminants would not be eliminated.

- Overall Protection of Human Health and the Environment: The No Action Alternative would not remove or contain the contaminated sediments. Therefore it would not be protective of human health and the environment. There would be no reduction in the toxicity or mobility of the contaminants. Some years would be required for the natural attenuation to reduce the level of arsenic within the sediment in the river areas to below the target levels. It would take longer for natural mechanisms to reduce exposed sediment arsenic concentrations to below this cleanup level. Presently the existing cancer risk levels from exposed and submerged sediments are greater than $1x10^{-5}$. It would take some years to reach these levels naturally.

  This alternative does not respond to the remedial objective. It provides a base case for comparison between other alternatives.

- State Acceptance: The NJDEP has indicated that sediment modeling should be conducted to determine the rate of natural reduction of sediment arsenic concentrations. The results of this model can be compared with the time of remediation in the other alternatives to determine if remedial actions are appropriate for the submerged sediments or if natural flushing (No Action) would achieve the same end in a comparable time frame.

- Community Acceptance: No public comments have been received to date.



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### 4.2.2 Alternative 2A - Dredging/Excavation/Thickening/Fixation/ Off-Site Nonhazardous Disposal

#### 4.2.2.1 Description

The major features of this alternative include hydraulic dredging of contaminated submerged river sediments, excavation of contaminated exposed floodplain sediments, sediment treatment and off-site nonhazardous disposal, and supernatant water treatment and discharge. A schematic diagram is shown in Figure 4-1. This is a source control (removal/treatment) alternative in which the contaminated sediments will be removed and fixated. The processed sediments will be disposed of in an off-site nonhazardous landfill facility.

- Hydraulic Dredging

  Hydraulic dredging would be performed to remove contaminated submerged sediment. As shown in Figure 4-2 the contaminated sediment is located in different areas at sediment thicknesses ranging from 0 to 3 feet. Hydraulic dredges remove and transport sediment in liquid slurry form containing approximately 10% to 20% solids by volume. It is expected that the river water would provide a minimum water depth to maintain hydraulic dredge mobility.

  A "portable" dredge is a type of hydraulic dredge that is designed for use in shallow bodies of water and industrial settling ponds, and is transportable by truck. One of the most widely used portable dredges is the Mud Cat dredge. The Mud Cat is also known as a horizontal-auger dredge.

  The Mud Cat is pontoon-mounted and features a horizontally mounted, auger-like cutting device that feeds the dredged sediment to the suction intake of a diesel-driven centrifugal pump, producing an 8 ft-wide cut. The auger is mounted along the base of a bulldozer-type blade. The entire configuration, with suction pipe attached, is controlled by a hydraulic boom. The dredge is moved along an anchored cable during each traverse of the excavation, and the dredged material is discharged ashore through a float-supported pipeline. Mud Cat has indicated that advances in its equipment design have enabled dredging in areas with very little water available. Site-specific tests would be required to confirm this.

  The Mud Cat is considered to be the best dredge for use in the Maurice River and the Blackwater Branch for the following reasons:

  1. Small size; the Mud Cat can be transported to the site by a conventional tractor-trailer truck and placed in the water by crane.

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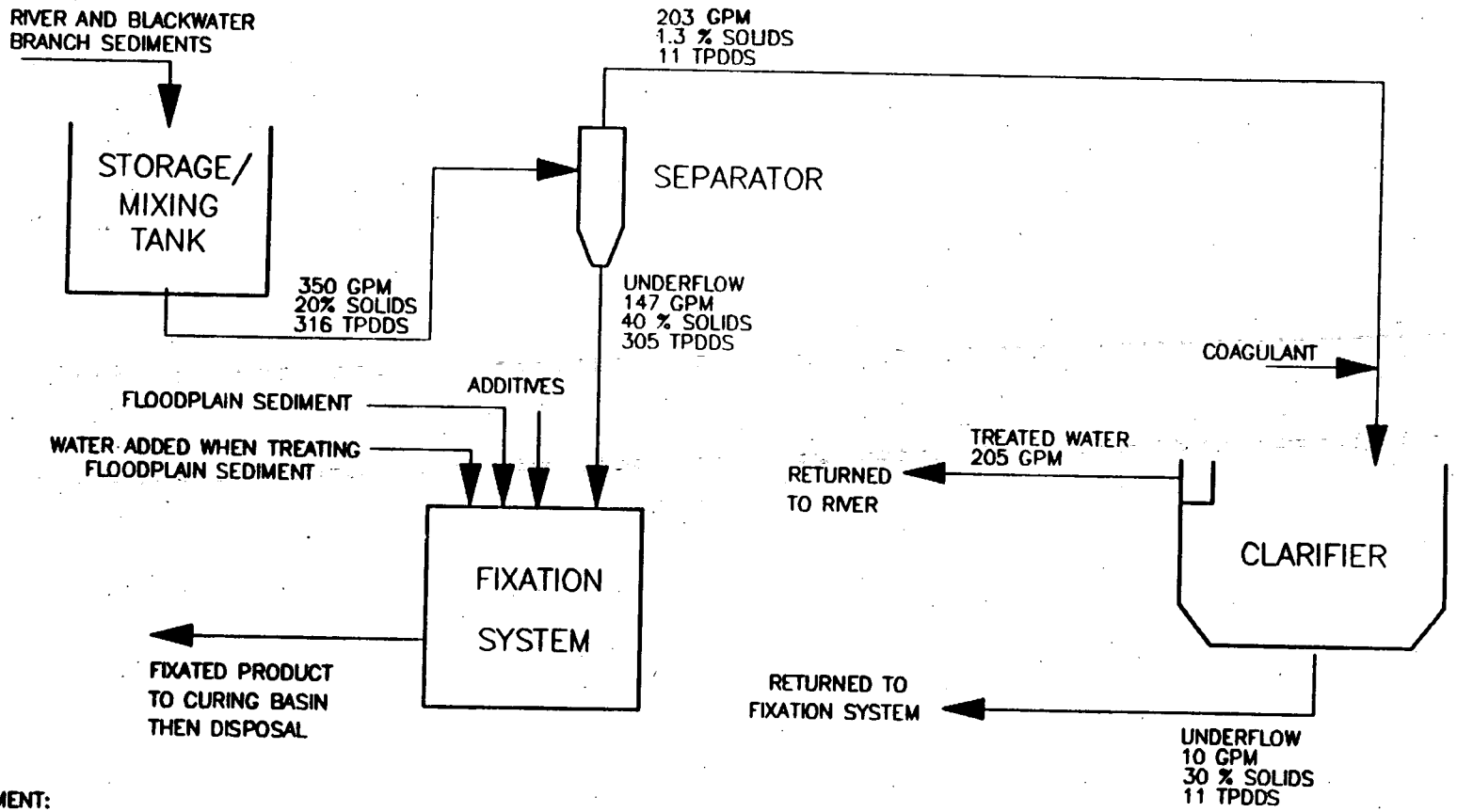
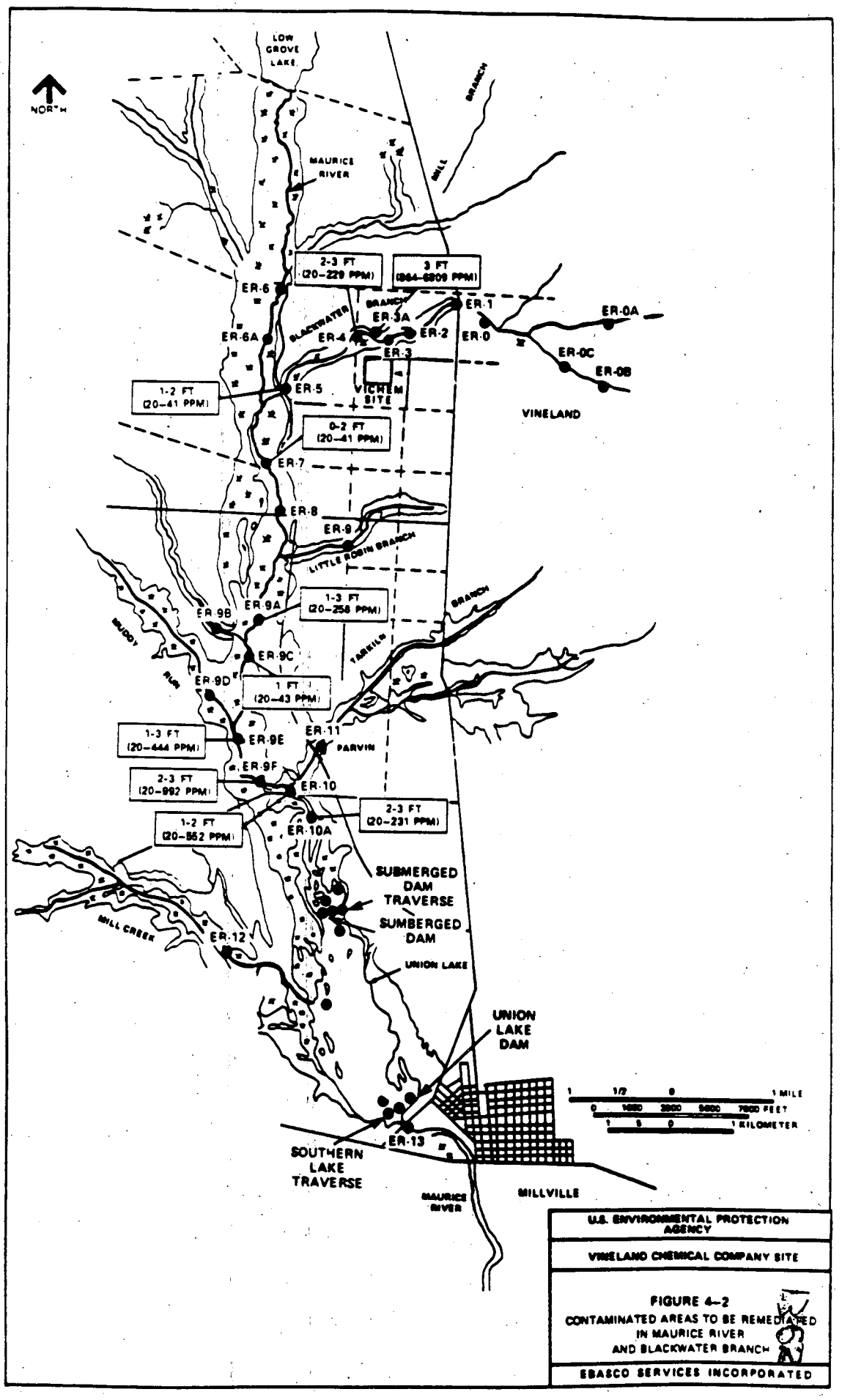
# FIGURE 4-1
# FIXATION SYSTEM




COMMENT:

1. SYSTEM OPERATES WITH EITHER THE RIVER AND BLACKWATER BRANCH SEDIMENTS OR THE FLOODPLAIN SEDIMENT.
2. ONLY THE FIXATION SYSTEM IS NEEDED WHEN THE FLOODPLAIN SEDIMENTS ARE TREATED.
3. THE FLOW RATES ARE FOR THE DAYTIME (8 HOURS/DAY) OPERATION. FOR 16 HOURS/DAY THE OPERATION IS AT 50 % OF THE FLOW RATES SHOWN.
4. % SOLIDS IS ON A WEIGHT BASIS.
5. THE TONS PER DAY OF DRY SOLIDS (TPDDS) IS COMPUTED FOR 24 HOURS AT THE ACTUAL RATES.




U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 4-2
CONTAMINATED AREAS TO BE REMEDIATED IN MAURICE RIVER AND BLACKWATER BRANCH

EBASCO SERVICES INCORPORATED

2. Shallow draft; it draws under 2 ft.

3. Low resuspension of sediments during dredging activities. Based on recent studies by the US Army Corps of Engineers for the USEPA, Mud Cat dredging equipment can be operated to produce a resuspension plume that does not migrate from the immediate vicinity of the dredge intake. Accomplishing this does come at the expense of dredge optimization, since flows must be increased to pull in more water to minimize the size of the plume. As an added precaution, silt curtains would be situated downstream to capture resuspended sediment. Transport modeling with dye studies would enable strategic placement of silt curtains during final design.

Two Mud Cats could dredge in-place sediments at a combined rate of approximately 100 cubic yards of sediment/slurry per hour, eight hours a day. The 21,800 cy of contaminated submerged sediment could be removed by the Mud Cats over a period of about six months. The total pumping rate of the water-sediment dredge slurry, with approximately 20% solids by weight, would be approximately 350 gpm. The slurry would be pumped through a floating piping system to an on-site treatment facility.

o <u>Excavation</u>

Soil excavation includes the removal of the exposed arsenic-contaminated sediment deposited in the Blackwater Branch floodplain. This area, shown in Figure 4-3, was flooded with arsenic contaminated groundwater and surface water for approximately 18 to 24 months from 1985 to 1987. The area is now mostly dry following the removal of a downstream beaver dam. Analysis of samples from 23 boring locations in the floodplain taken in November of 1988 indicated that approximately 56,200 cy of sediment contained arsenic concentrations in excess of the exposed sediment cleanup level of 20 mg/kg. The concentrations of contaminant varied laterally and vertically, as depicted in Figure 4-3.

This material would be removed from the area using a backhoe. A low ground pressure backhoe, which is used for excavating soft material, would be suitable for this area. This type of backhoe is capable of excavating sediment at a rate of approximately 12 cy per hour. Two backhoes would be used; therefore the rate would be 192 cy per day (in an 8 hour day). This sediment, which is assumed to be approximately 54% solids by weight, would be transported directly to an on-site treatment facility. Clean fill and seeded topsoil cover would be used to restore the scarred floodplain.

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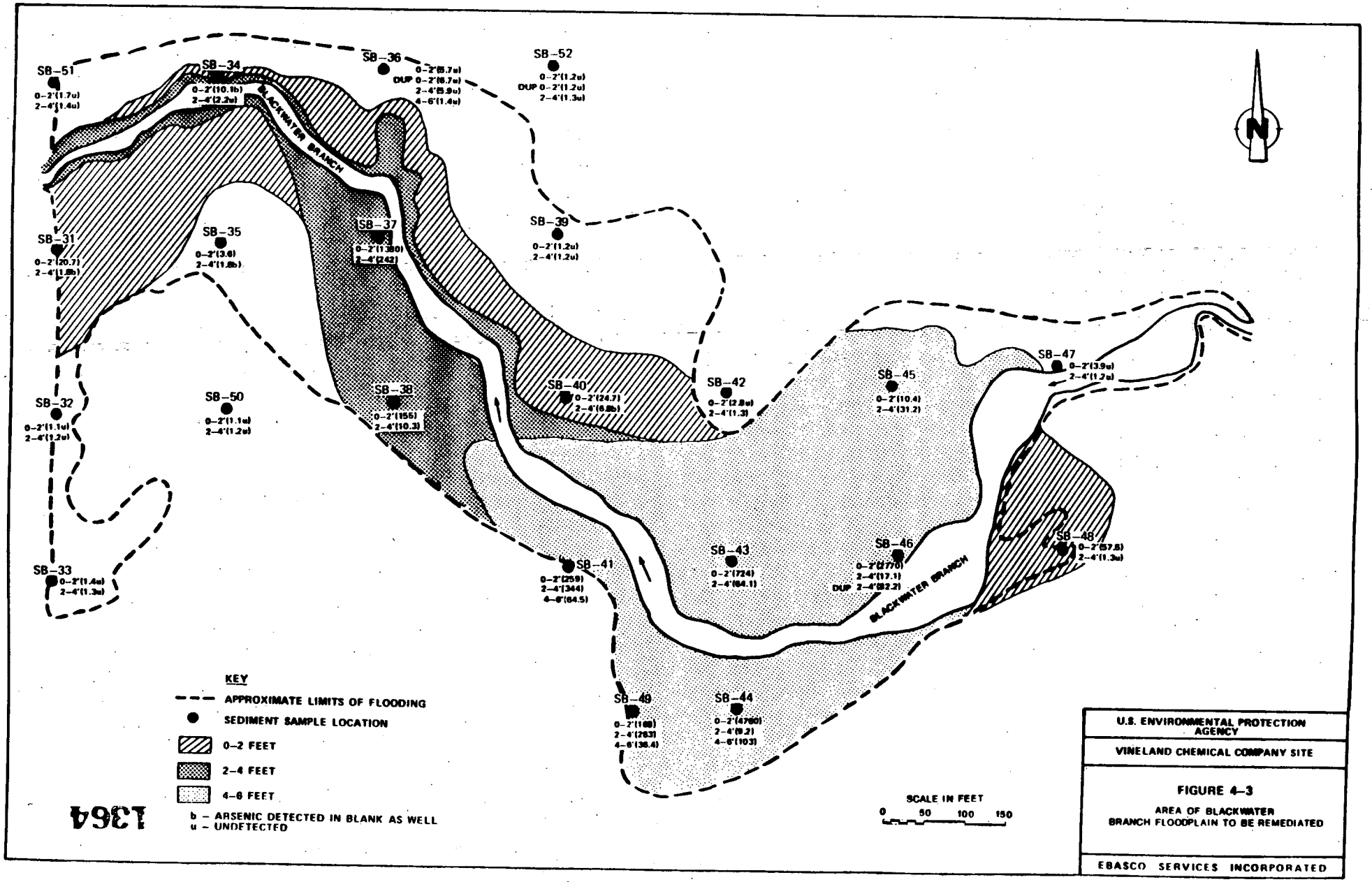
SB-51
0-2'(1.7u)
2-4'(1.4u)
SB-34
0-2'(10.1b)
2-4'(2.2u)
SB-36
0-2'(5.7u)
DUP 0-2'(6.7u)
2-4'(5.9u)
4-6'(1.4u)
SB-52
0-2'(1.2u)
DUP 0-2'(1.2u)
2-4'(1.3u)
BLACKWATER BRANCH
SB-31
0-2'(20.7)
2-4'(1.8b)
SB-35
0-2'(3.6)
2-4'(1.8b)
SB-37
0-2'(1380)
2-4'(242)
SB-39
0-2'(1.2u)
2-4'(1.2u)
SB-32
0-2'(1.1u)
2-4'(1.2u)
SB-50
0-2'(1.1u)
2-4'(1.2u)
SB-38
0-2'(155)
2-4'(10.3)
SB-40
0-2'(24.7)
2-4'(6.8b)
SB-42
0-2'(2.8u)
2-4'(1.3)
SB-45
0-2'(10.4)
2-4'(31.2)
SB-47
0-2'(3.9u)
2-4'(1.2u)
SB-33
0-2'(1.4u)
2-4'(1.3u)
SB-41
0-2'(259)
2-4'(344)
4-6'(64.5)
SB-43
0-2'(724)
2-4'(64.1)
SB-46
0-2'(270)
2-4'(17.1)
DUP 2-4'(82.2)
SB-48
0-2'(57.8)
2-4'(1.3u)
BLACKWATER BRANCH
SB-49
0-2'(168)
2-4'(263)
4-6'(36.4)
SB-44
0-2'(4760)
2-4'(9.2)
4-6'(103)
KEY
APPROXIMATE LIMITS OF FLOODING
SEDIMENT SAMPLE LOCATION
0-2 FEET
2-4 FEET
4-6 FEET
b - ARSENIC DETECTED IN BLANK AS WELL
u - UNDETECTED
SCALE IN FEET
0 50 100 150
N
U.S. ENVIRONMENTAL PROTECTION AGENCY
VINELAND CHEMICAL COMPANY SITE
FIGURE 4-3
AREA OF BLACKWATER BRANCH FLOODPLAIN TO BE REMEDIATED
EBASCO SERVICES INCORPORATED

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Construction access roads would have to be cleared and graded using bulldozers and front end loaders to accommodate excavation and dredging operations. Two roads would have to be built to both sides of the Blackwater Branch into North Mill Road. These roads would have to be built at a substantial distance from the stream to avoid areas of contamination and to maintain structural integrity; clean fill may be required if the floodplain sediments cannot bear the loads of the construction equipment.

o <u>Chemical Fixation and Supernatant Water Treatment</u>

The sediment would be treated at a facility constructed on the site using the chemical fixation treatment processes. Due to the length of the river and the remoteness of the areas that are to be treated, the treatment facility would be relocated several times during the remediation. Therefore portable equipment and/or equipment that can be disassembled and reassembled easily is preferred. The dredged sediment would first be thickened by means of 14 hydroclones operating in parallel. Seven hydroclones would operate while the other seven would be on standby. The thickened sediments would be treated in mixing tanks using the fixation process. The fixated sediments would be cured in an on-site storage area for a specified period of time (approximately 48 hours) to complete the fixation/ stabilization process. Excavated sediments would be transported by truck to the treatment system and fed by means of belt elevators. Water would be pumped into the mixing tank with the excavated sediments to obtain proper chemical proportions.

Bench-scale tests were performed to prove the feasibility of chemical fixation for the contaminated sediment by utilizing a commercial proprietary "K-20/LSC" process. The "K-20/LSC" process is based upon a chemical treatment utilizing three components: thickened/dewatered sediments, a dry reagent and a liquid reagent. The dry reagent is made from Portland cement, fly ash and activated carbon powder. The liquid reagent is a commercial silicated blend known as K-20/LSC which has been developed and manufactured by Lopat Enterprises, Inc. of Wanamassa, New Jersey. The K-20/LSC System has been demonstrated and proven to be effective, having the ability to be custom-blended as needed for a particular application.

The sediment and dry reagent would be thoroughly blended in specially designed high-powered tanks. After blending, the liquid reagent would be injected into the mass and further blending would take place. A rapid chemical

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reaction would occur, transforming the product into a gel. The gel would then be extruded into a confinement (curing basin) where it would be kept for 48 hours. This confinement would be in the immediate vicinity of the treatment system to avoid any hauling of materials before curing is complete. The fixated product in the treatability test achieved an unconfined compressive strength (UCS) of approximately 9,000 psf, which significantly exceeded the test's design strength of 1,500 psf.

The resulting product of this process would be chemically fixated and physically stabilized. All constituents of concern, such as arsenic, are bound within the K-20/LSC gel. The product would be a solid with a rock-like appearance and would be suitable for nonhazardous disposal. Details of the test results are given in Section 7.0 and Appendix A of the River Areas RI Report.

- Supernatant Water Treatment

  The overflow from the thickeners would be directed into two clarifiers 20 ft in diameter by 10 ft high. Alum, ferric chloride and polymer would be added and mixed in order to remove suspended solids and reduce arsenic to below 0.05 mg/l. The clarified effluent would then be tested and returned to the Maurice River through a discharging system. The settled solids from the clarifiers would be pumped back to the fixation units and would be treated in the same manner as the contaminated sediments. In order to optimize this system, a pilot-scale study would be required.

- Off-Site Nonhazardous Disposal

  The fixated sediment would be loaded onto trucks for transport to a nearby nonhazardous landfill. This means of disposal would be preceded by a NJDEP ID 27 waste classification for the treated sediments. The total volume of fixated sediment is estimated to be 182,755 tons (101,103 cu yd) free of water. The trucks would be lined, sealed, and decontaminated prior to leaving the site.

The major construction components and facilities for this alternative are outlined in Table A-2 of Appendix A.

4.2.2.2 Assessment

- Short-Term Effectiveness: The potential public health threats to area residents during the implementation of this alternative would include direct contact with spilled wastes and the inhalation of fugitive dust. The sediment

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treatment plant would be located at a minimum of 500 feet away from the nearest recreational facility or house. The entire treatment plant would be fenced and "keep out" signs would be posted. Access would be limited to authorized personnel only. The sources of fugitive dust emission would include dried sediment, cement and fly ash from the fixation process. The storage and handling of these materials would be performed in a closed silo and in a vessel equipped with proper dust control devices. The fixated sediments waiting to be transported off-site would be contained to prevent release to the environment. Therefore the short-term public health threats resulting from this remedial action would be minimal.

Hydraulic dredging operations would result in localized resuspension of sediments and could temporarily affect biota. Since hydraulic dredging would be done in limited local areas, suspensions would settle in a short period of time, enabling fish and wildlife to have adequate room to avoid the disturbed areas. The use of the Maurice River would be restricted during the dredging operations. Any adverse effects on the river environment would be temporary and localized.

On-site risk to workers would be minimized by the use of adequate preventive measures and proper personnel protection equipment, which would prevent ingestion and inhalation of fugitive dust. All unit operations, such as dredging, excavation, thickening, fixation, curing and transportation, would be performed with adequate containment (tanks, vessels and silos) and in confined areas. The chemical reaction involving the sediments and additives would not produce off-gases or by-products that would pose health risks to workers. The proprietary agent, K-20/LSC, is non-toxic. Any leachate or drainage generated from the curing basin would be collected and treated for suspended solids. The supernatant would be tested for arsenic prior to being discharged to the river. The short-term risks to workers would be minimal.

The short-term impacts on the environment include increased traffic and construction operations in the area. The trucks carrying the fixated sediments would be decontaminated and covered; however, passage of these trucks through the neighboring communities could have some impacts on them. Additional traffic could cause noise pollution, an increase in accidents and air pollution. On-site safety issues would include the truck traffic, accidents, noise and airborne particulates from transportation. An appropriate local traffic control plan would be implemented by the local authorities. Proper dust control measures such as water spraying would be provided in order to minimize air pollution.



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Adverse short-term impacts to the environment may occur with this alternative. Some of the areas to be remediated, particularly the Blackwater Branch floodplain, may be considered wetlands areas. Determination of these areas would have to be done during detailed design. Protective measures may have to be implemented during remediation.

The time required to complete this remedial action and to achieve protection is estimated at approximately three years.

- Long-Term Effectiveness: Immobilization through chemical fixation is designed to render contaminants insoluble, prevent leaching from the fixated wastes, reduce the potential of direct human contact and improve waste handling characteristics. This alternative would reduce the mobility of the contaminants; it would not achieve a reduction of toxicity or volume of contaminants. Chemical fixation would convert contaminated sediments into a stable cement-type matrix with minimal free water. The supernatant separated from the dredged sediments would be treated using physical-chemical precipitation processes in order to remove arsenic to levels below 0.05 mg/l (Safe Drinking Water Standards) prior to discharge back into the river. The fixated sediment would be transported and disposed of in a licensed off-site nonhazardous landfill facility. This facility would not be expected to pose public health risks or risks to the environment because it would be a fixed facility that would comply with all appropriate regulations.

The major long-term effectiveness concerns would include any beneficial and adverse effects on public health and the environment that might result from the completion of this remediation. The major benefits associated with this alternative include reducing the amount of arsenic-contaminated sediments that have been determined to pose public health risks through ingestion, and reducing the migration of arsenic-contaminated sediments in the river water. Also, the potential for arsenic to leach from the sediments into the river water would be reduced.

This alternative would minimize potential public risks from the sediment exposure pathways. As a result of this remedial action, the cancer risk for arsenic via all sediment-related exposure pathways would be reduced to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river using the most plausible sediment exposure pathways. The cancer risk level would be reduced to $2x10^{-6}$ in the more accessible areas of the river.

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After remedial activities are completed, the potential for sediments with arsenic concentrations above the more stringent cleanup level of 20 mg/kg to reconcentrate by natural forces would persist. Therefore, a long-term monitoring plan would be required to measure the effectiveness of this alternative and to assess the potential for future remedial activities. In addition, the presence of arsenic-contaminated sediments on-site following remediation triggers CERCLA requirements of five-year reviews of the site to determine the effectiveness of the alternative and to identify new technologies that could be applied to any problems existing at the site.

No long-term adverse environmental impacts are expected to result from the implementation of this alternative. Any wetland areas that might be disturbed during the implementation of this alternative would be identified and taken into consideration during final design. Impacts from dredging operations would be kept at a minimum by controlling the sediment resuspension plume by varying the intake flow rate. The fixated sediment would be transported and disposed of in a licensed off-site nonhazardous landfill facility. This facility would not be expected to pose public health risks or risks to the environment because it would be a fixed facility in compliance with all appropriate regulations, and in addition, the mobility of the arsenic in the fixated sediments is low.

- Reduction of Toxicity, Mobility or Volume: Immobilization is well suited for solidifying sediments containing heavy metals and other inorganics such as arsenic. This form of fixation is generally affected by the sediment matrix, contaminant constituents and the fixation additives. Many of the commercially available processes use proprietary additives and claim to stabilize a broad range of compounds from divalent metals to organic wastes. Some research results (USEPA, 1985b) indicate that successful fixation of arsenic-contaminated sediment could be obtained by utilizing a modified process that involved the use of sodium silicates.

  Sediment chemical fixation has been designed based on the results of bench-scale treatability tests including three different additive formulations (see the River Areas RI Report Section 7.0). The treatability test results indicated that samples consisting of sediments, K-20/LSC, activated carbon, Portland cement and fly ash might meet the performance criteria. After 48 hours of curing, the mixture yielded RCRA EP Toxicity Test results of approximately 1 mg/l of leachable arsenic. The fixated

sample would have approximately 9,000 psf of Unconfined Compressive Strength (UCS), which is much higher than the 1,500 psf generally required for landfilling to support truck traffic and other earth-moving equipment. In addition, the sample yielded USEPA Multiple Extraction Procedure (MEP) results with a maximum arsenic leachate concentration of less than 0.32 mg/l. The MEP is used to estimate the long-term stability of the treated material under conditions simulating 1,000 years of exposure to acid rain (48 CFR 52686-87, November 22, 1982). Based on these test results, as well as the discussion presented in Subsection 3.1.1.2.2, it is assumed that the fixation process could be optimized to enable delisting of the fixated sediments.

K-20/LSC is an inorganic silicate-based material that has the following major functions contributing to successful fixation:

- Precipitation of inorganic arsenic;
- Encapsulation of arsenic contaminants;
- Protection and stabilization of encapsulated arsenic contaminants; and
- Activated carbon power adsorption of organic arsenic in a fixated matrix.

Based on the MEP test data, the treatment processes used for this alternative would be irreversible, and arsenic bound in the sediment would not be expected to be leachable. Thus chemical fixation would provide an almost permanent remedy by reducing the total mobility of both inorganic and organic arsenic in the contaminated sediments that are treated. The off-site nonhazardous landfilling of the fixated sediments would also provide an adequate containment for reducing the mobility of contaminants, but would not contribute to overall reduction in the toxicity or volume of the contaminants. This alternative would greatly reduce the mobility of arsenic sediments that pose threats to human health. The toxicity of the river water throughout the study area may be reduced as a consequence of reducing the suspension of contaminated solids and the phase transfer of soluble arsenic.

- <u>Implementability</u>

<u>Technical Feasibility</u>: This alternative involves on-site hydraulic dredging, excavation, chemical fixation and off-site disposal at a nonhazardous landfill. These are all proven technologies and are commercially available.

Hydraulic dredging for shallow water sediment removal, using equipment such as a Mud Cat, can be provided by many vendors by lease or purchase. Excavation using a low ground pressure backhoe can be provided by several vendors. Chemical fixation technologies can be provided by many manufacturers. Equipment required for chemical fixation includes standard cement mixing and handling facilities, which are commercially available. A commercial silicated blend known as K-20/LSC used in the treatability fixation process has been developed and can be provided by Lopat Enterprises of Wanamassa, New Jersey. This fixation system was selected for the treatability study because of its ability to be custom-blended as needed for a particular application. Similar blends are also available from other vendors. Other materials required for chemical fixation, such as Portland cement, fly ash and carbon powder, are all common industrial materials that are commercially available. The physical-chemical precipitation systems required for treating the supernatant are traditional wastewater treatment processes, which can be installed using "off-the-shelf" hardware. Nonhazardous landfill facilities are available and have indicated a willingness to accept the treated material within a reasonable distance from the site.

Hydraulic dredging and backhoe excavation can be easily performed to depths below the expected limit of contamination (0 to 3 feet). On-site sediment and water testing would be required to monitor the Mud Cat's effectiveness (1 run removes a maximum of approximately 1.5 feet of sediment). If necessary, a second pass over the same area can be performed to meet the specified cleanup level. The chemical fixation process can handle many variations in the sediment composition. The solidification/stabilization of sediments is simple from a technical standpoint; there are no appreciable construction and operation difficulties. Similarly, construction and operation of the wastewater treatment system is not expected to present any problems.

The chemical fixation process provides a reliable method for meeting all performance goals. It is unlikely that any technical difficulties would lead to schedule delays. Labor and materials are readily available for all components of this alternative. The relatively complex components of this alternative are sediment and water treatment; however, these are proven technologies. The other components are comparatively simple.

Conditions external to the site, such as equipment and disposal facility availability, present no problems at this time. This remedial alternative provides a reliable process for handling the contaminated sediment.

The time required for implementation of this remedial alternative is estimated to be three years, assuming that the flow of contaminated groundwater into the river is halted. This estimate may be altered based on sediment volumes and site conditions assessed during final design.

Administrative Feasibility: Treated overflow from the sediment dewatering process would be returned to the Maurice River or the Blackwater Branch. A discharge permit would not be required since this is an on-site Superfund discharge. However, a statement that this discharge would be in compliance with ARARs would be required for state and local approvals. Since the overflow would be treated to meet the New Jersey Surface Water Quality Standards, obtaining state and local approvals should not pose a problem.

Institutional administration would be required to locate a nearby nonhazardous landfill to dispose of the fixated sediments. Since the waste would be disposed of off-site, NJDEP would be responsible for approving the petition for delisting. This could result in a relatively lengthy process. Based on the results of the treatability study, with confirmation from the vendor, and with concurrence from USEPA Region II, the fixated sediment is expected to meet substantive delisting requirements; therefore, disposal of the sediments as nonhazardous material would not be expected to pose any problems other than time considerations for approval. Following the delisting process, the NJDEP would make the determination of whether or not the material is ID 27 waste. The classification of the treated sediment as ID 27 waste would allow for landfilling of the material in a permitted facility. In addition, coordination with the local traffic authorities would be required to control the additional traffic resulting from the transportation of treated solids. An appropriate local traffic control plan would be implemented by the local authorities. Some administrative effort would be required to identify wetland areas and regulations pertaining to construction activities in them.

- Cost: The capital cost for this alternative, outlined in Table B-2, is estimated at $29,058,000. Annual short-term operation and maintenance costs and long-term operation and maintenance costs, outlined in Table B-8, are estimated at $17,793,000 and $13,000, respectively. The present worth cost, based on a discount rate of 5% after inflation is $60,809,000. This represents all of the activities to dredge, excavate, thicken, fixate, haul, and landfill sediments; perform all operation and maintenance functions on the treatment system components; perform periodic sampling of the Blackwater Branch and the Maurice River; and perform the six required five-year reviews.

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A cost sensitivity analysis, outlined in Table 4-3 and graphically depicted in Figure 4-4, was performed for this alternative by varying the volume of submerged river sediments to be remediated and calculating the present worth. The volume of exposed floodplain sediments was held constant due to the extensive field data obtained in this area. Sensitivity to sediment volumes was analyzed for 0%, 50%, 100%, and 200% of the present volume of submerged sediment estimates. These parameters were chosen because of the inherent dynamics associated with the river system and their capacity to distribute sediments over time. Present worth costs ranged from $52,800,000 to $68,536,000 for the 0% and 200% sediment volume cases, respectively. These costs represented a range of -13% to +13% over the estimated present worth of the alternative.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be reviewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth of the alternative, assuming no disposal costs or operation and maintenance costs associated with disposal, is $37,596,000.

In the event that treated soils cannot be delisted, off-site RCRA landfilling would be required. The present worth associated with disposing of the treated soils in an off-site RCRA landfill is estimated at $90,984,750.

- Compliance With ARARs: Hydraulic dredging and excavating activities in the riverine areas would require appropriate preventive measures to minimize resuspension, erosion and dissolved oxygen depletion in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10. The riverine areas would be within the broader "waters of the U.S." jurisdiction of Section 401 and Section 404 of the Clean Water Act (CWA). Section 401 of the CWA requires that any activity must not result in a discharge that violates any water quality and water body classifications. Section 404 of the CWA requires that no activity affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. To comply with these ARARs, contaminated sediments would have to be remediated to protect future use of the river shores. It is assumed that all sediments exceeding the health risk-based cleanup levels would be removed.

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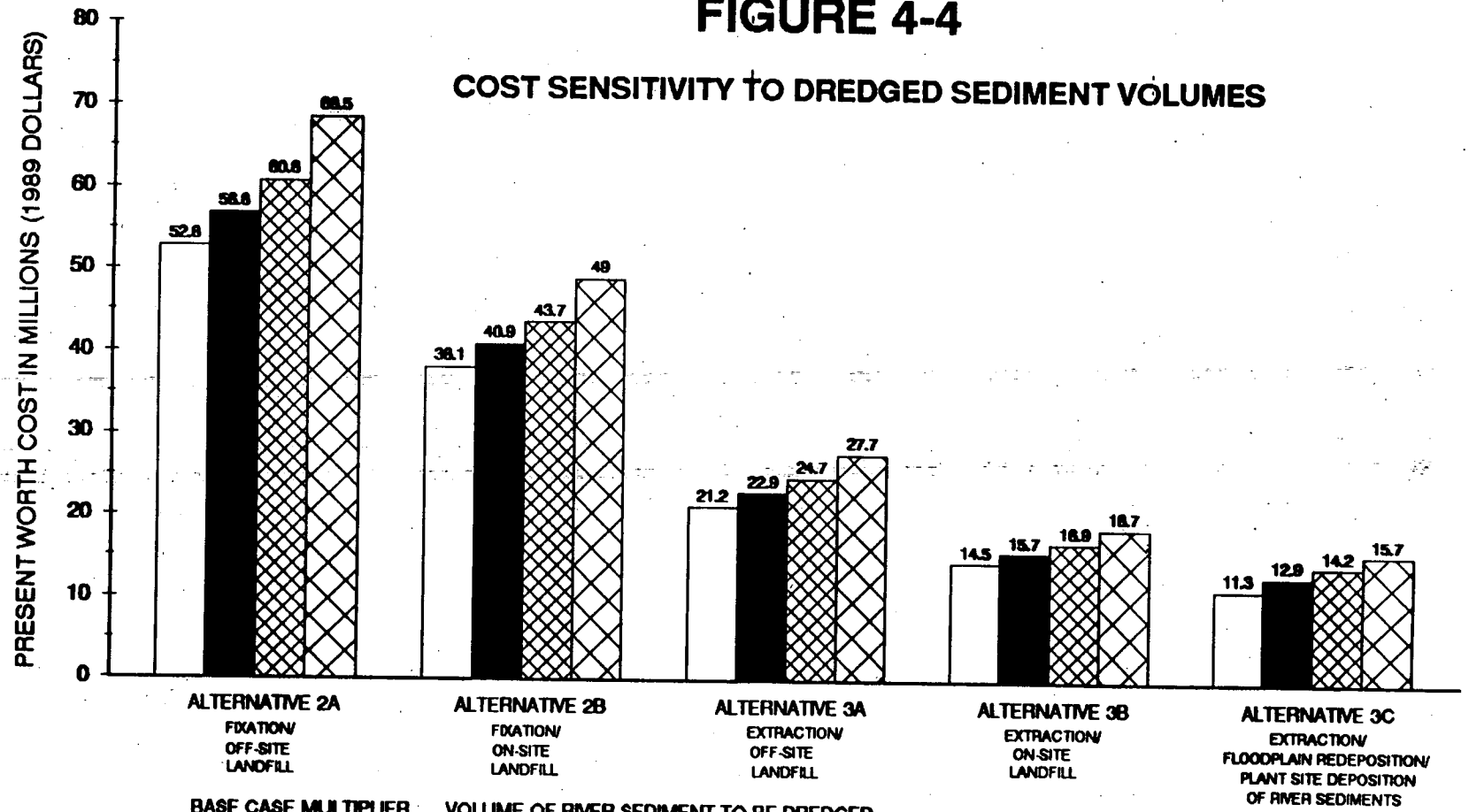
TABLE 4-3
SENSITIVITY ANALYSIS OF COSTS (1989 DOLLARS)
BASED ON THE AMOUNT OF SEDIMENT TREATED
IN THE BLACKWATER BRANCH AND RIVER

| ALT | PERCENTAGE OF SUBMERGED SEDIMENT TREATED | CAPITAL COST | | | ANNUAL O & M | | PRESENT WORTH |
|---|---|---|---|---|---|---|---|
| | | DIRECT | INDIRECT | TOTAL | LONG TERM | SHORT TERM | |
| 1 | DOES NOT APPLY | $ 35,000 | $ 9,450 | $ 44,450 | $ 49,455 | $ | $ 874,245 |
| 2A | 100 | $22,880,219 | $ 6,177,659 | $29,057,878 | $ 13,020 | $17,792,599 | $60,808,653 |
| | 0 | $20,084,875 | $ 5,422,916 | $25,507,791 | $ 13,020 | $29,812,886 | $52,800,049 |
| | 50 | $21,482,547 | $ 5,800,288 | $27,282,835 | $ 13,020 | $21,793,915 | $56,825,288 |
| | 200 | $25,675,563 | $ 6,932,402 | $32,607,965 | $ 13,020 | $16,317,416 | $68,536,278 |
| 2B | 100 | $ 8,684,740 | $ 2,344,880 | $11,029,620 | $ 79,698 | $17,792,599 | $43,665,831 |
| | 0 | $ 7,857,072 | $ 2,121,409 | $ 9,978,481 | $ 70,989 | $29,812,886 | $38,079,015 |
| | 50 | $ 8,270,906 | $ 2,233,145 | $10,504,051 | $ 75,343 | $21,793,915 | $40,894,553 |
| | 200 | $ 9,512,409 | $ 2,568,350 | $12,080,759 | $ 88,407 | $16,317,416 | $48,986,031 |
| 3A | 100 | $17,048,746 | $ 4,603,161 | $21,651,907 | $ 13,020 | $ 1,589,880 | $24,709,821 |
| | 0 | $15,261,006 | $ 4,120,472 | $19,381,478 | $ 13,020 | $ 1,680,218 | $21,156,577 |
| | 50 | $16,154,876 | $ 4,361,817 | $20,516,693 | $ 13,020 | $ 1,614,546 | $22,933,708 |
| | 200 | $18,836,486 | $ 5,085,851 | $23,922,337 | $ 13,020 | $ 1,607,166 | $27,675,868 |
| 3B | 100 | $10,446,483 | $ 2,820,550 | $13,267,033 | $ 54,448 | $ 1,589,880 | $16,875,075 |
| | 0 | $ 9,592,386 | $ 2,589,944 | $12,182,330 | $ 49,177 | $ 1,680,218 | $14,461,578 |
| | 50 | $10,019,434 | $ 2,705,247 | $12,724,681 | $ 51,812 | $ 1,614,546 | $15,669,554 |
| | 200 | $11,300,579 | $ 3,051,156 | $14,351,735 | $ 59,718 | $ 1,607,166 | $18,710,439 |
| 3C | 100 | $ 8,762,653 | $ 2,365,916 | $11,128,569 | $ 13,020 | $ 1,589,880 | $14,186,482 |
| | 0 | $ 7,507,506 | $ 2,027,027 | $ 9,534,533 | $ 13,020 | $ 1,680,218 | $11,309,632 |
| | 50 | $ 8,283,284 | $ 2,236,487 | $10,519,771 | $ 13,020 | $ 1,614,546 | $12,936,786 |
| | 200 | $ 9,426,129 | $ 2,545,055 | $11,971,184 | $ 13,020 | $ 1,607,166 | $15,724,715 |

NOTE:
1. The percent of sediment treated refers to the amount of submerged Blackwater Branch and River sediments. The floodplain sediments treated were held constant at 56,170 cubic yards.
2. Long Term O&M includes site monitoring and maintenance of the on-site landfill.
3. Short Term O&M includes the remediation cost requiring one year for all cases.
4. Periodic O&M of a site review (costing $25,000) once every five years is included in the present worth computations.

# FIGURE 4-4

## COST SENSITIVITY TO DREDGED SEDIMENT VOLUMES




| BASE CASE MULTIPLIER | VOLUME OF RIVER SEDIMENT TO BE DREDGED |
|---|---|
| 0.0 | NONE |
| 0.5 | 7,708 cubic yards |
| 1.0 | 15,416 cubic yards |
| 2.0 | 30,832 cubic yards |

NOTE: COSTS INCLUDE REMEDIATION OF SUBMERGED AND EXPOSED FLOODPLAIN SEDIMENT

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE 4-4
SENSITIVITY OF REMEDIATION COSTS TO VOLUME OF SUBMERGED RIVER SEDIMENT

EBASCO SERVICES INCORPORATED

RI/FS/EN/S

As required by Federal and State location-specific ARARs, any remediation activity (e.g., dredging, excavation), performed in wetlands, floodplains, or coastal areas would be performed to mitigate adverse impacts on sensitive areas. Excavation or dredging of contaminated soil/sediment, which by itself fulfills the goals of these regulations, would be limited to the extent necessary to achieve the cleanup objectives. The contractor would avoid wetlands and floodplains during the implementation of all other remedial actions to prevent degradation of these areas. Other examples of control measures that would be taken include erosion control, flow restoration and treatment of discharges.

The U.S. Fish and Wildlife Coordination Act requires that any appropriate agency exercising jurisdiction over a wildlife resource, and the U.S. Fish and Wildlife Service, be consulted before undertaking any action that modifies a body of water. Any number of agencies may exercise jurisdiction over specific wildlife resources, therefore the specific resources must be identified and then the appropriate agency can be identified. Special attention must be given to the impact on wetlands and floodplains (river shores) in accordance with Executive Orders 11990 and 11888. The National Endangered Species Act requires that special attention be given to the impact on areas where endangered species reside.

The dredged and excavated sediments would be chemically fixated on-site. The requirements for the treatment activities are that the facilities would be constructed, operated and maintained according to RCRA facility standards, and OSHA Industry Standards and Regulations concerning hazardous wastes. RCRA 40 CFR 264 is applicable for these activities. RCRA 40 CFR 261.2 (c)(1) and (d)(1) govern the degree of treatment applicable in regulating particulate air emissions from handling and transporting the fixated materials for off-site disposal. Dust suppression measures would be provided for any potential fugitive dust pollution.

The New Jersey Solid Waste Regulation (NJAC 7:26), particularly Subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfills (May 5, 1986) would be considered for managing treated nonhazardous wastes for off-site landfilling. This regulation would give guidance on classifying materials as ID 27 wastes.

The liquid waste stream would be treated and discharged in compliance with the effluent requirements of the National Pollutant Discharge Elimination System (NPDES) and New Jersey State NJPDES permit (NJAC 7:14A.2), as well as the New Jersey Surface Water Quality Standards.

The treated sediments would be transported off-site according to Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7).

As discussed in Subsection 3.1.1.2.2, it is assumed that the material can meet substantial delisting requirements to be delisted and no longer subject to RCRA LDRs.

Since arsenic-contaminated sediments would remain in the river areas, CERCLA as amended would require the site to be reviewed every five years to determine the effectiveness of the alternative, or to identify new technologies that could be applied to any problems at the site.

At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be conducted according to the National Historic Preservation Act.

Based on the above analyses, this alternative is expected to comply with all ARARs and TBCs.

- <u>Overall Protection of Human Health and the Environment</u>: This alternative involves removal and treatment of the contaminated sediments. Removal of the source would provide permanent protection to the public health, and fixation of the contaminants would prevent the further release of contamination to the environment. This assumes that the source of contaminated groundwater (from the ViChem site) entering the river is eliminated. Furthermore, the treated sediments would be contained in an off-site nonhazardous landfill in order to minimize further exposure of the environment to the contaminants.

The removal and treatment of the contaminated sediments that contain arsenic compounds exceeding the cleanup criterion would reduce the existing cancer risk level from the sediment exposure pathways to $1x10^{-5}$ for the floodplain and the less accessible river sediments, using the most plausible sediment exposure pathway models. The cancer risk level in the more accessible areas of the river would be reduced to $2x10^{-6}$. The remaining arsenic-contaminated sediments in the river areas should not pose an appreciable public health threat.

The chemical fixation processes produce a solidified and stabilized matrix, which result in a product that would be nonhazardous and subsequently meet delisting requirements. Chemical fixation would be a permanent and irreversible remedy for the contaminated sediments. It would completely reduce the mobility of the arsenic compounds in the sediments.



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The off-site disposal of the treated sediments would greatly reduce the toxicity, mobility and volume of contaminants remaining on-site, thus minimizing the adverse impacts to the riverine environment. Generally speaking, only a reduction of the mobility of contaminants would be realized by landfilling the treated sediments. The contaminated groundwater must be eliminated from entering the river to improve the riverine environment overall. Periodic monitoring of sediment redistribution patterns would be necessary to quantify the effects of dynamic and advective forces present within the river areas. The results of such monitoring efforts would afford an assessment of environmental impacts to the river areas.

- State Acceptance: No specific comments to the fixation process were received. The general comment concerning sediment modeling prior to a remedial action is appropriate here. Also, additional sediment sampling was performed in the Blackwater Branch to better estimate quantities for removal. A cost sensitivity analysis varying the quantity of submerged sediments was done to better define possible costs with different sediment volumes. This alternative also presents a detailed discussion of RCRA LDR's, which were a major state concern.

- Community Acceptance: No public comments have been received to date.

### 4.2.3 Alternative 2B - Dredging/Excavation/Thickening/Fixation/On-Site Nonhazardous Landfill

#### 4.2.3.1 Description

The major features of this alternative, depicted in Figure 4-1, include hydraulic dredging of contaminated sediment, excavation of contaminated exposed floodplain sediment, chemical fixation of contaminated sediment, supernatant treatment and discharge, and on-site nonhazardous landfilling of the treated sediments. This is a source control (removal and treatment) alternative that is exactly the same as Alternative 2A, except that the fixated sediments would be disposed of in an on-site landfill. The hydraulic dredging, excavation, thickening, chemical fixation, and water treatment systems would be the same as discussed in Alternative 2A.

- Treated Sediment Disposal

  The fixated sediment would be transported by trucks from the curing area to a nonhazardous landfill constructed on-site and disposed of there. The landfill would be situated in the southern section of the ViChem plant

site. The ability to place the landfill on ViChem property has been facilitated by USEPA's definition of the River Areas as being part of the "Superfund Site."

The land area required for the landfill is approximately seven acres. Some of the area would be used for roads and maintenance facilities. The landfill would be constructed in accordance with the New Jersey Solid Waste Regulations (NJAC 7:26) requirements for nonhazardous sanitary landfills. The on-site landfill facility depicted in Figure 4-5 and Figure 4-6 would contain a relatively impermeable base and liner system, a leachate collection system, and a multilayer capping system.

Two feet of clay, with a permeability of less than $10^{-7}$ cm/sec, would be used as the landfill base. A synthetic liner of 60 mil high density polyethylene (HDPE) would be placed over the clay bed. The leachate collection system would consist of a two-foot thick sand layer with a network of six-inch diameter piping consisting of groups of perforated drainage pipe headed and backfilled with a gravel envelope. A layer of geotextile material would be placed on top of the sand to provide structural support while allowing filtration of leachate. Design considerations would include a base liner slope of two percent and pipe grades of 0.005 feet at a spacing of 100 feet. The leachate would be collected in a sump and trucked to the nearby industrial treatment plant for disposal.

The treated sediments would be deposited, graded, and compacted. After the completion of waste deposition, a three-layer capping system would be installed. The capping system would consist of a bottom clay layer, an intermediate drainage and geotextile layer and a vegetative cover layer. The two-foot clay layer would be placed directly on the site surface and would have a permeability of $10^{-7}$ cm/sec or less. A one-foot sand layer would be installed as a drainage layer and would have a permeability greater than $1 \times 10^{-3}$ cm/sec. Two feet of seeded topsoil would be placed on top of the sand layer to prevent erosion. As indicated in Alternative 2A, the total fixated sediment volume to be disposed of would be approximately 101,013 cubic yards.

A long-term, 30-year post closure groundwater monitoring program would be required to detect any leaching of contaminants from the fixated sediments. The groundwater monitoring system would include at least four monitoring wells. One well would be located upgradient and three wells would be situated downgradient of the landfill.

## FIGURE 4-5
# SCHEMATIC OF ON-SITE NON-HAZARDOUS LANDFILL

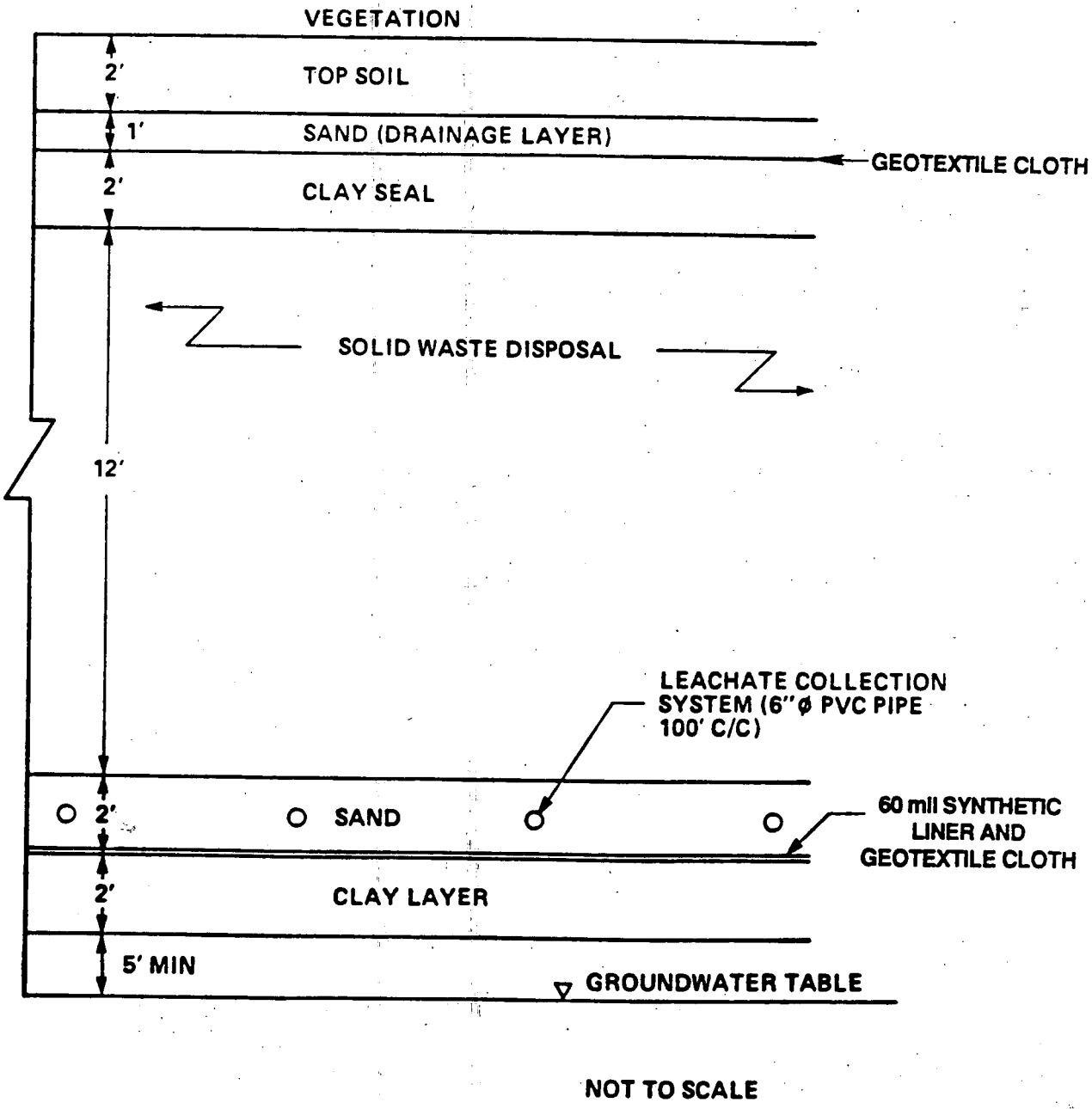
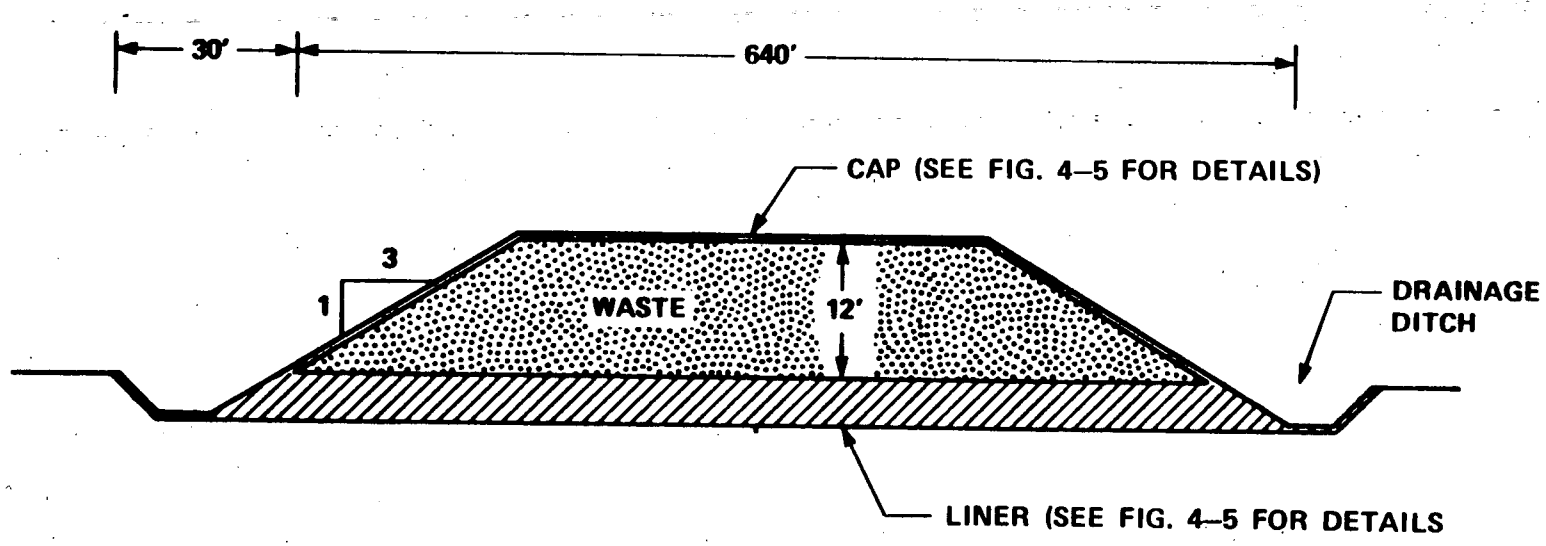


FIGURE 4-6

# ON-SITE NON-HAZARDOUS LANDFILL LONGITUDIONAL CROSS SECTION




NOT TO SCALE

The major facilities and construction components for the on-site landfill are summarized in Table A-3 of Appendix A.

4.2.3.2 Assessment

- Short-Term Effectiveness: The short-term effectiveness of hydraulic dredging, excavation and on-site chemical fixation would be identical to that presented for Alternative 2A described in Subsection 4.2.2.2. This alternative differs from Alternative 2A in that the fixated sediments would be disposed of in an on-site nonhazardous landfill facility. During construction of the landfill, workers would be properly protected against dermal contact and dust inhalation that would be generated during remedial action activities. The landfill activities would require local transportation and disposal, therefore adverse impacts on the environment resulting from traffic would be small. The nonhazardous landfill would be located at the ViChem Plant site. The construction of the facility would have minimal impacts on public health and the environment.

  It is estimated that this remedial alternative would take three years to complete. The short-term effects from implementation of this alternative would be minimized by appropriate control and protection measures.

- Long-Term Effectiveness: As with Alternative 2A, arsenic-laden sediment dispersion in the river areas as well as the potential for direct exposure of human beings and aquatic life to contaminated sediments containing health risks would be substantially reduced. The removal and treatment of contaminated sediments would reduce the baseline human health risks associated with ingestion of the sediments. Alternative 2B differs from Alternative 2A in that it utilizes a nonhazardous landfill constructed on-site for the disposal of fixated sediments. The main benefits associated with this alternative would be the elimination of lengthy and excessive transportation to the off-site landfill facility and the associated costs.

  As discussed in Subsection 3.1.1.2.2, the fixated sediments would be expected to meet delisting requirements and would be considered nonhazardous. Such materials, even if disposed of in an unlined and uncapped landfill, would pose a very low threat of groundwater contamination.

  The landfill design would consist of a relatively impermeable base, a synthetic liner, a cap, a runoff collection and drainage system. It would be designed to meet the New Jersey Sanitary landfill requirements. This design would assure that virtually no leachate would

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penetrate into the groundwater. The combination of chemically fixating and landfilling the sediments would provide double protection against contaminant migration.

The proposed landfill site on ViChem plant site property would not be located in a sensitive area. On-site landfilling of fixated sediments would pose little risk to groundwater and surface water quality. This would be due to the low mobility of arsenic in the fixated sediments, the effectiveness of the designed landfill facility, and the location of the proposed landfill site in an environmentally nonsensitive area. Institutional controls would be required to ensure that the landfill area would not be disturbed in the future. A long-term management plan would be implemented to monitor the effectiveness of the landfill.

- Reduction of Toxicity, Mobility, or Volume: Alternative 2B entails dredging, excavation and chemical fixation, which would result in the same significant reduction in the mobility of arsenic as discussed in Alternative 2A. Removing contaminated sediments would reduce the volume of contaminants in the river areas, and thus reduce future suspension and transport of contaminants into the river water and to Union Lake. Chemical fixation processes do not detoxify directly, but do serve to contain contaminants in a matrix. The fixation process would increase the mass and volume of the material after treatment is complete.

  An on-site landfill would provide the same reduction in mobility that an off-site landfill would. On-site landfilling would differ from off-site landfilling in that it would not completely remove the potential source of contamination from the site. The future use of the landfilled areas would be limited to minimize disturbances to the waste cells.

- Implementability

  Technical Feasibility: As discussed in Alternative 2A, soil fixation is a well-established process, particularly for inorganic contaminants. It is very reliable as proven through bench-scale testing. The fixated product would be an impermeable nonhazardous mass with structural stability that could withstand wet-dry and freeze-thaw weather conditions. Under this alternative, the landfill would effectively contain the wastes, as long as it is properly constructed and regularly maintained.

  The primary limiting factor regarding the implementation of this alternative would be the delisting of the treated sediment. Treatability results and discussions with the

fixation vendor have indicated that treating sediments to obtain EP Toxicity leachate arsenic concentrations below 0.32 mg/l would be technically feasible. Upon meeting this goal, the treated sediments would meet the substantive delisting requirements of USEPA Region II.

The availability of land at the ViChem plant site would not be expected to be an issue. The construction of a nonhazardous landfill would not be complex, but would require a substantial on-site construction effort with conventional heavy equipment. It would not pose a constructibility or technology problem.

The time to complete remediation would be approximately three years. Contractors and equipment would be readily available. The time required to construct the landfill would be approximately six months. The major drawback would be the uncertain lifespan of the synthetic liner, which would be very difficult to replace.

Administrative Feasibility: Since the landfill would be located on-site, a delisting petition to the NJDEP would not be necessary. Rather, according to USEPA SPGB personnel, the Regional Administrator in USEPA's Region II could authorize nonhazardous disposal provided the delisting requirements are met. Following the delisting process, the NJDEP would make the determination of whether or not the material is ID 27 waste to allow for landfilling of the material. On-site landfilling of fixated sediments would require appreciable administrative efforts to coordinate with state and local agencies to negotiate and secure an agreement on land acquisition. The ViChem plant site is in a partly residential area, therefore there may be considerable administrative effort to obtain local public approval for siting a landfill there. Implementability of an onsite nonhazardous landfill would entail efforts to ensure proper design and construction. Long-term administrative management would be necessary to monitor the landfill and the underlying groundwater source, as well as to perform five-year reviews. To ensure adequate containment of waste, long-term maintenance would also be required.

- Cost: The capital cost for this alternative, outlined in Table B-3, is estimated at $11,030,000. Annual short-term operation and maintenance costs and long-term operation and maintenance costs, outlined in Table B-9, are estimated at $17,793,000 and $80,000, respectively. The present worth cost, based on a 5% discount rate after inflation is valued at $43,666,000, and represents all of the activities to dredge, excavate, thicken, fixate, haul, and landfill sediments; construct a landfill and perform all operation

and maintenance functions on the treatment system components and the landfill; perform periodic sampling of the Blackwater Branch and the Maurice River; and perform the six required five-year reviews.

A cost sensitivity analysis, outlined in Table 4-3 and graphically depicted in Figure 4-4, was performed for this alternative by varying the volume of submerged river sediments to be remediated and calculating the present worth. The volume of floodplain sediments was held constant due to the extensive field data obtained in this area. Sensitivity to sediment volumes was analyzed for 0%, 50%, 100%, and 200% of the present submerged sediment volume estimates. These parameters were chosen because of the inherent dynamics associated with the river system and their capacity to distribute sediments over time. Present worth costs ranged from $38,079,000 to $48,986,000 for the 0% and 200% sediment volume cases, respectively. These costs represented a range of -11% to +12% over the estimated present worth of the alternative.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth of the alternative, assuming no disposal costs or operation and maintenance costs associated with disposal, is $37,423,000.

In the event that treated soils cannot be delisted, on-site RCRA landfilling would be required. The present worth associated with disposing of the treated soils in an on-site RCRA landfill is estimated at $44,360,000.

- Compliance with ARARs: The same action-specific ARARs and key regulations that apply to the hydraulic dredging, excavation, chemical fixation and supernatant treatment/discharge activities discussed for Alternative 2A are applicable to this alternative. These ARARs and regulations include RCRA and OSHA requirements, as well as New Jersey Surface Water Quality Standards and New Jersey Solid Waste Regulations.

  This alternative also includes on-site nonhazardous landfilling of treated sediment. Chemical fixation of sediments posing human health risks would immobilize arsenic to levels compatible with delisting criteria. Requirements of RCRA LDRs would be waived after the

sediments are treated and delisted. Landfilling of the treated sediments would result if the NJDEP classified them as ID 27 waste.

The New Jersey Solid Waste Regulations (NJAC 7:26) Subchapter 2A - Additional Specific Disposal Regulation for Sanitary Landfill (May 5, 1986) would regulate the design of the on-site nonhazardous landfill facility. These regulatory requirements and standards were established for the design and construction of sanitary landfills to ensure that adverse impacts would be minimized and controlled and that environmental pollution would be prevented.

At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be conducted according to the National Historic Preservation Act.

Based upon this analysis, Alternative 2B is expected to comply with all ARARs and TBCs identified for the alternative.

- Overall Protection of Human Health and the Environment: The evaluation of overall protection of human health and the environment discussed in Alternative 2A is also applicable for this alternative, except in this alternative the treated sediments would be disposed of in an on-site nonhazardous landfill. Chemical fixation of dredged and excavated sediments would prevent the leaching of arsenic contaminants to minimize exposure to human and environmental receptors. As discussed in Alternative 2A, this remedial alternative would reduce the cancer risks from the sediment exposure pathways to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river using the most plausible sediment exposure pathways. The cancer risk level would be reduced to $2x10^{-6}$ in the more accessible areas of the river. Contaminated sediment would remain on-site where it could naturally reconcentrate to levels that could pose risks to human health.

The on-site nonhazardous landfill facility would be constructed at the ViChem plant site in an area that does not contain a sensitive ecosystem. The fixated sediments would be considered "nonhazardous" such that their disposal in an on-site landfill facility would pose very little risk to groundwater and surface water quality. This would be due to the low mobility of arsenic in the fixated sediments, the effectiveness of the landfill facility and the location of the proposed landfill site in a low sensitivity environment. Therefore, disposing treated sediments in an on-site landfill would provide significant and permanent protection to the public health and the environment.

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- State Acceptance: State comments were not directed at the actual fixation treatment process. Concern was given towards surface water quality and sediment transport modeling, which would be performed during final design. Additional sampling of the Blackwater Branch was performed as discussed in Alternative 2A. A modification of the key parameter of the sensitivity analysis was done to better grasp the effects of a dynamic river system on costs. This alternative also considers the RCRA LDRs.

- Community Acceptance: No public comments have been received to date.

### 4.2.4 Alternative 3A - Dredging/Excavation/Extraction/Sediments to Off-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

#### 4.2.4.1 Description

The major features of this alternative include hydraulic dredging of contaminated submerged sediment, excavation of contaminated exposed sediments from the floodplain area, sediment water extraction treatment and disposal, water treatment and discharge, and hazardous sludge disposal. A two-stage water extraction process and associated wastewater treatment system would be utilized to remove the arsenic from the sediments. A schematic diagram is shown in Figure 4-7. This is a source control (removal and treatment) alternative in which the contaminated sediments would be removed and the arsenic would be extracted from the sediments. The highly contaminated arsenic sludge generated by the extraction process would be treated and disposed of by a vendor at an off-site RCRA hazardous waste facility. The processed sediments would be disposed of in an off-site nonhazardous landfill facility as discussed in Alternative 2A.

- Sediment Water Extraction and Wastewater Treatment

  The in-place sediment is approximately 54% solids by weight. The dredging operation would draw river water into the sediment so that a slurry of approximately 20% solids would be pumped into a mixing vessel (actually 2 mixers in parallel) with a two-hour retention time. A separate feed line of river water, operating on density control, would add water to the mixer so that the maximum solids concentration would not exceed 20%. The slurry would be pumped to a bank of 14 six-inch-diameter hydroclones mounted in parallel. Seven hydroclones would be operating units and seven would be standby units. An underflow of 45% solids would discharge into a second mixer (actually two mixers in parallel); the overflow would go to a supernatant water treatment system. River water would also be pumped into the second set of mixers, under density control, to maintain a slurry of 20% solids. The slurry would then be pumped to



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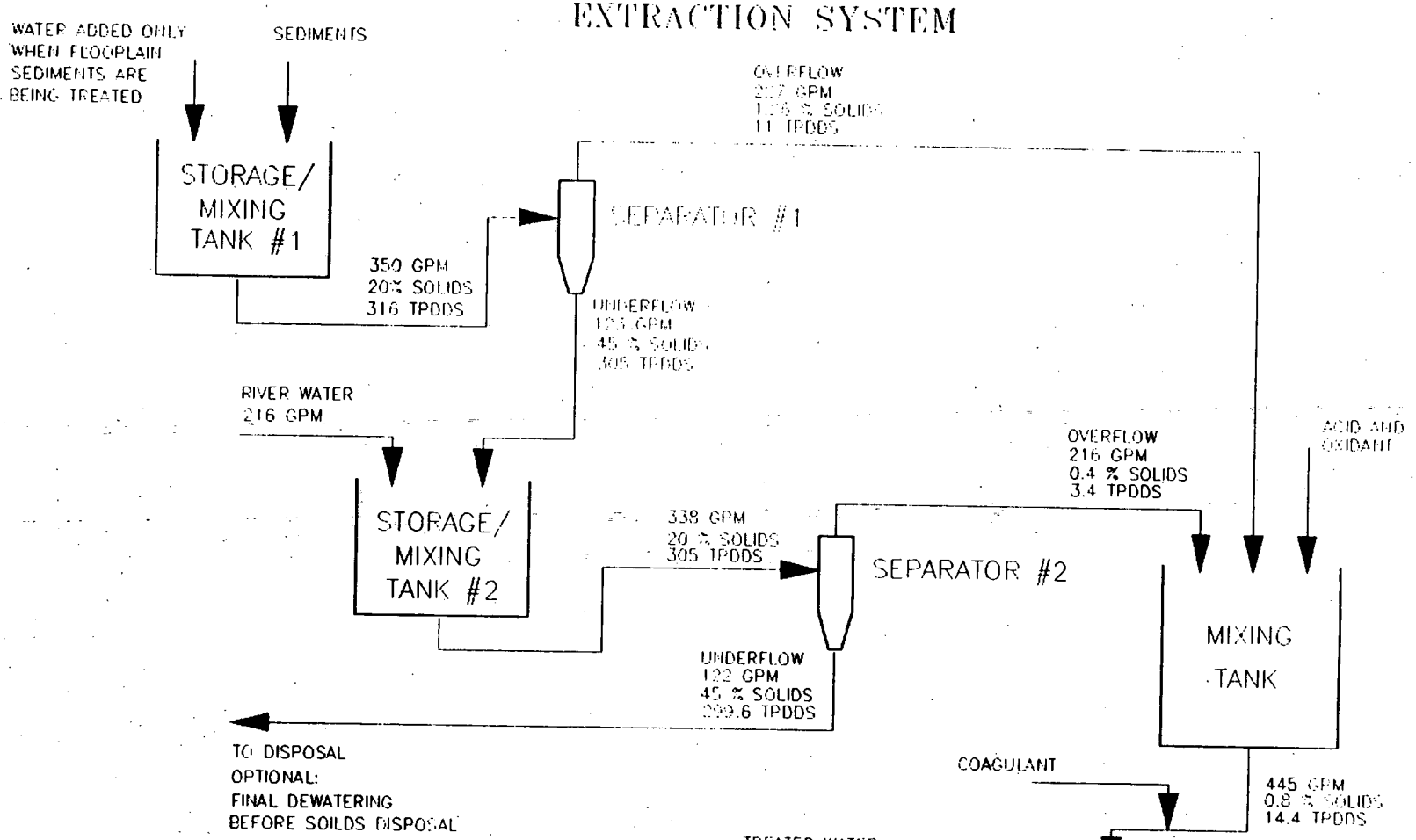
# FIGURE 4-7
# EXTRACTION SYSTEM




COMMENT:

1. SYSTEM OPERATES WITH EITHER THE RIVER AND BLACKWATER BRANCH SEDIMENTS OR THE FLOODPLAIN SEDIMENT.
2. THE FLOW RATES ARE FOR THE DAYTIME (8 HOURS/DAY) OPERATION. FOR 16 HOURS/DAY THE OPERATION IS AT 50 % OF THE FLOW RATES SHOWN.
3. % SOLIDS IS ON A WEIGHT BASIS.
5. THE TONS PER DAY OF DRY SOLIDS (TPDDS) IS COMPUTED FOR 24 HOURS AT THE ACTUAL RATES.

a second bank of 14 hydroclones (seven operating and seven standby). The residual arsenic in the underflow solids would be a maximum of 10% of the original amount of arsenic present in the sediment. The underflow would then go to final dewatering, as described in Alternative 2A. The dewatered sediment would then be disposed of as nonhazardous material.

The overflow from the second bank of hydroclones would go to the same supernatant water treatment system as the overflow from the first bank of hydroclones.

The overflow streams from the hydroclones would be discharged to a reactor tank. Any soluble arsenic would be in the form of $As_2O_3$, which is soluble in water. The $As_2O_3$ would be oxidized with potassium permanganate to $As_2O_5$, which is insoluble in water and would precipitate out of solution. The reaction is:

$$5As_2O_3+4MnO_4^-+12H^+ = 5As_2O_5+4Mn^{++}+6H_2O$$

The reaction requires a low pH of 2.0, therefore hydrochloric acid would be added ahead of the permanganate.

The liquid/solids mixture would flow to a clarifier, where the liquid pH would be raised to 6.5 with the addition of sodium hydroxide (NaOH) or lime ($Ca(OH)_2$). Ferric chloride ($FeCl_3$) would be added to coagulate the arsenate, manganate and manganese dioxide precipitate into larger and denser particles to facilitate settling. A liquid polymer would also be added to aid in the flocculation of the large particles.

The effluent from the clarifier would be discharged back to the river after arsenic concentrations are reduced below the 0.05 mg/l MCL. A portion of the water would be used as a washwater later in the extraction process.

o <u>Off-Site Hazardous Sludge Disposal</u>

Sludge generated from the clarifier would contain settled solids, metallic and organic arsenic, and other residues from the treatment process in a concentrated form. This sludge would be hauled off-site by a licensed vendor to a disposal facility where treatment could incorporate any number of viable technologies (for the purpose of this report, it is assumed that fixation would be used). Landfilling would take place once land disposal standards are obtained from the treatment process (assumed to be a treatability variance of 1 mg/l arsenic in the EP Toxicity extract from the treated sludge).

The major construction components and facilities for this alternative are outlined in Table A-4 of Appendix A.

4.2.4.2 Assessment

- Short-Term Effectiveness: The potential public health threats to area residents during the implementation activities discussed for Alternative 2A (Subsection 4.2.2.2), are also applicable for this alternative. As stated in Alternative 2A, the short-term public health threats resulting from these remedial actions could be minimized by using an appropriate prevention and control plan.

  The potential adverse effects on the river ecosystem and the environment during the implementation of this alternative would be similar to that of Alternative 2A. These effects would be temporary and localized.

  The potential risks to workers would be higher for two-stage water extraction and extractant treatment than for chemical fixation. Extraction would utilize more liquid chemicals, which can spill more easily than solid chemicals. However, adequate preventive measures and proper personnel protection equipment would be provided to workers to prevent direct contact with wastes and chemicals. As stated in Alternative 2A, the short-term risks to workers would be minimal for this alternative.

  The short-term impacts on the environment from this alternative, such as traffic problems and associated noise and air pollution, would be similar to those for Alternative 2A in Subsection 4.2.2.2. An appropriate local traffic control plan would be implemented to minimize these short-term environmental impacts.

  Potential short-term impacts to wetland areas would be similar to those for Alternative 2A. Proper measures would have to be taken to minimize these impacts.

  The time required to complete this remedial action and to achieve protection is approximately two years. Adequate dust suppression measures would be instituted to prevent both workers and the community from inhaling or coming in direct contact with dust generated during the remediation period.

- Long-Term Effectiveness: Extraction methods are designed to remove arsenic compounds from contaminated sediments, thus attaining a reduction in toxicity, mobility and volume of the arsenic-contaminated sediments. Removing the contaminated sediments from the river areas would reduce public health risks and environmental impacts. The processed sediments would contain total arsenic below the more stringent cleanup level of 20 mg/kg for the



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sediments. The treated sediments would not leach arsenic above 0.32 mg/l (VHS model delisting criterion), which would serve as the basis for delisting the sediments. The liquid stream containing the extracted arsenic would be treated to remove arsenic to below the target level of 0.05 mg/l prior to discharge. The extractant sludge is not expected to pass the 0.032 mg/l criterion for delisting, but is expected to pass the 1 mg/l treatability variance criterion, allowing the material to be disposed of at an off-site RCRA treatment and disposal facility.

As with Alternative 2A, the major benefits associated with this alternative would be the removal of arsenic-contaminated sediments from the river areas. As a result of this remedial action, the potential of leachate generation and the migration of the contaminated sediment in river water would be greatly reduced. The cancer risk from the sediment exposure pathways would be reduced to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river using the most plausible sediment exposure pathways. The cancer risk level in the more accessible areas of the river would be reduced to $2x10^{-6}$. Assuming that the arsenic-contaminated groundwater discharge to the river system would be controlled, the quality of the overall river system would improve. The long-term potential for contaminated sediment redistribution and reconcentration would persist after remediation. Periodic sampling would be performed to assess river conditions and measure the potential for additional remedial efforts.

The technology for this alternative would be expected to reduce the level of arsenic contamination in the sediments sufficiently to meet the hazardous waste delisting criteria. The treated sediment would be deposited in a nonhazardous landfill facility and the treated liquid stream would be discharged back to the river with minimal adverse impact to the environment.

- <u>Reduction of Toxicity, Mobility or Volume</u>: This alternative would reduce the toxicity and volume of contaminants in the river areas by removing and treating the arsenic-contaminated sediments. Removing contaminated sediments from the river areas would minimize the mobility of the contaminated sediments in the river water. Reducing the toxicity would be achieved by extracting arsenic from the sediments by a two-stage washing process with water. Results from the bench-scale treatability studies (see River Areas RI, Section 7.0) indicated that a single stage extraction with water would drastically reduce the sediment arsenic concentration to 34 mg/kg. It is assumed that a two-stage wash, which was used in this FS, would further

reduce the arsenic concentration to below 20 mg/kg. It is assumed that the washed sediments would pass the EP Toxicity leaching criterion of 0.32 mg/l. Subsequent chemical oxidation and physicochemical precipitation would reduce the toxicity of the arsenic and would remove it from the liquid stream. The combination of both sediment and wastewater treatment would greatly reduce the toxicity and volume of the contaminant. Disposing the treated sediments in an off-site landfill and disposing the sludge containing the arsenic in a RCRA treatment and disposal facility would further reduce the mobility of the contaminants, and would reduce the volume of contaminants remaining on-site.

- Implementability

Technical Feasibility: As stated in Alternative 2A, (Subsection 4.2.2.2) hydraulic dredging, excavation, water treatment and disposal of treated sediments in an off-site landfill facility are all well-developed technologies that are commercially available. Equipment necessary for implementing these technologies is readily available. These technologies are highly feasible, reliable and are expected to be available for the site.

The water extraction process would be a reliable technology that would meet the designated process efficiencies and performance goals. It would be unlikely that any unusual technical difficulties would arise. Labor and materials would be readily available for all components of this alternative. The relatively complex components of this alternative would be sediment and water treatment, which are proven technologies. The other components would be comparatively simple. There would be no major treatment difficulties expected during the implementation of this alternative based on the following considerations:

- Mud Cat dredges have been successfully used in various shallow water hydraulic dredging operations. Resuspension of sediments in river environments can be minimized by increasing the water content of the influent stream.

- Water extraction is a conventional industrial process. Treatability studies indicated that water could extract arsenic from sediments to obtain health risk-based cleanup levels.

- EP Toxicity results for arsenic in untreated sediment samples yielded results below 0.32 mg/l, the substantive delisting requirement.

- Chemical oxidation and coagulation/flocculation/precipitation with $FeCl_3$, are traditional wastewater treatment technologies that have applications in removing arsenic and organics.

More than one vendor or manufacturer would be capable of providing a competitive bid for each component of this alternative. It is estimated that approximately three years would be required to implement this alternative. The time to achieve beneficial results would follow the dredging and excavation of the river sediments, and the implementation of a successful groundwater management of migration program at the ViChem facility.

Administrative Feasibility: The treated overflow from the separators and the treated extractant waste streams would be returned to the Maurice River or the Blackwater Branch. A discharge permit would not be required since this would represent an on-site Superfund discharge. However, a demonstration that these discharges would be in compliance with ARARs would be required for State and local approvals. Since the supernatant would be treated to meet New Jersey Surface Water Quality Standards and NJPDES requirements, State and local approvals should not pose a problem. The treated liquid waste stream would contain total arsenic below the State's discharge limit (i.e., 0.05 mg/l).

In order to operate and maintain this treatment system, an operation and maintenance program would be required. Institutional administration would be required to secure a nearby nonhazardous landfill site for the disposal of the extracted sediments. Since the treated sediment is expected to be delisted by the NJDEP as nonhazardous, it can be disposed of at a nonhazardous landfill after an ID 27 waste classification is given by the NJDEP. Delisting would require a petition and may require considerable time and effort to accomplish. Arranging for the transport and disposal of wastewater sludges within a RCRA treatment/disposal facility would require administrative effort. The growing number of licensed multiservice waste handling vendors should aid in the manageability of this remediation aspect. Periodic site monitoring and five-year reviews would demand long-term administrative attention. In addition, coordination with local traffic authorities would be required to control the additional traffic involved with transporting the treated sediments to the nonhazardous landfill. An appropriate local traffic control plan and air pollution control measures such as dust suppression would be implemented.

- Cost: The capital cost for this alternative, outlined in Table B-4, is estimated at $21,652,000. Annual short-term operation and maintenance costs, outlined in Table B-10, are estimated at $1,590,000 and $13,000, respectively. The present worth cost, based on 5% discount rate after inflation is valued at $24,710,000, and represents all of the activities to dredge, excavate, extract with water, dewater, haul, and landfill nonhazardous sediments and hazardous treatment sludges; perform all operation and maintenance functions on the treatment system components; perform periodic sampling of the Blackwater Branch and the Maurice River; and perform the six required five-year reviews.

  A cost sensitivity analysis, outlined in Table 4-3 and graphically depicted in Figure 4-4, was performed for this alternative by varying the volume of submerged river sediments to be remediated and calculating the present worth. The volume of floodplain sediments was held constant due to the extensive field data obtained in this area. Sensitivity to sediment volumes was analyzed for 0%, 50%, 100%, and 200% of the present submerged sediment volume estimates. These parameters were chosen because of the inherent dynamics associated with the river system and their capacity to distribute sediments over time. Present worth costs ranged from $21,157,000 to $27,676,000 for the 0% and 200% sediment volume cases, respectively. These costs represented a range of -14% to +12% over the estimated present worth of the alternative.

  The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth of the alternative, assuming no disposal costs or operation and maintenance costs associated with disposal, is $13,060,000.

  In the event that treated soils cannot be delisted, off-site RCRA landfilling would be required. The present worth associated with disposing the treated soils in an off-site RCRA landfill is estimated at $39,854,000.

- Compliance with ARARs: The discussion on the compliance with ARARs in Alternative 2A in Subsection 4.2.2.2 is applicable for this alternative as well. The only items in Alternative 3A that differ from Alternative 2A are the additional effluent discharge to the Maurice River

generated from the water treatment system and the arsenic-contaminated sludge generated from the process. The evaluation of Alternative 3A with respect to compliance with ARARs is summarized as follows:

- Appropriate preventive measures would be provided to minimize resuspension and erosion during hydraulic dredging in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10.

- Hydraulic dredging and excavation would avoid the wetland areas where possible, and wetland restoration would be implemented for the disturbed areas in order to comply with Sections 401 and 404 of the CWA identified in Alternative 2A.

- The extraction processes would be performed in order to convert the contaminated sediments into nonhazardous wastes in accordance with RCRA 40 CFR 261.2 requirements.

- The installation and operation of the two-stage extraction system, including the water treatment system, would comply with RCRA 40 CFR 264 Standards for Owners and Operators of Hazardous Waste Treatment Facilities.

- The liquid waste stream would be treated in compliance with the effluent requirements of Federal Clean Water Act Quality Criteria, New Jersey Surface Water Quality Standards, and Clean Water Act NJPDES Discharge to Surface Water Requirements.

- The Clean Air Act and National Air Quality Standards would be complied with for particulate air emissions resulting from the handling and transporting of the extracted materials to an off-site disposal facility.

- Disposal of delisted treated sediments at a nonhazardous landfill facility and treatment/disposal of the arsenic-contaminated sludge at RCRA facility would comply with RCRA LDRs.

- DOT Rules for Transportation of Hazardous Materials (40 CFR Parts 107, 171-1-171.500) would be complied with for transport of the arsenic-contaminated sludge to a RCRA treatment and disposal facility.

- Federal and New Jersey Transportation Requirements for Hazardous and Nonhazardous Waste (40 CFR 263 and NJAC 7:26-3 and 7) would be complied with for the transport of the treated sediments to a nonhazardous landfill.

- New Jersey Solid Waste Regulations (NJAC 7:26) would be used to verify that existing sanitary landfill facilities could dispose of the treated sediment.

- At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be performed in accordance with the National Historic Preservation Act.

Based upon the above analyses and assumptions, Alternative 3A is expected to meet all applicable ARARs and TBCs.

- Overall Protection of Human Health and the Environment: This alternative would have the same overall protection of human health and the environment as discussed in Alternative 2A. Removal of the contaminated sediments would achieve a reduction in the risks to public health in the river environment. Extraction would remove arsenic compounds from the contaminated sediments and would result in a reduction of the toxicity of the sediments and the volume of contaminants in the sediments. Off-site disposal of the treated sediments and off-site treatment and disposal of the sludge containing the arsenic would further reduce the volume of contaminants remaining on-site.

  As with Alternative 2A, this removal and treatment alternative would reduce the existing cancer risk level to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river. The cancer risk level in the more accessible areas of the river would be reduced to $2x10^{-6}$. After implementing this alternative, and after implementing a successful management of migration alternative for the groundwater at the ViChem facility, the public health risks from the river areas would be greatly reduced. Any remaining contaminated sediments in the river areas would not pose an appreciable human health threat; long-term monitoring would be implemented to identify sediment redistribution patterns that could pose significant health threats.

- State Acceptance: State comments were received concerning biological treatment in the extractant treatment system. A biological treatment step had been included previously since sodium citrate had been planned as the extracting agent. Since the current system calls for a two-stage

water wash and no sodium citrate has been added, biological treatment has been eliminated from the extractant treatment system. The previous comments concerning sediment modeling and additional sediment sampling are applicable here as well. This alternative also incorporates RCRA LDR concerns.

- o Community Acceptance: No public comments have been received to date.

### 4.2.5 Alternative 3B: Dredging/Excavation/Extraction/On-Site Nonhazardous Landfill/Off-Site Hazardous Sludge Disposal

#### 4.2.5.1 Description

The major features of this alternative, depicted in Figure 4-7, include hydraulic dredging of contaminated submerged sediments; excavation of contaminated exposed sediments from the Blackwater Branch floodplain; two-stage water extraction of the dewatered and excavated sediments; wastewater treatment and on-site nonhazardous landfilling of the treated sediments; and off-site hazardous disposal of treatment sludges. This is a source control (removal and treatment) alternative and is exactly the same as Alternative 3A, except that the treated sediments would be disposed of on-site. The on-site nonhazardous landfill for this alternative is similar to that of Alternative 2B except the landfill area would be slightly smaller. It is estimated that approximately five acres of land would be needed for the landfill and access roads. Approximately 61,300 cy yd would be disposed of in the on-site landfill. A long-term monitoring program would be required.

The major construction components and facilities for this alternative are outlined in Table A-5 of Appendix A.

#### 4.2.5.2 Assessment

- o Short-Term Effectiveness: Short-term effectiveness for Alternative 3B is the same as Alternative 3A (Subsection 4.2.4.1) except that in this alternative the extracted sediments would be disposed of in an on-site nonhazardous landfill facility. On-site workers would potentially be exposed to contaminants by dermal contact and by dust inhalation during hydraulic dredging, excavation, water extraction, and sediment and sludge transfer to the disposal facilities. To minimize or prevent such exposure, dust control measures and personnel protection equipment would be used. The treated sediment would be transported via truck over a short distance to the on-site landfill at the ViChem site. The adverse impacts on the environment during the remedial alternative would be temporary and could be minimized. The time required to complete this remedial action and to achieve protection is approximately three years.



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- Long-Term Effectiveness: Alternative 3B has the same long-term beneficial effectiveness as Alternative 3A. There are expected to be minimal adverse environmental impacts resulting from installing an on-site nonhazardous landfill at the ViChem site.

  An on-site nonhazardous landfill would require long-term administrative management, including facility maintenance and groundwater monitoring. A secondary waste management program would be required to handle the potential leachate from the remaining arsenic compounds in the treated wastes.

  As discussed in Alternative 3A, this alternative would provide protection to the public health and the environment. It would reduce the cancer risk level via the sediment exposure pathways to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river. The cancer risk level in the more accessible areas of the river would be reduced to $2x10^{-6}$. Long-term monitoring would be implemented to measure the effectiveness of this alternative in terms of arsenic-contaminated sediment distribution patterns.

- Reduction of Toxicity, Mobility or Volume: The removal and treatment of the contaminated sediments would reduce the existing arsenic loads from the river areas and would also minimize the potential migration of arsenic contaminants from sediments to surface water and then to Union Lake. The two-stage water extraction process would extract arsenic from the contaminated sediments to below the target levels. Alternative 3B would result in a reduction in toxicity and volume of arsenic in the contaminated sediments. The mobility of the remaining arsenic in the treated sediments would be reduced because the sediments would be contained in the landfill. Alternative 3B would yield the same results as Alternative 3A except the nonhazardous landfill would be located on-site.

- Implementability

  Technical Feasibility: The technical feasibility of hydraulic dredging, excavation, two-stage extraction, and wastewater treatment presented in Alternative 3A is identical to that of Alternative 3B. These technologies are considered highly feasible, reliable and are expected to be available. The implementation of this remedial alternative requires approximately three years for construction, operation and maintenance. There are no major treatment difficulties expected during the implementation of this alternative.

The construction of a nonhazardous landfill facility is a simple task, which utilizes normal construction equipment. The only technical difficulty for the landfill facility maintenance would be the repair of the bottom synthetic liners. However, a well-maintained capping system would minimize rainfall infiltration. This would prolong the useful lifetime of the synthetic membranes.

The disposal of treatment sludges would be facilitated by a licensed vendor with treatment and landfill facilities.

Administrative Feasibility: As with Alternative 2B, an on-site landfill would require more administrative efforts than an off-site landfill. An on-site landfill would require the following institutional involvement:

- Coordination with State and local governments and the owner of the ViChem property to negotiate and secure an agreement on land acquisition;

- Review, supervision and management to ensure proper design and construction of an on-site landfill facility; and

- A long-term administrative management program for landfill maintenance, leachate collection and disposal, and groundwater monitoring.

Additional administrative efforts would be required of the USEPA Region II Regional Administrator to decide that nonhazardous disposal of the extracted sediments is acceptable. However, it would not be necessary to file a delisting petition to the NJDEP, which would ease administrative efforts somewhat. Classification of the treated sediments as ID 27 waste would have to be made by NJDEP. Five-year reviews of the landfill and annual reviews of the river areas would be required. These institutional requirements are considered to be feasible.

- Cost: The capital cost for this alternative, outlined in Table B-5, is estimated at $13,267,000. Annual short-term operation and maintenance costs and long-term operation and maintenance costs outlined in Table B-11, are estimated at $1,590,000 and $54,000, respectively. The present worth cost, based on a 5% discount rate after inflation and valued at $16,875,000, represents all of the activities to dredge, excavate, thicken, extract with water, haul, and landfill nonhazardous sediments and hazardous treatment sludges; construct a nonhazardous landfill

and perform all operation and maintenance functions on the treatment system components and the landfill; perform periodic sampling of the Blackwater Branch and the Maurice River; and perform the six required five-year reviews.

A cost sensitivity analysis, outlined in Table 4-3 and graphically depicted in Figure 4-4, was performed for this alternative by varying the volume of submerged river sediments to be remediated and calculating the present worth. The volume of floodplain sediments was held constant due to the extensive field data obtained in this area. Sensitivity to submerged sediment volumes was analyzed for 0%, 50%, 100%, and 200% of the present volume estimates. These parameters were chosen because of the inherent dynamics associated with the river system and their capacity to distribute sediments over time. Present worth costs ranged from $14,462,000 to $18,710,000 for the 0% and 200% sediment volume cases, respectively. These costs represented a range of -14% to +11% over the estimated present worth of the alternative.

The disposal option for this alternative assumes that the treated sediments are classified by the NJDEP as ID 27 wastes. In the event that they are not classified as such and can be put to beneficial and marketable use, local vendors could haul the materials off-site and distribute them to their customers. This situation could be viewed as a cost savings to this alternative, since it would eliminate virtually all disposal costs. The present worth of the alternative, assuming no disposal costs or operation and maintenance costs associated with disposal, is $12,888,000.

In the event that treated soils cannot be delisted, on-site RCRA landfilling would be required. The present worth associated with disposing of the treated soils in an on-site RCRA landfill is estimated at $17,382,000.

- Compliance with ARARs: Alternative 3B would comply with the ARARs discussed in Alternative 3A. In addition, the New Jersey Solid Waste Regulations (NJAC 7:26) Chapter 2A - Additional Specific Disposal Regulation for Sanitary Landfill, would be used as the basis for the design, operation, closure, and monitoring plans of the on-site nonhazardous landfill.

  At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be performed in accordance with the National Historic Preservation Act.

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Based on this analysis, Alternative 3B is expected to comply with all ARARs identified.

- Overall Protection of Human Health and the Environment: Alternative 3B would provide the same overall protection for human health and the environment as evaluated in Alternative 3A. The beneficial impacts would include reducing the sediment-related cancer risk level in the river areas. In addition, the implementation of this alternative may improve the river ecosystem by minimizing the potential exposure pathways of the arsenic contaminants to the fish and wildlife in the river. The removal of contamination sources (i.e., sediment and contaminated groundwater entering the river areas) would provide protection to public health and the environment.

  As with Alternative 2B, this alternative would dispose of the treated sediments in a nonhazardous landfill facility built on the plant site. The landfill components, such as the capping system and the lining system, would further protect human health and the environment by minimizing leachate generation and fugitive dust dispersion. Even if such materials were disposed of in unlined and uncapped landfills, the threat of groundwater and surface water contamination would be considered relatively low. This alternative would provide adequate protection to public health and the environment and it would greatly reduce the existing toxicity, mobility and volume of arsenic contaminants in the river sediments.

- State Acceptance: The same comments mentioned previously concerning biological treatment, additional sampling, and a consideration of RCRA LDR's are applicable here as well.

- Community Acceptance: No public comments have been received to date.

### 4.2.6 Alternative 3C - Dredging/Excavation/Extraction/Floodplain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/Off-Site Hazardous Sludge Disposal

#### 4.2.6.1 Description

The major features of this alternative, depicted in Figure 4-7, include hydraulic dredging of submerged contaminated river and Blackwater Branch sediments, excavation of exposed contaminated floodplain sediments, two-stage water extraction of the sediments, wastewater treatment with discharge to the Maurice River, uniform deposition of the treated floodplain sediments in the Blackwater Branch floodplain, plant site deposition of the treated river sediments, and off-site hazardous disposal of treatment sludges. This is a source control (removal and

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treatment) alternative and is similar to Alternatives 3A and 3B except that the treated floodplain sediments would be redeposited in the Blackwater Branch floodplain and the treated river sediments would be deposited on the site.

o Floodplain Redeposition

The treated floodplain sediments would be transported by trucks to the Blackwater Branch floodplain. Approximately 52,800 cubic yards of treated sediment would be redeposited on the floodplain. The sediments would be redeposited in areas scarred by remedial excavation activities. The former grade would be reconstructed. Bulldozers and graders would compact and grade the sediment to simulate the original topography.

o Site Deposition

The treated river sediments would be transported by trucks to the ViChem Plant site and deposited in the undeveloped areas of the site (approximately 25 acres). Approximately 8,325 cubic yards of treated sediment would be deposited on the site. Bulldozers, compactors and graders would work conjunctively to cut and fill the deposition areas to establish new topography. This topography would be designed to maintain the present runoff on and off the site. Temporary construction controls such as silt fences, haybails, and runoff diversion ditches would be established to protect the site and any adjacent properties. When deposition is complete, clean fill and/or seeded topsoil would be used to protectively cover the areas from natural eroding forces.

The major construction components and facilities for this alternative are outlined in Table A-6 of Appendix A.

4.2.6.2 Assessment

o Short-Term Effectiveness: The short-term effectiveness of Alternative 3C is very similar to that already presented for Alternative 3B. The fundamental difference between the two is that Alternative 3C entails the deposition of treated floodplain sediments and river sediments in a less-controlled environment (i.e., the floodplain and the site) than Alternative 3B, which calls for the construction of an on-site nonhazardous landfill. Thus short-term concerns over dust generation, protection to workers and the public, and increased traffic would all be handled accordingly, as prescribed in Alternative 3B. Furthermore, additional controls would be implemented to disturb as little of the floodplain environment as possible. Measures that would be taken would be the increased use of silt curtains, temporary relocation of natural fauna and wild life, and additional fencing and security measures, which

would prevent any disturbances that might impede the restoration of the original environment. Depositing the material on-site would have no different short-term effectiveness concerns than depositing the material in an on-site nonhazardous landfill. The time to complete remediation would be approximately three years.

- Long-Term Effectiveness: Alternative 3C has essentially the same long-term effectiveness concerns as Alternative 3B; additional concerns would arise over the deposition of the treated sediments in a natural, less-controlled environment than a manmade landfill. The fundamental premise that would enable the implementation of this alternative to allow for floodplain redeposition and site deposition would be the determination by the USEPA's Region II Regional Administrator that the cleaned sands can be delisted, and the determination by the NJDEP that the treated sediments do not exhibit the characteristics of and would not be classified as ID 27 wastes. Thus long-term adverse impacts to humans and the environment from the treated materials would have been considered to be minimal prior to the implementation of this alternative. Regardless of the confidence given to the treated sediments, a long-term monitoring program would be implemented to measure the effectiveness of the remediation, with particular attention given to evaluating groundwater and river water for the appearance of leachate from the sediments.

To be redeposited in the floodplain or disposed on site, the extraction process must reduce the sediment arsenic concentration to below 20 mg/kg, the action level in the floodplain and for the plant site soils, and the sediments must have a leachable arsenic concentration of 0.32 mg/l or less in an EP Toxicity Test extract. The actual leaching concentration when saturated with water would presumably be less than this, since an EP Toxicity Test is performed by boiling a solid in an acetic acid solution and measuring extracted concentrations. The actual leaching concentration with water is important, however, in terms of protecting the site groundwater quality and the surface water quality in the Blackwater Branch. The in-stream standard for arsenic in New Jersey surface waters is 0.05 mg/l.

As discussed in detail in the Plant site FS, the 7-day Q10 (low flow expected to occur for seven consecutive days once every 10 years) for the Blackwater Branch at the ViChem Plant site is approximately 4.9 CFS. Calculations showed that if the arsenic concentration in the groundwater were reduced to 0.35 mg/l, the in stream arsenic standard of 0.05 mg/l in the Blackwater Branch would be maintained. This is because of the dilution afforded by the Blackwater Branch to the groundwater discharge.

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Applying that same logic to leachate which may be generated off of the sediments, if they leach arsenic even at the worst-case EP Toxicity level of 0.32 mg/l, the in-stream arsenic standard should still be maintained. Since water will be the leaching fluid, as opposed to acetic acid that is used in the EP Toxicity Test, it is reasonable to assume the leaching concentration would be less than 0.32 mg/l. Even as a worst case, however, the in-stream arsenic standard should be maintained, even under the 7 day Q10 low flow conditions, if floodplain deposition and site deposition of the treated sediments were performed. Treatability studies should be performed during design to determine the actual water leaching concentration from the extracted sediments.

The remaining long-term concerns associated with this alternative would be identical to those presented in Alternative 3B. This action would reduce cancer risk levels stemming from the ingestion exposure pathway to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river. In the more accessible areas of the river the cancer risk level would be reduced to $2x10^{-6}$ as a result of the implementation of this alternative. Recreational use of the river areas could be instituted following completion of remediation. Secondary waste management issues would be negligible since the hazardous treatment sludges would be handled at a licensed off-site facility.

- <u>Reduction of Toxicity, Mobility, or Volume</u>: This alternative would greatly reduce the toxicity, mobility, and volume of arsenic-contaminated sediments in the river areas and the floodplain to the extent that acceptable risks to human health would be achieved. The toxicity and volume of arsenic within the environment would be reduced by extracting the arsenic from the sediments, altering its form through oxidation, consolidating it into a sludge, and disposing of it to a vendor equipped with the technologies to safely manage it. The mobility of arsenic in the environment would decrease, not to the extent that could be achieved, though, if placed in a properly lined and capped landfill. The control of leaching of contaminants into groundwater or river water would be more attainable with a lined landfill, a cap, and a leachate collection system.

- <u>Implementability</u>

  <u>Technical Feasibility</u>: The technical feasibility of the dredging, excavation, extraction, wastewater treatment, and sludge disposal operations are identical to those presented in Alternatives 3A and 3B. All are considered to be highly available, reliable and implementable. Floodplain and

plant site deposition of treated sediments with associated compacting and grading activities is considered to be technically achievable since it would involve standard construction practices. No major problems would be encountered. Accessibility to floodplain areas too saturated with water to withstand the loads associated with heavy equipment could be achieved through the use of specialized cranes that could deposit and compact materials to increase soil bearing capacity. It should be noted that backfilling the excavated Blackwater Branch floodplain would be necessary in all of the removal alternatives considered. The only difference in this case is that the cleaned sediments would be backfilled in this alternative rather than bringing in clean fill as would be done with Alternatives 3A and 3B.

The sediments must be classified as non-ID 27 waste by NJDEP in order to be deposited on the plant site and the Blackwater Branch floodplain. A substantive requirement for classification as non-ID 27 waste is a reduction in the sediment arsenic concentration to 20 mg/kg, the plant site action level for soils and the action level for the Blackwater Branch floodplain. If during final design, it is discovered that a two-stage water wash would not sufficiently reduce the arsenic concentration to 20 mg/kg, an alternate extracting agent would be required. Treatability tests indicated that sodium citrate would reduce the sediment arsenic concentration to 21 mg/kg. This process could be optimized to achieve an arsenic concentration of 20 mg/kg in the treated sediments.

Plant site deposition of the river sediments would require standard earthwork equipment and construction practices to develop the on-site topography without hindering off-site flow. These are standard construction practices and as such are considered easily implementable. A greater land area would be available for on-site deposition of the river sediments than for an on-site landfill, since there are certain restrictions in locating a landfill in close proximity to property boundaries. Since there is more land area, the material could be spread thinner, creating less of a mound. Additionally, site deposition does not require the inclusion of the clay liners and leachate collection system associated with a landfill. Also, a 4-foot bottom and top layer would not be required, meaning the deposited areas would not be as high as a landfill (1.5 ft. vs. 20 ft.).

Once remediation is completed, the activities to monitor the areas and generate the findings of the studies would be obtainable. The time to achieve remediation is estimated at three years.

Administrative Feasibility: Deposition of treated sediments would require a considerable administrative effort to reach fruition. Prior to full-scale remediation of the river areas, a number of decisions regarding the fate of the treated sediments would have to be made. First, if the areas are classified as "on-site", delisting, which has been shown as feasible, would be implemented by USEPA Region II. Otherwise, the NJDEP would have to be petitioned for a delisting classification for the treated sediments. Since the areas considered for deposition would be "on-site," a lengthy petitioning process would be avoided.

Following delisting, the NJDEP would be responsible for classifying the material for ultimate disposition. According to New Jersey Solid/Hazardous Waste Rules (refer to NJAC 7:26-1.6), solid wastes are generally regarded as materials that either no longer serve a beneficial use or are being disposed of such that their constituents can be released to the environment. Following treatment, the sediments would contain leachable arsenic below the regulatory disposal levels. Therefore, deposition of the treated sediments would pose minimal threat to human health and the environment. Following excavation of the Blackwater Branch floodplain, clean fill material would be required to restore the sensitive ecosystem to its original state. Assuming a nonhazardous classification for the treated sediments, an immediate and beneficial use would be found in their placement in the areas of excavation. Thus the classification of the material as ID 27 waste would be averted.

The discharge of treated water from the extraction process would not require a permit; however, a statement that all ARARs would be obtained would have to be provided. As discussed in the other alternatives, substantial institutional effort would be required to carry out periodic site evaluations and five-year reviews. These long-term concerns could be manageable from an administrative viewpoint. Thus this alternative is considered to administratively feasible.

Cost: The capital cost for this alternative, outlined in Table B-6, is estimated at $11,129,100. Annual short-term operation and maintenance costs and long-term operation and maintenance costs, outlined in Table B-12, are estimated at $1,590,000 and $13,000, respectively. The present worth cost, based on 5% discount rate after inflation is valued at $14,186,000, and represents all of the activities to dredge, excavate, thicken, extract with water, haul, and deposit nonhazardous sediments and hazardous treatment sludges; perform all operation and maintenance functions on



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the treatment system components and maintain the floodplain and site cover; perform periodic sampling of the Blackwater Branch and the Maurice River; and perform the six required five-year reviews.

A cost sensitivity analysis, outlined in Table 4-3 and graphically depicted in Figure 4-4, was performed for this alternative by varying the volume of submerged sediments to be remediated and calculating the present worth. The volume of floodplain sediments was held constant due to the extensive field data obtained in this area. Sensitivity to sediments volumes was analyzed for 0%, 50%, 100%, and 200% of the present volume estimates. These parameters were chosen because of the inherent dynamics associated with the river system and their capacity to distribute sediments over time. Present worth costs ranged from $11,310,000 to $15,725,000 for the 0% and 200% sediment volume cases, respectively. These costs represented a range of -20% to +11% over the estimated present worth of the alternative.

If the extracted sediments fail to pass the leaching criterion to be considered delistable, this alternative may not be feasible. Regulatory approval to dispose of a listed hazardous waste in a sensitive floodplain area, despite the fact that the sediments were removed from the floodplain and would have been treated somewhat, is considered unlikely. RCRA LDR consideration would apply to the sediments if they were not delistable, therefore they would have to be disposed of in a Subtitle C hazardous waste facility (assuming they met the 1 mg/l treatability variance).

- Compliance with ARARs: The same action-specific ARARs and key regulations that apply to hydraulic dredging, two-stage extraction and supernatant treatment and discharge activities discussed in Alternative 3A are applicable for this alternative, including the U.S. Fish and Wildlife Coordination Act, the Clean Water Act and RCRA LDRs. The extracted sediment is assumed to meet delisting requirements and thus is not subject to the RCRA LDRs.

  At the start of the remedial design a Stage IA Survey, consisting of a comprehensive literature search, would be performed in accordance to the National Historic Preservation Act.

  It is expected that this alternative would comply with all identified ARARs.

- Overall Protection of Human Health and the Environment: Alternative 3C would provide the same overall protection of human health as discussed in Alternative 3A. The

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beneficial impact would include reducing the sediment cancer risk to levels protective of human health. If the remaining contaminated sediment redistributes to areas where sediment exposure is a feasible pathway, additional remedial actions would be required to adequately protect human health.

The implementation of this alternative may improve the riverine ecosystem by reducing the potential exposure pathways of the arsenic contaminants to the fish and wildlife.

State Acceptance: In addition to the comments mentioned previously, this alternative addresses a major state comment, namely that alternatives be considered that did not require either on-site or off-site landfill disposal.

- Community Acceptance: No public comments have been received to date.

## 4.3 COMPARISON AMONG ALTERNATIVES

A comparative analysis will be conducted in this section to evaluate the relative performance of each alternative in relation to each specific evaluation criterion. The purpose of this comparative analysis is to identify the advantages and disadvantages of each of the alternatives relative to one another.

### 4.3.1 Short-Term Effectiveness

The implementation of Alternative 1 would result in minimal short-term effects to the local community; however, it could possibly restrict the use of the river areas. There would be no construction involved at the site, no threat to neighboring communities, and no significant impacts on the public health and environment during implementation. Education programs and public meetings would be presented to the neighboring communities during the remedial action.

The implementation of Alternatives 2A, 2B, 3A, 3B, and 3C would pose potential public health threats to the neighboring communities via direct contact with spilled wastes and the inhalation of fugitive dust. While the chemicals involved in Alternatives 2A and 2B would be stored in closed silos, equipped with dust emission control devices, there would be a potential for limited dust emissions. In Alternatives 3A, 3B, and 3C, the chemicals utilized would be either liquid or granular in nature as opposed to a fine dust. The implementation of Alternatives 2A, 2B, 3A, 3B or 3C would present minor threats to public health. Standard construction dust-suppression techniques would minimize potential threats.

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During the implementation of all the alternatives, on-site workers would be provided with personnel protective equipment to minimize exposure from direct contact with wastes and chemicals, and the inhalation of fugitive dust.

There would be no significant adverse impacts on the environment during the implementation of Alternative 1. Alternatives 2A, 2B, 3A, and 3B pose some environmental impacts, which include an increase in traffic from construction activities and the transportation of sediments. The increased truck traffic might result in an increase in traffic accidents. The construction activity and increased truck traffic pose a potential increase in air pollution, noise pollution and increased exposure to spilled wastes. Proper traffic control and dust suppression measures would be required to minimize these short-term adverse environmental impacts. Also, dredging activities conducted in Alternatives 2A, 2B, 3A, 3B or 3C could disturb wetland areas, causing possible short-term environmental impacts. Measures may have to be taken during and after dredging activities to minimize the adverse impacts and restore potential wetland areas.

The time required to achieve protection for Alternative 1 would be approximately three to four weeks. This would include monitoring the river areas and posting warning signs. The time required to complete Alternatives 2A, 2B, 3A, 3B and 3C is estimated to be three years. The estimated time periods run from the start of construction to the completion of treatment and disposal activities.

### 4.3.2 Long-Term Effectiveness

The implementation of Alternative 1 would result in a large residual risk remaining on-site; the arsenic contaminated sediment would not be removed from the river areas or treated in place. It would take some years for natural attenuation and transport mechanisms to significantly reduce the volume of arsenic in the river and floodplain sediments. This alternative would prevent the exposure to contaminated sediments by restricting access to the river areas. The long-term effectiveness of the alternative in minimizing human health risks would depend on its success in preventing access to the site.

After implementation of Alternatives 2A, 2B, 3A, 3B, or 3C, the sediment arsenic concentration would be reduced to below the target level. These alternatives would remove and treat those sediments identified as a public health risk, thus reducing the exposure risks. If significant redistribution of the sediments occurs via natural mechanisms, human disturbance, or the growth of vegetation, the sediments may reconcentrate, resulting in areas exceeding the target health risk established for this FS. Additional remedial actions may then be needed.

The treated sediments from either extraction or fixation are expected to meet substantive delisting requirements. Thus they could be disposed of as nonhazardous materials in an off-site nonhazardous landfill or an on-site nonhazardous landfill. If the NJDEP classified the treated material as non-ID 27 waste the material could be deposited in the floodplain or on the plant site. The supernatant water from the dredging and the supernatant water from the extraction would be treated by standard physical-chemical wastewater treatment processes to remove arsenic to levels below 0.05 mg/l. These levels would meet the NJPDES requirements and New Jersey Surface Water Quality Standards before discharge of the water to the river. The arsenic-contaminated sludge generated from the extraction process would be transported to an off-site RCRA treatment and disposal facility. The sludge would ultimately be disposed of in a RCRA Subtitle C landfill.

Alternatives 2A, 2B, 3A, 3B, and 3C employ treatment technologies that solidify or extract arsenic present in the sediments. Both technologies have been tested and proven. All equipment necessary for implementing these alternatives is available from several vendors. The chemicals employed in the fixation and extraction processes are all readily available. Pilot-scale studies would be performed to optimize the treatment processes. Alternatives 2A or 3A specify disposal of the treated material in an off-site landfill, and thus would not require a long-term management program as part of the site remedy. Alternatives 2B and 3B include the disposal of treated sediments in an on-site landfill. A long-term management and maintenance program would be required for the on-site landfill facility, however, implementation of this program does not pose any problems. Alternative 3C would also require a long-term management program to evaluate the effectiveness of the alternative. Long-term monitoring of sediments remaining on-site would be required for all the alternatives, to monitor for any redistribution. If these sediments collect in areas identified as posing a potential public health risk, additional actions may be required.

The reliability of control in Alternative 1 is low because the long-term effectiveness of this alternative is dependent upon the restriction of site access. Alternatives 2A, 2B, 3A, 3B and 3C are not likely to fail, because the arsenic is fixed in or extracted from the sediments. Any remaining arsenic is assessed to be safe from a public health standpoint.

Alternatives 2A, 2B, 3A, and 3B would all entail redeposition of clean fill in the Blackwater Branch floodplain where excavation occurred. In Alternative 3C, additional clean fill would not be necessary since the treated sediments would themselves be the clean fill. Treatability studies would be necessary to verify the leachate concentration from the cleaned sediments in

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Alternative 3C in order to protect the in-stream arsenic standard of 0.05 mg/l. As discussed in the text, even as a worst-case (7-day Q10 low flow in the Blackwater Branch and 0.32 mg/l leachate concentration from the treated sediment), it is expected that the in-stream arsenic standard would be maintained. More attention to leachate monitoring would be necessary for Alternative 3C than from the other alternatives.

Alternative 1 would not reduce human health risks. Alternatives 2A, 2B, 3A, 3B, and 3C would all reduce human health risks via the sediment ingestion pathway. As discussed previously, the source of arsenic into the river water from the ViChem plant site must be eliminated to reduce the overall human health risks in the river areas. This remedial action to manage migration should be taken before any remedial action is taken on river area sediments.

### 4.3.3 Reduction of Toxicity, Mobility or Volume

Alternative 1 does not reduce the toxicity, mobility or volume of the contaminants because arsenic is not removed from the river areas. Alternatives 2A, 2B, 3A, 3B, and 3C reduce the mobility and the volume of contaminants in the river sediments. Alternatives 2A and 2B reduce the toxicity of the sediments in the river and floodplain. Fixation does not reduce the toxicity of the arsenic; the contaminant becomes immobilized within a tightly bound matrix, thus the presence of arsenic in the overall environment is not diminished. Alternatives 3A, 3B, and 3C reduce the toxicity of the sediments in the river areas. Alternatives 2A and 2B produce a larger volume of treated sediment to be disposed of than Alternatives 3A, 3B, and 3C, because the fixation process requires large volumes of additives.

Both on-site and off-site nonhazardous landfilling options offer a similar reduction of mobility from treated sediments. Floodplain and plant site deposition of water-washed sediments associated with Alternative 3C may not reduce contaminant mobility to the extent that the other treatment alternatives do, since final disposition is not in a controlled, manmade landfill.

### 4.3.4 Implementability

The implementation of Alternative 1 consists of simple tasks, such as monitoring, inspection of the river areas and posting warning signs. These tasks present no implementation difficulties. The implementation of either Alternative 2A, 2B, 3A, 3B, or 3C involves the use of standard equipment that is commercially available. There is no technology involved in Alternative 1, whereas in Alternatives 2A, 2B, 3A, 3B, and 3C, the technologies are well developed and proven.

After the implementation of Alternative 1, if additional remedial action is necessary it can be implemented with no anticipated problem. In Alternatives 2A, 2B, 3A, 3B, and 3C, it is not anticipated that there would be a need for future or additional remedial actions. In the event that additional action is required, there would be no technical difficulties to overcome when implementing the task. However, a good deal of the remediation would have to be redone if Alternative 3C failed, since the Blackwater Branch would have to be reexcavated and the deposition areas of the plant site removed. The other alternatives have more controlled disposal conditions, so the remediation would not have to be redone. Landfill failure is not expected, but is more controllable than floodplain or plant site deposition.

With the application of Alternative 1, there is a need for surveillance in order to attain effective access restriction. Regular public awareness meetings would be required to increase the effectiveness of this alternative. With the application of either Alternatives 2A, 2B, 3A, 3B, or 3C, long-term operation and maintenance activities would include periodic site sampling, performing five-year reviews, and monitoring on-site landfills (Alternatives 2B and 3B) and deposition areas (Alternative 3C). The processes are reliable and would meet the designated efficiencies and performance goals.

No permits are required for the implementation of Alternative 1. Alternatives 2A, 2B, 3A, 3B, or 3C may require some permits. In carrying through all the alternatives, coordination would be required with other agencies to obtain all necessary agreements, particularly for Alternatives 2B, 3B, and 3C, which involve on-site landfilling or the on-site deposition of treated materials.

Treatment capacity and disposal service requirements are not required in Alternative 1. Treatment capacity, storage capacity and disposal services are all adequately available for Alternatives 2A, 2B, 3A, 3B and 3C. The nonhazardous off-site landfills have the capacity to handle the treated sediments. The nonhazardous on-site landfill would be designed to contain the total amount of the treated sediments. The relocation of sediment involved in Alternative 3C should not place any burden on or drastically disrupt the ecosystem of the Blackwater Branch floodplain or the plant site.

The availability of necessary special equipment and personnel is not required for Alternative 1. Standard equipment and operations utilized in Alternatives 2A, 2B, 3A, 3B, and 3C are commercially available.

Bench-scale tests have proven that fixation (Alternatives 2A and 2B) and extraction (Alternatives 3A, 3B, and 3C) are feasible for treating the arsenic-contaminated sediments. However, pilot-scale tests are required to provide relevant design criteria for

the remedial design. Pilot-scale tests would be performed if any of these alternatives is selected. Since further testing is required, general comparisons between fixation and extraction treatment processes cannot be made on implementability criteria. Site deposition, the simplest means of final disposition, may be difficult to implement administratively; proof would have to be presented to the NJDEP that the material does not constitute a waste and has a beneficial use, and that its leachability would protect the in-stream arsenic standard of 0.05 mg/l. It is now expected that the in-stream standard would be maintained even under worst-case conditions.

### 4.3.5 Cost

Table 4-4 presents a summary of the costs developed for each of the alternatives. Figure 4-8 presents a graphic representation of these costs. The total present worth for Alternative 1 is estimated at $874,200 based on a 30-year period and a 5% discount rate. This includes capital costs, annual operation and maintenance costs and six five-year reviews.

The total present worth of Alternatives 2A, 2B, 3A, 3B and 3C ranged from a low of $14,186,000 for Alternative 3C to a high of $60,809,000 for Alternative 2A.

Based on the present worth analysis, there are slight differences among Alternatives 2A, 2B, 3A, 3B, and 3C. The differences are most heavily dependent upon chemical costs, in which fixation outweighs extraction, and landfilling location options, which indicate that on-site is preferable to off-site. Floodplain and plant site deposition, the disposal option for Alternative 3C, is less costly than both landfilling options. Without considering implementability and other factors other than cost, Alternative 3C, extraction with floodplain deposition, would appear to be the most economical alternative.

The sensitivity analyses performed for all of the treatment alternatives evaluated the effect of varying the volume of contaminated submerged sediment to be remediated. The sediment volume parameter was chosen because natural dynamics associated with a riverine environment can redistribute sediment over short periods of time. All of the cost demonstrated variations within a range of -20% to +13% when submerged sediment volumes ranged from 0% to 200% of presently estimated figures.

### 4.3.6 Compliance with ARARs

Action-specific ARARs for Alternative 1 apply to the posting of warning signs and the site-monitoring activities. Requirements for these activities include OSHA Health and Safety Standards, which Alternative 1 would meet.

TABLE 4-4

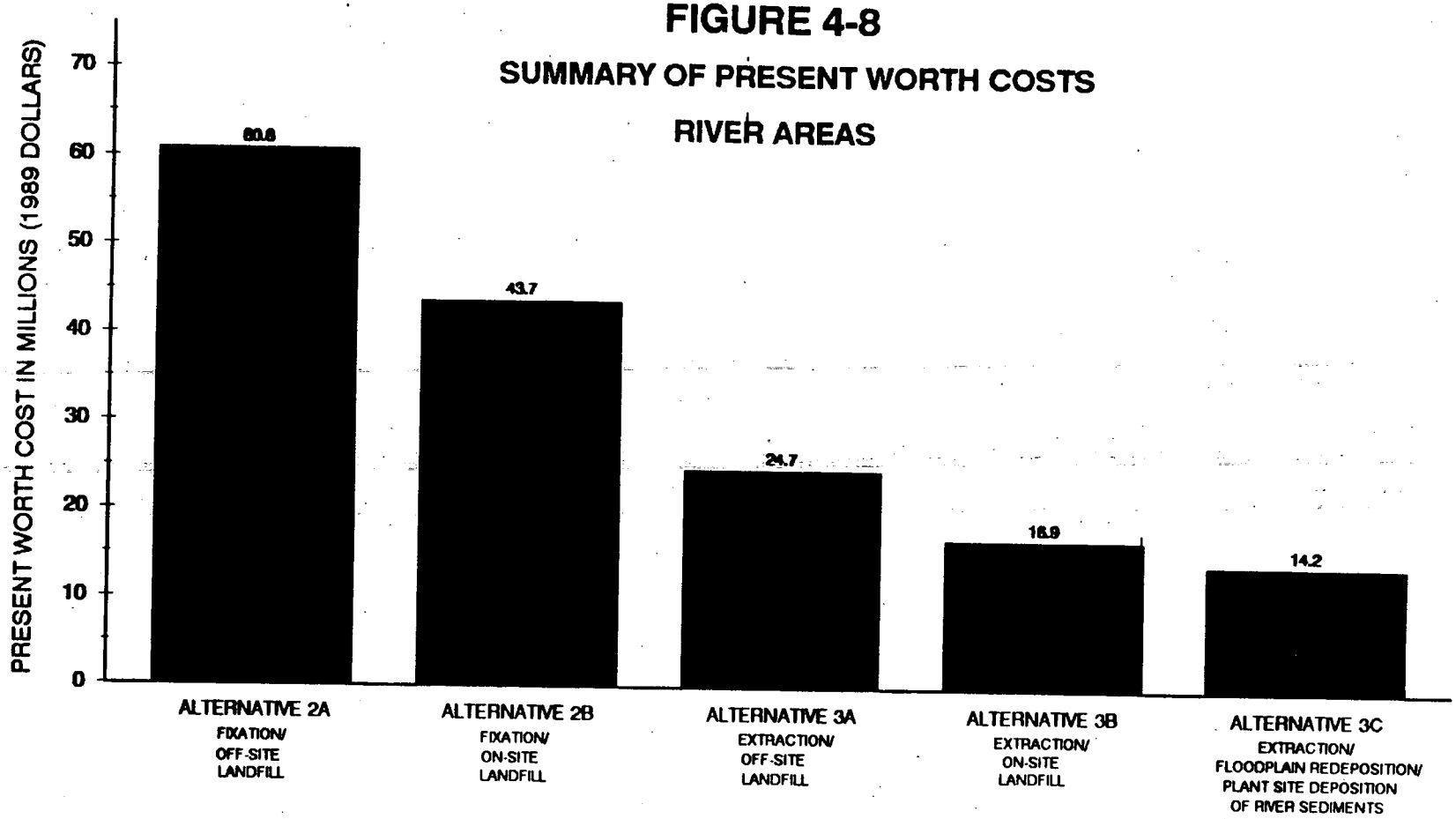
SUMMARY OF COST ANALYSIS (1989 DOLLARS)
(SOURCE CONTROL)

| ALT | CAPITAL COST | | | ANNUAL O&M | | PRESENT WORTH |
|---|---|---|---|---|---|---|
| | DIRECT | INDIRECT | TOTAL | LONG TERM | SHORT TERM | |
| 1 | $35,000 | $9,450 | $44,450 | $49,455 | | $874,245 |
| 2A | $22,880,219 | $6,177,659 | $29,057,878 | $13,020 | $17,792,599 | $60,808,653 |
| 2B | $8,684,740 | $2,344,880 | $11,029,620 | $79,698 | $17,792,599 | $43,665,831 |
| 3A | $17,048,746 | $4,603,161 | $21,651,908 | $13,020 | $1,589,880 | $24,709,821 |
| 3B | $10,446,483 | $2,820,550 | $13,267,033 | $54,448 | $1,589,880 | $16,875,075 |
| 3C | $8,762,653 | $2,365,916 | $11,128,569 | $13,020 | $1,589,880 | $14,186,482 |

# FIGURE 4-8

## SUMMARY OF PRESENT WORTH COSTS

## RIVER AREAS




PRESENT WORTH COST TO REMEDIATE 56,170 CU. YD. OF EXPOSED FLOODPLAIN SEDIMENT, 6,411 CU. YD. OF SUBMERGED FLOODPLAIN SEDIMENT, AND 15,416 CU. YD. OF SUBMERGED RIVER SEDIMENT

| |
|---|
| U.S. ENVIRONMENTAL PROTECTION AGENCY |
| VINELAND CHEMICAL COMPANY SITE |
| FIGURE 4-8<br>SUMMARY OF DETAILED COST ANALYSIS FOR RIVER AREAS REMEDIAL ALTERNATIVES |
| EBASCO SERVICES INCORPORATED |

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Hydraulic dredging activities in the riverine areas would require appropriate preventive measures to minimize resuspension and erosion in order to comply with the requirements of the Federal Rivers and Harbors Act Section 10. The Clean Water Act Section 404 requires that no activity affecting a wetland shall be permitted if a practicable alternative with less impact on the wetland is available. Alternatives 2A, 2B, 3A, 3B and 3C would remove contaminants from the river areas with minimal disturbance to the wetland. After the completion of the remediation, any wetlands that have been disturbed would be restored to their original conditions with minimal impact on them.

The U.S. Fish and Wildlife Coordination Act requires that the appropriate agency exercising jurisdiction over wildlife resources, and the U.S. Fish and Wildlife Service, must be consulted before undertaking any action that modifies a body of water. Any number of agencies may exercise jurisdiction over wildlife resources, depending on exactly what wildlife is considered. Special attention must be given to the impact on wetlands and floodplains in accordance with Executive Order 11990 and 11888. This is not applicable to Alternative 1 because it does not modify a water body in any way. Alternatives 2A, 2B, 3A, 3B, and 3C would be expected to comply with this regulation if implemented.

All alternatives would have to comply with RCRA facility standards and OSHA industry standards and regulations concerning hazardous wastes. RCRA 40 CFR 261 and 262 are applicable to activities including dredging and excavating hazardous sediments, transferring these materials to a treatment facility, and treating hazardous materials through a fixation process (Alternatives 2A and 2B) or a water extraction process (Alternatives 3A, 3B and 3C). Alternative 1 would not be subject to these ARARs because this alternative would not remove or contain any contaminated sediments.

RCRA LDRs restrict the placement of wastes into land disposal facilities. The fixated and extracted wastes are expected to meet substantive delisting requirements, as discussed in Section 3.0. The treated sediments could thus be safely disposed of as nonhazardous materials. In addition, if delisted, the extracted sediments could be deposited on the Blackwater Branch floodplain or on the plant site in accordance with the LDRs. The NJDEP would have to waive an ID 27 waste classification of the treated sediments to enable this. As Alternative 1 does not involve any removal of the contaminated sediments, RCRA LDRs are not applicable to it.

Treatment of the wastewaters generated from Alternatives 2A, 2B, 3A, 3B, and 3C are expected to meet NJPDES permit requirements. A NJPDES permit would not be required for on-site discharge, but the permit conditions regarding arsenic concentration (0.05 mg/l) would be met. The treated effluent would also meet the New

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Jersey Surface Water Quality Standards in terms of arsenic (0.05 mg/l) and other conventional parameters (such as suspended solids and pH). Alternatives 2A, 2B, 3A, 3B and 3C would treat the dredged supernatant for suspended solids and arsenic removal and the effluent would then be discharged back to the river. The disposal of the supernatant would comply with the USEPA guidelines for disposal of dredged or fill material (40 CFR 280) by restoring and maintaining the chemical, physical and biological integrity of river water in accordance with the Clean Water Act (CWA Section 401).

The treated sediments would meet substantive delisting requirements and be considered nonhazardous. DOT regulations for transporting nonhazardous, solid wastes would pertain to all of the treatment alteratives. DOT rules for transporting hazardous waste would not be applicable to Alternatives 2A and 2B. However, the extraction alternatives, Alternatives 3A, 3B and 3C, produce an arsenic-contaminated sludge that would be transported to a RCRA facility for treatment and disposal. Therefore transport of the sludges would be in accordance with DOT rules. For all the alternatives involving off-site disposal, the Clean Air Act and National Ambient Air Quality Standards would be applicable in regulating particulate air emission arising from handling and transporting the stabilized materials. Adequate dust suppression measures would be provided for any potential fugitive dust emissions. These considerations may not apply to Alternatives 2B and 3B, as treated soils are disposed of at an on-site landfill. Alternative 1 does not involve any treatment or transportation; therefore these ARARs would not apply.

The New Jersey Solid Waste Regulation (NJAC 7:26), particularly Subchapter 2A, Additional Specific Disposal Regulation for Sanitary Landfills (May 5, 1986), would be considered in managing treated nonhazardous wastes for both on-site and off-site landfills under Alternatives 2A, 2B and 3A or 3B.

At the start of remedial design for any of the treatment alternatives a Stage IA Survey, consisting of a comprehensive literature search, would be conducted in accordance with the National Historic Preservation Act.

### 4.3.7 Overall Protection of Human Health and the Environment

Alternative 1 would entail no removal, containment or treatment of the contamination source. It would not contribute to the protection of human health and the environment since there would not be any reduction in the toxicity, mobility or volume of contaminants. Some years would be required for natural attenuation to reduce arsenic-contaminated sediments in the river areas to below the cleanup criterion. This alternative is not considered responsive to the remedial objectives, but provides a "base case" for comparison among other alternatives.

Alternatives 2A, 2B, 3A, 3B and 3C involve actual removal and treatment of the contaminated sediments identified as a public health threat (chemical fixation for Alternatives 2A and 2B and two-stage water extraction for Alternatives 3A, 3B and 3C) to affect the permanent immobilization or extraction of arsenic compounds. Using these alternatives to remove the contaminated source, assuming no significant redistribution of the remaining contaminated sediments, and that the contaminated groundwater entering the river from the ViChem site is controlled, would facilitate protection of human health and the environment. Fixation and extraction processes would prevent future releases of arsenic into the environment. Alternatives 2A, 2B, 3A and 3B would contain treated sediments in a nonhazardous landfill, minimizing the chances of further exposure to the contaminants. Alternative 3C would deposit the clean treated sediments on the Blackwater Branch floodplain or on the plant site. These clean sediments would not pose a risk to public health since they would be classified as fill material, but the potential for leaching, even at low levels, must be addressed.

Treated sediments can be classified as nonhazardous and thus pose little or no risk to groundwater or surface water quality. The removal of contaminated sediments in Alternatives 2A, 2B, 3A, 3B, and 3C would attain the cleanup criteria in areas posing a public health risk and reduce the sediment cancer risk level to $1x10^{-5}$ in the Blackwater Branch floodplain and in the less accessible areas of the river. The sediment cancer risk level in the more accessible areas of the river would be reduced to $2x10^{-6}$. It is assumed that shortly after the implementation of the management of groundwater migration at the ViChem facility and following completion of remedial activities in the river areas, the risks in the river areas would be sharply reduced. Any remaining contaminated sediments would contain levels of arsenic below the action-level for the river areas and would not be deemed as a public health risk. The possibility of redistribution and reconcentration of sediments would still exist, however, as all sediments with elevated arsenic concentrations would not have been removed.

State Acceptance

This FS addresses several major comments that the State had to the Draft FS, namely:

- Provide additional sediment data in the Blackwater Branch;
- Consider the implications of the LDR to the remedial alternatives;
- Provide alternatives which do not require either on-site or off-site nonhazardous disposal.

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In addition, each specific comment raised by the NJDEP to the first Draft FS has been responded to by the USEPA in a letter to the NJDEP.

Community Acceptance

No public comments have been received to date.

## 4.4 SUMMARY OF DETAILED ANALYSIS

Table 4-5 summarizes the analysis of the alternatives discussed in the previous sections. A brief description of the key points in each of the nine evaluation criteria is presented.

In addition to the previous discussions, several other factors should be considered when selecting a remedial alternative for the river areas. These factors are listed below:

- The source of arsenic into the river areas is the groundwater discharge from the ViChem plant. The data suggest that eliminating this source should improve the downstream surface water quality. Therefore this source should be eliminated before any downstream remedial actions are taken.

- Extraction and fixation were seen as feasible remedial technologies for the soils on the ViChem site. They may also be feasible for the contaminated sediments in the river areas and Union Lake. Therefore, it may be more cost-effective to combine remedial actions in the various areas so that only one treatment system, for example, a nonhazardous landfill, is constructed to remediate a given problem. Combining alternatives for the various study areas can be looked in to after the optional alternatives for each area are determined.

TABLE 4-5

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 1 - No Action | Alternative 2A-Dredging/ Excavation/Thickening/ Fixation/Off-Site Non-hazardous Landfill | Alternative 2B-Dredging/ Excavation/Thickening/ Fixation/On-Site Nonhazardous Landfill |
|---|---|---|---|
| Key Components | Limiting access to site, public education programs, site-use restrictions, long-term monitoring | Hydraulic dredging, excavation, sediment fixation, wastewater treatment, off-site non-hazardous landfill, long-term monitoring | Hydraulic dredging, excavation, sediment fixation, wastewater treatment, on-site nonhazardous landfill, long-term monitoring |
| Short Term Effectiveness | | | |
| -Protection of community during remedial actions | No short-term threats to communities. | Potential for direct contact of spilled waste and inhalation of fugitive dust. | Same as Alternative 2A. |
| -Protection of workers during remedial actions | Personnel protection equipment required against dermal contact and inhalation during sign posting, sample collection, inspection. | Minimal risk to workers. Personnel protection equipment required against direct contact with wastes and inhalation of fugitive dust. | Same as Alternative 2A. |
| -Environmental Impacts | No significant adverse environmental impacts from site activities. | Increased traffic, noise, and air pollution. Sediment re-suspension minimized by increasing water intake of dredge and use of silt curtains. | Minimal increase in traffic, noise and air pollution. Sediment resuspension minimized by increasing water intake of dredge and use of silt curtains. |
| -Time until remedi-ation | Some years. | Estimated to be 3 years from start of construction to completion of remediation work. | Same as Alternative 2A. |



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TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 3A-Dredging/ Excavation/Extraction/ Sediments to Off-Site Non-hazardous Landfill/Off-Site Hazardous Sludge Disposal | Alternative 3B-Dredging/ Excavation/Extraction/Sedi-ments to On-Site Nonhazardous Landfill/Off-site Hazar-dous Sludge Disposal | Alternative 3C-Dredging/ Excavation/Extraction/Flood-plain Deposition of Exposed Sediments/Plant Site Deposition of River Sediments/Off-Site Hazardous Sludge Disposal |
|---|---|---|---|
| Key Components | Hydraulic dredging, excava-tion, sediment extraction, wastewater treatment, sedi-ments to off-site non-hazardous landfill, off-site hazardous sludge disposal, long-term monitoring | Hydraulic dredging, excavation, sediment extraction, wastewater treatment, sediments to nonhazardous landfill, off-site hazardous sludge disposal, long-term monitoring | Hydraulic dredging, excavation, sediment extraction, wastewater treatment, floodplain and plant site deposition of sediments, off-site hazardous sludge disposal, long-term monitoring |
| Short-Term Effectiveness | | | |
| -Protection of community during reme-dial actions | Potential for direct contact of spilled waste and inhala-tion of fugitive dust. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Protection of workers during remedial actions | Minimal risk to workers. Personnel protection equip-ment required against di-rect contact with wastes and inhalation of fugitive dust. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Environmental Impacts | Increased traffic, noise, and air pollution sediment resuspension minimized by increasing water intake of dredge and using silt curtains. | Minimal increase in traffic noise and air pollution, sedi-ment resuspension minimized by increasing water intake of dredge and using silt curtains.. | Same as Alternative 3B. |
| -Time until remediation | Estimated to be 3 years from start of construction to completion of remediation work. | Same as Alternative 3A. | Same as Alternative 3A. |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 1 | Alternative 2A | Alternative 2B |
|---|---|---|---|
| **Long-Term Effectiveness** | | | |
| -Magnitude of Residual Risks | Long-term evaluation required for natural degradation & transport reduction | Sediments identified as a public health risk would be removed and treated. Redistribution of contaminated sediments could result in a public health risk. Treated sediments would be delisted as nonhazardous waste, supernatant water treated to NJPDES standards. | Same as Alternative 2A On-site landfill maintenance and monitoring required. |
| -Adequacy of Control | Depends on success in preventing access to the site. | Proven technologies. Long-term monitoring program required for remaining sediment. | Same as Alternative 2A Long-term maintenance required for on-site landfill facility. |
| -Reliability of Minimal Controls | Migration of contaminants from sediments to water could occur. | If significant redistribution of sediments, additional remedial actions may be required. | Same as Alternative 2A. failure of on-site landfill facility. |
| **Reduction of Toxicity, Mobility or Volume** | | | |
| -Treatment Process and Remedy | No reduction of toxicity, mobility or volume. | Reduction in mobility of treated sediment and slight reduction in volume of on-site sediments. No reduction in toxicity. | Same as Alternative 2A. |
| -Amount of Hazardous Materials Remaining | No material removed or treated. | Sediments identified as a public health risk are removed and treated to be delisted. Remaining sediments are not considered to pose health risks by the sediment ingestion pathway. | Same as Alternative 2A. |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 3A | Alternative 3B | Alternative 3C |
|---|---|---|---|
| **Long-Term Effectiveness** | | | |
| -Magnitude of Residual Risks | Sediment identified as a public health risk would be removed and treated. Redistribution of contaminated sediments could result in a public health risk. Treated sediment delisted as nonhazardous waste. Water treated to NJPDES Standards. | Same as Alternative 3A. Long-term maintenance and monitoring for on-site landfill. | Same as Alternative 3A. Treated materials considered to be clean fill after delisting. |
| -Adequacy of Control | Proven Technology. Long-term monitoring program required for remaining sediments. | Same as Alternative 3A. Long-term maintenance required for on-site landfill facility. | Same as Alternative 3A. |
| -Reliability of Controls | If significant redistribution of sediments occur, additional remedial actions may be required. | Same as Alternative 3A. Minimal failure of on-site landfill facility. | Same as Alternative 3A. Minimal potential of leachate from delisted sediments deposited on floodplain and plant site. |
| **Reduction in Toxicity, Mobility or Volume** | | | |
| -Treatment Process and Remedy | Permanent reduction in toxicity of treated sediments. Reduction in volume and mobility of on-site contaminants. | Same as Alternative 3A. | Same as Alternative 3A. Deposition offers greater mobility than landfilling. |
| -Amount of Hazardous Material Remaining | Sediments identified as a public health risk are removed and treated to be delistable. Remaining sediments do not pose health risk by the sediment ingestion pathway. Significant quantity of arsenic-contaminated sludge generated from extraction process. | Same as Alternative 3A. | Same as Alternative 3A. |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 1 | Alternative 2A | Alternative 2B |
|---|---|---|---|
| -Irreversibility of The Treatment | N/A | Treatment is essentially irreversible. | Same as Alternative 2A. |
| -Type and Quantity of Residual Waste | N/A | Treated waste expected to be delisted. | Treated waste expected to be delisted. |
| Implementability | | | |
| o Technical Feasibility | | | |
| - Ability to Construct Technology | No difficulty. | Standard equipment commercially available. | Same as Alternative 2A. |
| - Reliability of Technology | No technology. | Well developed and proven technology. Pilot-scale studies required to optimize treatment. | Same as Alternative 2A. |
| - Ease of Undertaking Additional Remedial Action If Necessary | No difficulty. | Additional future remedial actions may be required. | Same as Alternative 2A. |
| - Monitoring Considerations | Long-term monitoring required, monitoring analysis techniques available. | Long-term monitoring required. | Long-term monitoring for on-site landfill and remaining sediment required. Monitoring analysis techniques available. |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 3A | Alternative 3B | Alternative 3C |
|---|---|---|---|
| -Irreversibility of The Treatment | Treatment is essentially irreversible. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Type and Quantity of Residual Waste | Treated waste expected to be delisted. Arsenic sludge generated from extraction process highly contaminated. | Same as Alternative 3A. | Same as Alternative 3A. |
| Implementability | | | |
| o Technical Feasibility | | | |
| -Ability to Construct | Standard equipment commercially available. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Reliability of Technology | Well developed and proven technology. Pilot-scale studies required to optimize treatment. | Same as Alternative 3A. | Same as Alternative 3A. Floodplain and plant site cover not as reliable as a landfill liner/cap scenario. |
| -Ease of Understanding Additional Remediation If Necessary | Additional future remedial actions may be required. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Monitoring Considerations | Long-term monitoring required. | Same as Alternative 3A. Long-term monitoring for on-site landfill required. Monitoring analysis techniques available. | Same as Alternative 3A. |



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TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 1 | Alternative 2A | Alternative 2B |
|---|---|---|---|
| o Administrative Feasibility | | | |
| -Ability to obtain Approvals | Permits not required. | Delisting approval required from NJDEP. | Delisting approval required from USEPA Region II. As the site is a CERCLA site, permits for landfill are not required. |
| -Coordination with Other Agencies | Coordination required. | Coordination required. | Intensive coordination required for on-site landfill facility. |
| -Availability of Services & Materials | | | |
| -Availability of Treatment Capacity & Disposal Services | Not required. | Treatment capacity and storage capacity are all adequately available. Off-site landfill requires administrative acquisition. | Same as Alternative 2A. On-site landfill provides higher availability for disposal. |
| -Availability of Necessary Equipment & Specialists | Not required. | Standard equipment and operations. No specialists required. | Same as Alternative 2A. |
| -Availability of Prospective Technologies | Not required. | Prospective technologies are available. Technologies are proven in bench-scale tests. Pilot studies would be required to optimize process. | Same as Alternative 2A. |
| Costs | | | |
| o Total Capital Cost | $ 44,500 | $ 29,058,000 | $11,030,000 |
| o Annual Operation and Maintenance Cost | $ 49,500 | $ 13,020 Long-term<br>$ 17,793,000 Short-term | $ 80,000 Long-Term<br>$17,793,000 Short-term |
| o Present Worth | $874,200 | $ 60,809,000 | $43,666,000 |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 3A | Alternative 3B | Alternative 3C |
|---|---|---|---|
| o Administrative Feasibility | | | |
| -Ability to obtain Approvals | Delisting approval required from NJDEP. | Delisting approval required from USEPA Region II. As the site is a CERCLA site, permits for landfill are not required. | Same as Alternative 3B. Approval for floodplain and plant site deposition may be difficult to obtain. ID 27 waste classification would prevent implementation of alternative. |
| -Coordination with Other Agencies | Coordination required for identification of off-site nonhazardous and | Intensive coordination required for on-site landfill facility and identification of off-site | Coordination required for approval of floodplain and plant site deposition and |
| identification | hazardous landfills. | hazardous landfill. | of hazardous landfill. |
| -Availability of Services & Materials | | | |
| -Availability of Treatment Capacity & Disposal Services | Treatment capacity and storage are all adequately available. Off-site landfill requires administrative acquisition. | Same as Alternative 3A. On-site landfill provides higher availability for disposal. | Treatment capacity, storage capacity and disposal capacity are all adequately available. |
| -Availability of Necessary Equipment & Specialists | Standard equipment and operations. No specialists required. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Availability of Prospective Technologies | Prospective technologies are available. Technologies are proven in bench-scale studies. Pilot-scale studies required to optimize process. | Same as Alternative 3A. | Same as Alternative 3A. |
| Costs | | | |
| o Total Capital Cost | $21,652,000 | $13,267,000 | $11,129,000 |
| o Annual Operation & Maintenance Cost | $ 13,020 Long-term<br>$ 1,590,000 Short-term | $ 54,000 Long-term<br>$ 1,590,000 Short-term | $ 13,020 Long-term<br>$ 1,590,000 Short-term |
| o Present Worth | $24,710,000 | $16,875,000 | $14,186,000 |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 1 | Alternative 2A | Alternative 2B |
|---|---|---|---|
| Compliance with ARARs | | | |
| -Compliance with contaminant-specific ARARs | No contaminant-specific ARAR established for arsenic contaminated sediment. Will not meet health-based levels. | No contaminant-specific ARAR established for arsenic contaminated sediments. Will meet health-based levels. | Same as Alternative 2A. |
| -Appropriateness of waivers | Not justifiable. | Treatability variance may be required. | Same as Alternative 2A. |
| -Compliance with action-specific ARARs | Not applicable. | All action-specific ARARs will be met. | Same as Alternative 2A. |
| -Compliance with appropriate criteria, advisories, and guidance | Not in compliance with state and local criteria and federal advisories. | Will be in compliance with State and local criteria and federal advisories. | Same as Alternative 2A. |
| Overall Protection of Human Health and the Environment | Risk of direct contact with contaminated sediment and water controlled but not eliminated. Contaminants remain on-site and their toxicity, mobility or volume unaltered. Cancer risk at $10^{-2}$ level. | Risk of sediment ingestion reduced. Contaminants removed and chemically fixated to reduce toxicity and eliminate mobility. Volume of fixated solids will increase. Cancer risk level for those sediments identified as a public health risk would be reduced to levels protective of human health. | Same as Alternative 2A. |
| State Acceptance | State comments indicated that the No Action Alternative would be protective of human health if restrictive measures were enacted. | General comments from the State include the need for additional sampling prior to the initiation of a remedial action. | Same as Alternative 2A. |
| Community Acceptance | No public comments have been received to date. | Same as Alternative 1. | Same as Alternative 1. |

TABLE 4-5 (Cont'd)

SUMMARY OF ALTERNATIVE ANALYSIS

| Assessment Factors | Alternative 3A | Alternative 3B | Alternative 3C |
|---|---|---|---|
| **Compliance with ARARs** | | | |
| -Compliance with contaminant-specific ARARs | No contaminant-specific ARAR established for arsenic. Treated sediment will meet health-based levels. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Appropriateness of waivers | Treatability variance may be required. | Same as Alternative 3A. | ID 27 waste classification must be waived. Treatability variance may be required. |
| -Compliance with action-specific ARARs | All action-specific ARARs will be met. | Same as Alternative 3A. | Same as Alternative 3A. |
| -Compliance with appropriate criteria, advisories, and guidance | Will be in compliance with state and local criteria and Federal advisories. | Same as Alternative 2A. | Same as Alternative 3A. |
| **Overall Protection of Human Health and the Environment** | Risk of sediment ingestion reduced. Contaminants removed and extracted and converted to nonhazardous form. Volume of contaminants unchanged. Cancer risk level for those sediments identified as a public health risk reduced to levels protective of human health. | Same as Alternative 3A. | Same as Alternative 3A. |
| **State Acceptance** | General comments received from the State include the need for additional sampling prior to the initiation of a remedial action. | Same as Alternative 3A. | Same as Alternative 3A. |
| **Community Acceptance** | No public comments received to date | Same as Alternative 3A. | Same as Alternative 3A. |

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# APPENDIX A

## BREAKDOWN OF MAJOR FACILITIES

## AND

## CONSTRUCTION COMPONENTS FOR REMEDIAL ALTERNATIVES

TABLE A-1

ALTERNATIVE 1 - NO-ACTION
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/Construction | Estimated Quantities | Description |
|---|---|---|
| 1. Posting of Warning Signs | 75 | 14 ft x 3 ft PVC signs on 6 ft posts along lake perimeter located approximately 500 ft apart. |
| 2. Public Awareness Program | 2 | 1 public meeting and 1 public workshop |





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TABLE A-2

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| I. SITE PREPARATION | | |
| 1. Parking Area (included in 2.) | | |
| 2. Equipment Parking and Storage Area | 100 ft x 100 ft | 1 ft thick crushed stone pavement. |
| 3. Security Fence & Gate | 1,000 lf | 8 ft high, all metal, 45° inclined barbed wire, double frame gate, each 12 ft wide, 8 ft high. |
| 4. Access Road | 3,000 ft x 25 ft | 1 ft thick crushed stone and drain ditch. |
| II. SUPPORT FACILITIES | 5 trailers | Trailers for a) EPA/DEP Office b) Engineer Office c) Health/Safety (Decontamination Equipment) d) Contractor Office e) Contractor's Equipment. |
| III. SEDIMENT HYDRAULIC DREDGING | 75,303 cy | Dredge sediments to 1.0 ft depth over 81 acres using two units of "Mudcat" dredge Model MC-915 @ 50 in place cy/hr each with one common pontooned floating pipeline to treatment plant. Dredging produces 20% solids by weight. Cost includes silt curtains, other temporary controls and clean fill where applicable. |
| IV. SEDIMENT EXCAVATION | | |
| 1. Excavation | 56,170 cy | Excavation of floodplain sediments of 55 volume % solids. |
| 2. Clean Fill | 44,936 cy | Clean fill used to replace excavated material. |
| 3. Topsoil | 11,234 cy | One foot depth of topsoil placed above clean fill. |
| 4. Vegetation | 8 acres | Grass seeding |
| V. HOLDING TANKS & MIXERS | 2 | Two 120,000 gallon steel tanks with mixers. |
| VI. SEDIMENT THICKENING SYSTEM | | |
| 1. Separator | 1 | 14-6 in. soft rubber lined hydroclones mounted in parallel. 7 operating, 7 stand-by. |
| 2. Slurry Pumps | 2 | 500 gpm each, diaphragm pumps. 1 operating, 1 standby. |

TABLE A-2 (Cont'd)

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| VII. SUPERNATANT TREATMENT SYSTEM | | |
| 1. Coagulator - Clarifiers | 2 | Two 20 ft diameter coagulator - clarifiers, steel tank, 10 ft sidewall depth, bottom slope 3 in./ft, built on-site, heavy duty rake mechanism, with rapid mixing, coagulation/flocculation and sedimentation chambers. |
| 2. Sludge Pumps | 2 | 10 gpm each, diaphragm pumps. |
| 3. Coagulant Feeding Pumps | 2 | Metering pumps, each 60 gph, stainless steel 316. |
| 4. Coagulant Day Tank | 1 | 500 gal day tank, fiberglass reinforced polyester with one mixer. |
| 5. Polymer Feeding Pumps | 2 | Metering pumps, each 20 gph, stainless steel 316. |
| 6. Polymer Day Tank | 1 | 200 gal day tank, fiberglass reinforced polyester with one mixer. |
| 7. Ferric Chloride Feeding Pumps | 2 | Metering pumps, each 60 gph, stainless steel 316. |
| 8. Ferric Chloride Day Tank | 1 | 500 gal day tank, fiberglass reinforced polyester with one mixer. |
| VIII. CHEMICAL FIXATION SYSTEM | | |
| 1. Slurry Mixing Tanks | 2 | 3,500 gal steel tanks, each with 20 min mixing time. |
| 2. Mixers | 2 | Turbine impellers with 6 ft flat blades. |
| 3. Chemical Tank (K-20 LSC) | 1 | 3,000 gal steel tank with one mixer (one week storage). |
| 4. Chemical Feeding Pumps | 2 | Metering pumps, each 60 gph, stainless steel 316. |
| 5. Carbon Powder Silo | 1 | 3,000 gal steel tank (one week storage) elevated steel structure support. |
| 6. Carbon Powder Feeding Systems | 2 | Adjustable 25 lb/min loss in weight type dry feeder each. |
| 7. Portland Cement Silo | 1 | 80,000 gal steel tank (one week storage tank), elevated steel structure support. |

TABLE A-2 (Cont'd)

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| VIII. CHEMICAL FIXATION SYSTEM (Cont'd) | | |
| 8. Portland Cement Feeding Systems | 2 | Adjustable 400 lb/min loss in weight type dry feeder each. |
| 9. Fly Ash Silo | 1 | 20,000 gal steel tank (one week storage tank), elevated steel structure support. |
| 10. Fly Ash Feeding Systems | 2 | Adjustable 100 lb/min loss in weight type dry feeder each. |
| 11. Sludge Pump | 2 | 150 gpm diaphragm pump. 1 operating, 1 standby. |
| 12. Process Water Delivery System | 1 | Includes tank, pump, piping, and high pressure water system. |
| 13. Soil Belt Conveyor and Hopper | 3 | Double vibrating screen hopper 45° belt is completely enclosed and capable of reaching 25 ft elevation. |
| IX. FIXATED SEDIMENT CURING SYSTEM | | |
| 1. Curing Basin Dike | 600 ft | Top width = 3 ft, slope = 1:3, height = 2 ft bottom width = 15 ft, basin area = 150 ft x 150 ft |
| 2. Clay Layer | 850 cy | Local clay with $1 \times 10^{-7}$ cm/sec permeability, 1 ft thick, 22,500 $ft^2$. |
| X. OFF-SITE NONHAZARDOUS LANDFILL | 182,775 ton | Trucked to nonhazardous landfill facilities (within 100 miles from Union Lake), 480 ton/day. |
| XI. PROCESS PIPING AND I&C | | For the above treatment facilities |
| XII. ELECTRICAL | | For the above treatment facilities. |
| XIII. BUILDINGS, PLATFORMS & STAIRS | | For the above treatment facilities |
| XIV. FOUNDATIONS & PADS | | For the above treatment facilities |

TABLE A-3

ALTERNATIVE 2B - DREDGING/EXCAVATION/THICKENING/FIXATION/ON-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/Construction | Estimated Quantities | Description |
|---|---|---|
| I. SITE PREPARATION | Same as Alt. 2A, Item I | Same as Alt. 2A, Item I |
| II. SUPPORT FACILITIES | Same as Alt. 2A, Item II | Same as Alt. 2A, Item II |
| III. SEDIMENT HYDRAULIC DREDGING | Same as Alt. 2A, Item III | Same as Alt. 2A, Item III |
| IV. SEDIMENT EXCAVATION | Same as Alt. 2A, Item IV | Same as Alt. 2A, Item IV |
| V. HOLDING TANKS | Same as Alt. 2A, Item V | Same as Alt. 2A, Item V |
| VI. SEDIMENT THICKENING SYSTEM | Same as Alt. 2A, Item VI | Same as Alt. 2A, Item VI |
| VII. SUPERNATANT TREATMENT SYSTEM | Same as Alt. 2A, Item VII | Same as Alt. 2A, Item VII |
| VIII. CHEMICAL FIXATION SYSTEM | Same as Alt. 2A, Item VIII | Same as Alt. 2A, Item VIII |
| IX. FIXATED SEDIMENT CURING SYSTEM | Same as Alt. 2A, Item IX | Same as Alt. 2A, Item IX |
| X. ON-SITE HAZARDOUS LANDFILL | | |
| 1. Liner System | | |
| o Clay Layer | 22,979 cy | 2 ft thick clay (permeability $10^{-7}$ cm/sec) |
| o Synthetic Liner | 305,588 sf | 40 mil high density polyethylene (HDPE) |
| o Geotextile Cloth | 287,253 sf | Polypropylene cloth to allow filtration of leachate into sand layer. |
| o Leachate Collection System | | |
| - PVC Pipe | 3,056 ft | 4 in. dia perforated |
| - RC Sump | 2 | 4 ft dia 6 ft deep |
| - Pumps | 2 | 25 gpm each, chemical resistant |
| o Sand Layer | 21,955 cy | 2 ft thick sand layer |
| 2. Fixated Sediment Hauling, Deposition and Compaction | 101,013 cy | 264 cy/day |
| 3. Capping System | | |
| o Clay Layer | 21,933 cy | 2 ft thick clay (permeability $10^{-7}$ cm/sec) |

TABLE A-3 (Cont'd)

ALTERNATIVE 2B - DREDGING/EXCAVATION/THICKENING/FIXATION/ON-SITE NONHAZARDOUS LANDFILL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/Construction | Estimated Quantities | Description |
|---|---|---|
| X. ON-SITE HAZARDOUS LANDFILL (Cont'd) | | |
| o Geotextile Cloth | 208,309 sf | Polypropylene cloth to allow filtration of leachate into sand layer. |
| o Drainage Layer | 11,463 cy | 1 ft thick sand layer |
| o Top Soil | 23,860 cy | 2 ft thick topsoil |
| o Vegetation (Grass Seeding) | 6.84 acres | |
| 4. Drainage Ditch | 3,032 ft | Top Width = 14 ft, Total Depth = 2 ft<br>Side Slope = 3:1, Bottom Width = 2 ft |
| o Clay Layer | 8,723 cy | 2 ft thick clay (permeability = $10^{-7}$ cm/sec) |
| o Topsoil | 2,906 cy | 2 ft thick topsoil |
| o Vegetation (Grass Seeding) | 0.76 acres | |
| XI. PROCESS PIPING AND I&C | Same as Alt. 2A, Item XI | Same as Alt. 2A, Item XI |
| XII. ELECTRICAL | Same as Alt. 2A, Item XII | Same as Alt. 2A, Item XII |
| XIII. BUILDINGS, PLATFORMS & STAIRS | Same as Alt. 2A, Item XIII | Same as Alt. 2A, Item XIII |
| XIV. FOUNDATIONS & PADS | Same as Alt. 2A, Item XIV | Same as Alt. 2A, Item XIV |

TABLE A-4

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| I. SITE PREPARATION | Same as Alt. 2A, Item I | Same as Alt. 2A, Item I |
| II. SUPPORT FACILITIES | Same as Alt. 2A, Item II | Same as Alt. 2A, Item II |
| III. SEDIMENT HYDRAULIC DREDGING | Same as Alt. 2A, Item III | Same as Alt. 2A, Item III |
| IV. SEDIMENT EXCAVATION | Same as Alt. 2A, Item IV | Same as Alt. 2A, Item IV |
| V. SEDIMENT EXTRACTION SYSTEM | | |
| 1. Primary Mixing Tank and Mixer | 2 | Two 120,000 gallon steel tanks with mixers. |
| 2. Primary Separator | 1 | 14-6 in. soft rubber lined hydroclones mounted in parallel. 7 operating, 7 on stand-by. |
| 3. Primary Slurry Pumps | 2 | 500 gpm, diaphragm pumps. 1 operating, 1 standby. |
| 4. Water Feeding Pumps | 2 | Each 200 gpm, metering pumps |
| 5. Piping | 1,000 lf | 6 in. dia. (insulated). |
| 6. Secondary Mixing Tank and Mixer | 2 | Two 60,000 gallon steel tanks with mixers. |
| 7. Secondary Separator | 1 | Same as above. |
| 8. Secondary Slurry Pumps | 2 | Each 500 gpm, diaphragm pumps. 1 operating, 1 standby. |
| 9. Process Water Delivery System | 1 | Includes tank, pump, piping and high pressure water system. |
| 10. Soil Belt Conveyor and Hopper | 3 | Double vibrating screen hopper 45° belt is completely enclosed and capable of reaching 25 ft. elevation. |

TABLE A-4 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| VI. EXTRACTANT TREATMENT SYSTEM | | |
| 1. Extractant Oxidation | | |
| o Reactor Tanks | 2 | Two 30 ft dia 12 ft sidewall reactor tanks, open top epoxy lined steel tank, 4 baffles - 90° apart, 12 ft deep, 1 ft wide, top to contain agitation mounting. |
| o Agitators | 2 | Two agitators, 2 - four pitch blade turbine impellers, top mounted, shaft 12 ft, stainless steel. |
| o Acid Feeders | 2 | Metering pumps, 40 gph, stainless steel. |
| o Acid Storage Tank | 1 | 3,000 gal carbon steel, horizontal tank, rubber lined. |
| o Potassium Permanganate Silo | 1 | 2,000 gal steel tank, elevated steel structure support. |
| o Potassium Permanganate Feeder | 2 | Each 1.0 lb/min adjustable, loss in weight type dry feeders. |
| 2. Extractant Coagulation/Flocculation/ Precipitation | | |
| o Coagulator - Clarifiers | 2 | Each 48 ft dia coagulator/clarifier, 12 ft sidewall depth, bottom slope 3 in/ft, concrete bottom, steel tank epoxy lined, heavy duty rake mechanism. |
| o Sludge Pumps | 2 | Four 10 gpm, diaphragm pumps. |
| o Water Pumps | 4 | 200 gpm, TDH = 25 ft, HP = 4.2 |
| o Ferric Chloride Storage Tank | 1 | 12 ft dia, 15 ft vertical, cone roof, steel bottom, carbon steel tank, rubber lined. |
| o Ferric Chloride Feeders | 2 | 30 gph metering pumps, Teflon lined. |
| o Polymer Feeders | 2 | 20 gph metering pump each, stainless steel 316. |

TABLE A-4 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| VI. EXTRACTANT TREATMENT SYSTEM (Cont'd) | | |
| o Polymer Day Tank | 1 | 200 gal day tank, fiberglass reinforced polyester. |
| o Caustic Storage Tank | 1 | 1,000 gal steel tank, rubber lined. |
| o Caustic Feeders | 2 | 40 gph, metering pumps stainless steel 316. |
| VII. OFF-SITE NONHAZARDOUS DISPOSAL | 91,728 ton | Trucked to nonhazardous landfill sites (within 100 miles from river), 150 ton/day. |
| VIII. OFF-SITE HAZARDOUS DISPOSAL | 7,415 ton | Trucked to RCRA "C" landfill sites |
| IX. PROCESS PIPING AND I&C | | For the above treatment facilities. |
| X. ELECTRICAL | | For the above treatment facilities |
| XI. BUILDINGS, PLATFORMS & STAIRS | | For the above treatment facilities |
| XII. FOUNDATIONS & PADS | | For the above treatment facilities |

TABLE A-5

ALTERNATIVE 3B - DREDGING/EXCAVATION/THICKENING/EXTRACTION/SEDIMENTS TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| I. SITE PREPARATION | Same as Alt. 2A, Item I | Same as Alt. 2A, Item I |
| II. SUPPORT FACILITIES | Same as Alt. 2A, Item II | Same as Alt. 2A, Item II |
| III. SEDIMENT HYDRAULIC DREDGING | Same as Alt. 2A, Item III | Same as Alt. 2A, Item III |
| IV. SEDIMENT EXCAVATION | Same as Alt. 3A, Item IV | Same as Alt. 3A, Item IV |
| V. SEDIMENT CHEMICAL EXTRACTION SYSTEM | Same as Alt. 3A, Item VI | Same as Alt. 3A, Item VI |
| VI. EXTRACTANT TREATMENT SYSTEM | Same as Alt. 3A, Item V | Same as Alt. 3A, Item V |
| VII. ON-SITE NONHAZARDOUS LANDFILL | Same as Alt. 3A, Item VI | Same as Alt. 3A, Item VI |
| 1. Liner System | | |
| o Clay Layer | 14,510 cy | 2 ft thick clay (permeability $10^{-7}$ cm/sec) |
| o Synthetic Liner | 192,694 sf | 60 mil high density polyethylene (HDPE) |
| o Geotextile Cloth | 180,149 sf | Polypropylene cloth to allow filtration of leachate into sand layer. |
| o Leachate Collection System | | |
| - PVC Pipe | 1,927 ft | 6 in. dia perforated |
| - RC Sump | 2 | 4 ft dia, 5 ft deep |
| - Pumps | 2 | 25 gpm each, chemical resistant |
| o Sand Layer | 13,807 cy | 2 ft thick sand layer |
| 2. Processed Sediment Hauling, Deposition and Compaction | 61,130 cy | 100 cy/day |
| 3. Capping System | | |
| o Clay Layer | 13,634 cy | 2 ft thick clay (permeability $10^{-7}$ cm/sec) |
| o Geotextile Cloth | 127,257 cy | Polypropylene cloth to allow filtration of leachate into sand layer. |
| o Drainage Layer | 7,139 cy | 1 ft thick sand layer |

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TABLE A-5 (Cont'd)

ALTERNATIVE 3B - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION COMPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| VII. ON-SITE NONHAZARDOUS LANDFILL (Cont'd) | | |
| o Topsoil | 14,884 cy | 6 in. topsoil |
| o Vegetation | 4.22 acres | |
| 4. Drainage Ditch | 2,067 ft | Top Width - 20 ft, Total Depth = 2 ft Bottom Width - 2 ft, Side Slope - 2:1 |
| o Clay Layer | 5,947 cy | 2 ft thick clay (permeability - $10^{-7}$ cm/sec) |
| o Topsoil | 1,981 cy | 2 ft thick topsoil |
| o Vegetation | 0.52 acres | Grass Seeding |
| VIII. OFF-SITE HAZARDOUS DISPOSAL | Same as Alt. 3A, Item VIII | Same as Alt. 3A, Item VIII |
| IX. PROCESS PIPING AND I&C | Same as Alt. 3A, Item IX | Same as Alt. 3A, Item IX |
| X. ELECTRICAL | Same as Alt. 3A, Item X | Same as Alt. 3A, Item X |
| XI. BUILDINGS, PLATFORMS AND STAIRS | Same as Alt. 3A, Item XI | Same as Alt. 3A, Item XI |
| XII. FOUNDATIONS AND PADS | Same as Alt. 3A, Item XII | Same as Alt. 3A, Item XII |

TABLE A-6

ALTERNATIVE 3C - DREDGING/EXCAVATION/EXTRACTION/FLOODPLAIN DEPOSITION OF SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL
MAJOR FACILITIES AND CONSTRUCTION CONPONENTS

| Facility/ Construction | Estimated Quantities | Description |
|---|---|---|
| I. SITE PREPARATION | Same as Alt. 2A, Item I | Same as Alt. 2A, Item I |
| II. SUPPORT FACILITIES | Same as Alt. 2A, Item II | Same as Alt. 2A, Item II |
| III. SEDIMENT HYDRAULIC DREDGING | Same as Alt. 3A, Item III | Same as Alt. 3A, Item III |
| IV. SEDIMENT EXCAVATION | Same as Alt. 3A, Item IV | Same as Alt. 3A, Item IV |
| V. SEDIMENT EXTRACTION SYSTEM | Same as Alt. 3A, Item VI | Same as Alt. 3A, Item VI |
| VI. EXTRACTANT TREATMENT SYSTEM | Same as Alt. 3A, Item V | Same as Alt. 3A, Item V |
| VII. FLOODPLAIN DEPOSITION | | Treated sediments to be deposited in the floodplain |
| 1. Deposition/Compaction/Grading | 52,806 cy | Treated sediments to be deposited in the floodplain |
| 2. Topsoil | 12,756 cy | One foot depth of topsoil placed above treated sediments |
| 3. Vegetation | 8 acres | Grass seeding |
| VIII. PLANT SITE DEPOSITION | | |
| 1. Deposition/Compaction/Grading | 8,325 cy | Treated sediments deposited on plant site |
| 2. Topsoil | 27,210 cy | One foot depth of topsoil placed above treated sediments |
| 3. Vegetation | 17 acres | Grass seeding |
| IX. OFF-SITE HAZARDOUS DISPOSAL | Same as Atl. 3A, Item VIII | Same as Atl. 3A, Item VIII |
| X. PROCESS PIPING I&C | Same as Alt. 3A, Item IX | Same as Alt. 3A, Item IX |
| XI. ELECTRICAL | Same as Alt. 3A, Item X | Same as Alt. 3A, Item X |
| XII. BUILDINGS, PLATFORMS AND STAIRS | Same as Alt. 3A, Item XI | Same as Alt. 3A, Item XI |
| XIII. FOUNDATIONS AND PADS | Same as Alt. 3A, Item XII | Same as Alt. 3A, Item XII |

APPENDIX B

# APPENDIX B

## DETAILED BREAKDOWN OF CAPITAL AND OPERATION AND MAINTENANCE COST ESTIMATES

TABLE B-1

ALTERNATIVE 1 - NO ACTION

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| I. POSTING OF WARNING SIGNS | 75 | 100.00 | 7,500 | 100.00 | 7,500 | 15,000 |
| II. PUBLIC AWARENESS PROGRAM | 2 | | | 10,000.00 | 20,000 | 20,000 |

| | |
|---|---|
| Total Direct Construction Cost (TDCC) | 35,000 |
| Contingency @20% of TDCC | 7,000 |
| Engineering @5% of TDCC | 1,750 |
| Legal and Administrative @ 2% of TDCC | 700 |
| Total Construction Cost | 44,450 |

TABLE B-2

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| I. SITE PREPARATION | | | | | | |
| 1. Parking Area (included in 2.) | | | | | | |
| 2. Equipment Parking and Storage Area | 1,110 sy | 7.50 | 8,325 | 6.78 | 7,526 | 15,851 |
| 3. Security Fence and Gate | 1,000 lf | 17.60 | 17,600 | 33.15 | 33,150 | 50,750 |
| 4. Access Road | 8,333 sy | 11.70 | 97,496 | 14.94 | 124,495 | 221,991 |
| | | | | | | 288,592 |
| II. SUPPORT FACILITIES | 5 trailers | 15,600.00 | 78,000 | | | 78,000 |
| III. SEDIMENT HYDRAULIC DREDGING | 75,303 cy | | | 5.76 | 433,746 | 433,746 |
| IV. SEDIMENT EXCAVATION | | | | | | |
| 1. Excavation | 56,170 cy | | | 13.30 | 747,061 | 747,061 |
| 2. Clean Fill | 44,936 cy | 10.00 | 449,360 | 4.54 | 204,009 | 653,369 |
| 3. Topsoil | 11,234 cy | 16.10 | 180,867 | 4.54 | 51,002 | 231,870 |
| 4. Vegetation | 8 acres | 1,100.00 | 8,800 | 668.00 | 5,344 | 14,144 |
| | | | | | | 1,646,444 |
| V. HOLDING TANKS AND MIXERS | 2 | 115,000.00 | 230,000 | 45,500.00 | 91,000 | 321,000 |
| VI. SEDIMENT THICKENING SYSTEM | | | | | | |
| 1. Separator | 1 | 63,000.00 | 63,000 | 10,000.00 | 10,000 | 73,000 |
| 2. Slurry Pump | 2 | 17,600.00 | 35,200 | 5,900.00 | 11,800 | 47,000 |
| | | | | | | 120,000 |

TABLE B-2 (Continued)

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| VII. SUPERNATANT TREATMENT SYSTEM | | | | | | |
| 1. Coagulator - Clarifier | 2 | 92,740.00 | 185,480 | 24,300.00 | 48,600 | 234,080 |
| 2. Sludge Pump | 2 | 3,200.00 | 6,400 | 890.00 | 1,780 | 8,180 |
| 3. Coagulant Feeding Pump | 2 | 1,900.00 | 3,800 | 510.00 | 1,020 | 4,820 |
| 4. Coagulant Day Tank | 1 | 6,000.00 | 6,000 | 2,295.00 | 2,295 | 8,295 |
| 5. Polymer Feeding Pump | 2 | 1,200.00 | 2,400 | 510.00 | 1,020 | 3,420 |
| 6. Polymer Day Tank | 1 | 4,000.00 | 4,400 | 2,040.00 | 2,040 | 6,440 |
| 7. Ferric Chloride Feeding Pump | 2 | 1,900.00 | 3,800 | 765.00 | 1,530 | 5,330 |
| 8. Ferric Chloride Day Tank | 1 | 6,000.00 | 6,000 | 2,295.00 | 2,295 | 8,295 |
| | | | | | | 278,860 |
| VIII. CHEMICAL FIXATION SYSTEM | | | | | | |
| 1. Slurry Mixing Tank | 2 | 10,970.00 | 21,940 | 4,210.00 | 8,420 | 30,360 |
| 2. Mixer | 2 | | | Included with Slurry Mixing Tank | | |
| 3. Chemical Tank (K-20 LSC) | 1 | 10,000.00 | 10,000 | 3,825.00 | 3,825 | 13,825 |
| 4. Chemical Feeding Pump | 2 | 1,900.00 | 3,800 | 765.00 | 1,530 | 5,330 |
| 5. Carbon Powder Silo | 1 | 4,500.00 | 4,500 | 1,785.00 | 1,785 | 6,285 |
| 6. Carbon Powder Feeding System | 2 | 21,000.00 | 42,000 | 1,275.00 | 2,550 | 44,550 |
| 7. Portland Cement Silo | 1 | 33,000.00 | 33,000 | 51,000.00 | 51,000 | 84,000 |
| 8. Portland Cement Feeding System | 2 | 17,500.00 | 35,000 | 1,275.00 | 2,550 | 37,550 |
| 9. Fly Ash Silo | 1 | 16,000.00 | 16,000 | 25,500.00 | 25,500 | 41,500 |

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TABLE B-2 (Continued)

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/OFF-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| VIII. CHEMICAL FIXATION SYSTEM (cont'd) | | | | | | |
| 10. Fly Ash Feeding System | 2 | 15,000.00 | 30,000 | 1,275.00 | 2,550 | 32,550 |
| 11. Sludge Pump | 2 | 8,550.00 | 17,100 | 3,250.00 | 6,500 | 23,600 |
| 12. Process Water Delivery System | 1 | 36,000.00 | 36,000 | 27,400.00 | 27,400 | 63,400 |
| 13. Soil Belt Conveyor and Hopper | 3 | 34,550.00 | 103,650 | 10,660.00 | 31,980 | 135,630 |
| | | | | | | 518,580 |
| IX. FIXATED SEDIMENT CURING SYSTEM | | | | | | |
| 1. Curing Basin Dike | 600 ft | 2.45 | 1,470 | 17.85 | 10,710 | 12,180 |
| 2. Clay Layer | 850 cy | 20.00 | 17,000 | 10.00 | 8,500 | 25,500 |
| | | | | | | 37,680 |
| X. OFF-SITE NONHAZARDOUS DISPOSAL* | 182,775 ton | | | 100.00 | 18,277,467 | 18,277,467 |
| XI. PROCESS PIPING AND I&C | LS | | 38,000 | | 63,750 | 101,750 |
| XII. ELECTRICAL | LS | | 200,000 | | 173,400 | 373,400 |
| XIII. BUILDINGS, PLATFORMS AND STAIRS | LS | | 180,000 | | 45,900 | 225,900 |
| XIV. FOUNDATIONS AND PADS | LS | | 36,000 | | 142,800 | 178,800 |

* If the fixated sediments must be disposed of as hazardous materials, the unit cost is $230/ton with a disposal cost of $42,083,458 for the 182,775 tons, and a total alternative cost of $59,233,975.

| | |
|---|---|
| Total Direct Construction Cost (TDCC) | 22,880,219 |
| Contingency @20% of TDCC | 4,576,044 |
| Engineering @5% of TDCC | 1,144,011 |
| Legal and Administrative @ 2% of TDCC | 457,604 |
| Total Construction Cost | 29,057,878 |

TABLE B-3

ALTERNATIVE 2B - DREDGING/EXCAVATION/THICKENING/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| I. SITE PREPARATION (See Table B-2) | | | | | | 288,592 |
| II. SUPPORT FACILITIES (See Table B-2) | | | | | | 78,000 |
| III. SEDIMENT HYDRAULIC DREDGING (See Table B-2) | | | | | | 433,746 |
| IV. SEDIMENT EXCAVATION (See Table B-2) | | | | | | 1,646,444 |
| V. HOLDING TANKS AND MIXERS (See Table B-2) | | | | | | 321,000 |
| VI. SEDIMENT THICKENING SYSTEM (See Table B-2) | | | | | | 120,000 |
| VII. SUPERNATANT TREATMENT SYSTEM (See Table B-2) | | | | | | 278,860 |
| VIII. CHEMICAL FIXATION SYSTEM (See Table B-2) | | | | | | 518,580 |
| IX. FIXATED SEDIMENT CURING SYSTEM (See Table B-2) | | | | | | 37,680 |
| X. ON-SITE NONHAZARDOUS LANDFILL | | | | | | |
| 1. Liner System | | | | | | |
| o Clay Layer (2 ft thick) | 22,979 cy | 20.00 | 459,585 | 10.00 | 229,793 | 689,378 |
| o Synthetic Liner | 305,588 sf | (Includes Material) | | 0.90 | 275,029 | 275,029 |

TABLE B-3 (Continued)

ALTERNATIVE 2B - DREDGING/EXCAVATION/THICKENING/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| X. ON-SITE NONHAZARDOUS LANDFILL (cont'd) | | | | | | |
| o Geotextile Cloth | 287,253 sf | | (Includes Material) | 0.26 | 74,686 | 74,686 |
| o Leachate Collection System | | | | | | |
| - PVC Pipe | 3,056 ft | 0.85 | 2,597 | 4.59 | 14,026 | 16,624 |
| - RC Sumps | 2 | 600.00 | 1,200 | 1,020.00 | 2,040 | 3,240 |
| - Pumps | 2 | 5,500.00 | 11,000 | 1,530.00 | 3,060 | 14,060 |
| o Sand Layer (2 ft thick) | 21,955 cy | 12.75 | 279,930 | 2.30 | 50,497 | 330,427 |
| 2. Fixated Sediment Hauling, Deposition and Compaction | 101,013 cy | | | 8.25 | 833,358 | 833,358 |
| 3. Capping System | | | | | | |
| o Clay Layer (2 ft thick) | 21,933 cy | 20.00 | 438,652 | 10.00 | 219,326 | 657,978 |
| o Geotextile Cloth | 208,309 sf | | (Includes Material) | 0.26 | 54,160 | 54,160 |
| o Drainage Layer (1 ft thick) | 11,463 cy | 12.75 | 146,156 | 2.30 | 26,365 | 172,522 |
| o Topsoil (2 ft thick) | 23,860 cy | 16.10 | 384,153 | 4.54 | 108,326 | 492,479 |
| o Vegetation (Grass Seeding) | 6.84 acres | 1,100.00 | 7,523 | 668.00 | 4,569 | 12,092 |
| 4. Drainage Ditch | 3,032 ft | | | 4.59 | 13,916 | 13,916 |
| o Clay Layer | 8,723 cy | 20.00 | 174,453 | 22.95 | 200,185 | 374,639 |
| o Topsoil | 2,906 cy | 16.10 | 46,787 | 6.63 | 19,267 | 66,054 |
| o Vegetation (Grass Seeding) | 0.76 acres | 1,100.00 | 838 | 668.00 | 509 | 1,346 |
| | | | | | | 4,081,988 |
| XI. PROCESS PIPING AND I&C (See Table B-2) | | | | | | 101,750 |
| XII. ELECTRICAL (See Table B-2) | | | | | | 373,400 |

TABLE B-3 (Continued)

ALTERNATIVE 2B - DREDGING/EXCAVATION/THICKENING/FIXATION/ON-SITE NONHAZARDOUS LANDFILL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| XIII. BUILDINGS, PLATFORMS AND STAIRS (See Table B-2) | | | | | | 225,900 |
| XIV. FOUNDATIONS AND PADS (See Table B-2) | | | | | | 178,800 |

* If the fixated sediments must be disposed of as hazardous materials the cost of the on-site landfill is increased $448,470 for a total on-site landfill cost of $4,530,458 and a total alternative cost of $11,599,178.

| | |
|---|---|
| Total Direct Construction Cost (TDCC) | 8,684,740 |
| Contingency @20% of TDCC | 1,736,948 |
| Engineering @5% of TDCC | 434,237 |
| Legal and Administrative @ 2% of TDCC | 173,695 |
| Total Construction Cost | 11,029,620 |

TABLE B-4

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| I. SITE PREPARATION (See Table B-2) | | | | | | 288,592 |
| II. SUPPORT FACILITIES (See Table B-2) | | | | | | 78,000 |
| III. SEDIMENT HYDRAULIC DREDGING (See Table B-2) | | | | | | 433,746 |
| IV. SEDIMENT EXCAVATION (See Table B-2) | | | | | | 1,646,444 |
| V. SEDIMENT EXTRACTION SYSTEM | | | | | | |
| 1. Primary Mixing Tanks and Mixer | 2 | 115,000.00 | 230,000 | 45,500.00 | 91,000 | 321,000 |
| 2. Primary Separator | 1 | 63,000.00 | 63,000 | 10,000.00 | 10,000 | 73,000 |
| 3. Primary Slurry Pump | 2 | 17,600.00 | 35,200 | 5,900.00 | 11,800 | 47,000 |
| 4. Water Feeding Pump | 2 | 4,700.00 | 9,400 | 1,300.00 | 2,600 | 12,000 |
| 5. Piping | 1,000 lf | 20.00 | 20,000 | 60.00 | 60,000 | 80,000 |
| 6. Secondary Mixing Tank | 2 | 70,000.00 | 140,000 | 30,000.00 | 60,000 | 200,000 |
| 7. Separator | 1 | 63,000.00 | 63,000 | 10,000.00 | 10,000 | 73,000 |
| 8. Secondary Slurry Pump | 2 | 17,600.00 | 35,200 | 5,900.00 | 11,800 | 47,000 |
| 9. Process Water Delivery System | 1 | 36,000.00 | 36,000 | 27,400.00 | 27,400 | 63,400 |
| 10. Soil Belt Conveyor and Hopper | 3 | 34,550.00 | 103,650 | 10,660.00 | 31,980 | 135,630 |
| | | | | | | 1,052,030 |
| VI. EXTRACTANT TREATMENT SYSTEM | | | | | | |
| 1. Extractant Oxidation | | | | | | |
| o Reactor Tank | 2 | 29,900.00 | 59,800 | 38,130.00 | 76,260 | 136,060 |

TABLE B-4 (Continued)

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| VI. EXTRACTANT TREATMENT SYSTEM (cont'd) | | | | | | |
| o Agitator | 2 | 11,000.00 | 22,000 | 1,530.00 | 3,060 | 25,060 |
| o Acid Feeder | 2 | 2,500.00 | 5,000 | 510.00 | 1,020 | 6,020 |
| o Acid Storage Tank | 1 | 6,000.00 | 6,000 | 1,530.00 | 1,530 | 7,530 |
| o Potassium Permanganate Silo | 1 | 5,000.00 | 5,000 | 1,785.00 | 1,785 | 6,785 |
| o Potassium Permanganate Feeder | 2 | 30,000.00 | 60,000 | 1,275.00 | 2,550 | 62,550 |
| 2. Extractant Coagulation/Flocculation/ Precipitation | | | | | | |
| o Coagulator - Clarifier | 2 | 491,750.00 | 983,500 | 179,140 | 358,280 | 1,341,780 |
| o Sludge Pump | 2 | 5,500.00 | 11,000 | 2,040 | 4,080 | 15,080 |
| o Water Pump | 4 | 4,700.00 | 18,800 | 1,300 | 5,200 | 24,000 |
| o Ferric Chloride Storage Tank | 1 | 9,500.00 | 9,500 | 7,650 | 7,650 | 17,150 |
| o Ferric Chloride Feeder | 2 | 2,900.00 | 5,800 | 510 | 1,020 | 6,820 |
| o Polymer Feeder | 2 | 1,200.00 | 2,400 | 510 | 1,020 | 3,420 |
| o Polymer Day Tank | 1 | 4,400.00 | 4,400 | 2,040 | 2,040 | 6,440 |
| o Caustic Storage Tank | 1 | 15,000.00 | 15,000 | 4,000 | 4,000 | 19,000 |
| o Caustic Feeder | 2 | 2,500.00 | 5,000 | 510 | 1,020 | 6,020 |
| | | | | | | 1,683,715 |
| VII. OFF-SITE NONHAZARDOUS DISPOSAL | 91,728 ton | | | 100 | 9,172,764 | 9,172,764 |
| VIII. OFF-SITE HAZARDOUS DISPOSAL | 7,415 ton | | | 230 | 1,705,555 | 1,705,555 |
| IX. PROCESS PIPING AND I&C | LS | | 60,800 | | 103,000 | 163,800 |

TABLE B-4 (Continued)

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENT TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| XII. ELECTRICAL | LS | | 200,000 | | 173,400 | 373,400 |
| XIII. BUILDINGS, PLATFORMS AND STAIRS | LS | | 219,000 | | 49,400 | 268,400 |
| XIV. FOUNDATIONS AND PADS | LS | | 36,700 | | 145,600 | 182,300 |

^ If the extracted sediments must be disposed of as hazardous materials, the unit cost is $230/ton with a disposal cost of $21,097,357 for the 91,728 tons, and a total alternative cost of $36,796,141.

| | |
|---|---|
| Total Direct Construction Cost (TDCC) | 17,048,746 |
| Contingency @20% of TDCC | 3,409,749 |
| Engineering @5% of TDCC | 852,437 |
| Legal and Administrative @ 2% of TDCC | 340,975 |
| Total Construction Cost | 21,651,908 |

TABLE B-5

ALTERNATIVE 3B - DREDGING/EXCAVATION/EXTRACTION/SEDIMENT TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| I. SITE PREPARATION (See Table B-2) | | | | | | 288,592 |
| II. SUPPORT FACILITIES (See Table B-2) | | | | | | 78,000 |
| III. SEDIMENT HYDRAULIC DREDGING (See Table B-2) | | | | | | 433,746 |
| IV. SEDIMENT EXCAVATION (See Table B-2) | | | | | | 1,646,444 |
| V. SEDIMENT EXTRACTION SYSTEM (See Table B-4) | | | | | | 1,052,030 |
| VI. EXTRACTANT TREATMENT SYSTEM (See Table B-4) | | | | | | 1,683,715 |
| VII. ON-SITE NONHAZARDOUS LANDFILL | | | | | | |
| 1. Liner System | | | | | | |
| o Clay Layer | 14,510 cy | 20.00 | 290,191 | 10.00 | 145,095 | 435,286 |
| o Synthetic Liner | 192,694 sf | | (Includes Material) | 0.90 | 173,425 | 173,425 |
| o Geotextile Cloth | 180,149 sf | | (Includes Material) | 0.26 | 46,839 | 46,839 |
| o Leachate Collection System | | | | | | |
| - PVC Pipe | 1,927 ft | 0.85 | 1,638 | 4.59 | 8,845 | 10,483 |
| - RC Sumps | 2 | 600.00 | 1,200 | 1,020.00 | 2,040 | 3,240 |
| - Pumps | 2 | 5,500.00 | 11,000 | 1,530.00 | 3,060 | 14,060 |
| o Sand Layer | 13,807 cy | 12.75 | 176,042 | 2.30 | 31,757 | 207,799 |
| 2. Extracted Sediment Hauling, Deposition and Compaction | 61,130 cy | | | 8.25 | 504,326 | 504,326 |
| 3. Capping System | | | | | | |
| o Clay Layer | 13,634 cy | 20.00 | 272,674 | 10.00 | 136,337 | 409,011 |

TABLE B-5 (Continued)

ALTERNATIVE 3B - DREDGING/EXCAVATION/EXTRACTION/SEDIMENT TO ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| VII. ON-SITE NONHAZARDOUS LANDFILL (cont'd) | | | | | | |
| o Geotextile Cloth | 127,257 sf | | (Includes Material) | 0.26 | 33,087 | 33,087 |
| o Drainage Layer | 7,139 cy | 12.75 | 91,023 | 2.30 | 16,420 | 107,443 |
| o Topsoil | 14,884 cy | 16.10 | 239,626 | 4.54 | 67,572 | 307,197 |
| o Vegetation (Grass Seeding) | 4.22 acres | 1,100.00 | 4,642 | 668.00 | 2,819 | 7,460 |
| 4. Drainage Ditch | 2,067 ft | | | 4.59 | 9,487 | 9,487 |
| o Clay Layer | 5,947 cy | 20.00 | 118,933 | 22.95 | 136,476 | 255,408 |
| o Topsoil | 1,981 cy | 16.10 | 31,897 | 6.63 | 13,135 | 45,032 |
| o Vegetation (Grass Seeding) | 0.52 acres | 1,100.00 | 571 | 668.00 | 347 | 918 |
| | | | | | | 2,570,501 |
| VIII. OFF-SITE HAZARDOUS DISPOSAL (See Table B-4) | | | | | | 1,705,555 |
| IX. PROCESS PIPING AND I&C (See Table B-4) | | | | | | 163,800 |
| X. ELECTRICAL (See Table B-4) | | | | | | 373,400 |
| XI. BUILDINGS, PLATFORMS AND STAIRS (See Table B-4) | | | | | | 268,400 |
| XII. FOUNDATIONS AND PADS (See Table B-4) | | | | | | 182,300 |

* If the extracted sediments must be disposed of as hazardous materials the cost of the on-site landfill is increased $327,588 for a total on-site landfill cost of $2,898,089 and a total alternative cost of $13,683,070.

| | |
|---|---|
| Total Direct Construction Cost (TDCC) | 10,446,483 |
| Contingency @20% of TDCC | 2,089,297 |
| Engineering @5% of TDCC | 522,324 |
| Legal and Administrative @ 2% of TDCC | 208,930 |
| Total Construction Cost | 13,267,033 |

TABLE B-6

ALTERNATIVE 3C - DREDGING/EXCAVATION/EXTRACTION/FLOODPLAIN REDEPOSITION OF SEDIMENTS/
PLANT SITE DEPOSITION OF RIVER SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| I. SITE PREPARATION (See Table B-2) | | | | | | 288,592 |
| II. SUPPORT FACILITIES (See Table B-2) | | | | | | 78,000 |
| III. SEDIMENT HYDRAULIC DREDGING (See Table B-2) | | | | | | 433,746 |
| IV. SEDIMENT EXCAVATION | 56,170 cy | | | 13.30 | 747,061 | 747,061 |
| V. SEDIMENT EXTRACTION SYSTEM (See Table B-4) | | | | | | 1,052,030 |
| VI. EXTRACTANT TREATMENT SYSTEM (See Table B-4) | | | | | | 1,683,715 |
| VII. FLOODPLAIN DEPOSITION | | | | | | |
| 1. Deposition/Compaction/Grading | 52,806 cy | | | 15.00 | 792,086 | 792,086 |
| 2. Topsoil | 12,756 cy | 16.10 | 205,372 | 4.54 | 57,912 | 263,284 |
| 3. Vegetation | 8 acres | 1,100.00 | 8,800 | 668.00 | 5,344 | 14,144 |
| | | | | | | 1,069,514 |
| VIII. PLANT SITE DEPOSITION | | | | | | |
| 1. Deposition/Compaction/Grading | 8,325 cy | | | 15.00 | 124,870 | 124,870 |
| 2. Topsoil | 27,210 cy | 16.10 | 438,081 | 4.54 | 123,533 | 561,614 |
| 3. Vegetation | 17 acres | 1,100.00 | 18,700 | 668.00 | 11,356 | 30,056 |
| | | | | | | 716,540 |
| IX. OFF-SITE HAZARDOUS DISPOSAL (See Table B-4) | | | | | | 1,705,555 |

TABLE B-6 (Continued)

ALTERNATIVE 3C - DREDGING/EXCAVATION/EXTRACTION/FLOODPLAIN REDEPOSITION OF SEDIMENTS/
PLANT SITE DEPOSITION OF RIVER SEDIMENTS/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

CAPITAL COST ESTIMATES (1989 DOLLARS)

| FACILITY/ CONSTRUCTION | ESTIMATED QUANTITIES | MATERIAL, $ UNIT PRICE | MATERIAL, $ COST | INSTALLATION,$ UNIT PRICE | INSTALLATION,$ COST | DIRECT CONSTRUCTION COST, $ |
|---|---|---|---|---|---|---|
| X. PROCESS PIPING AND I&C (See Table B-4) | | | | | | 163,800 |
| XI. ELECTRICAL (See Table B-4) | | | | | | 373,400 |
| XII. BUILDINGS, PLATFORMS AND STAIRS (See Table B-4) | | | | | | 268,400 |
| XIII. FOUNDATIONS AND PADS (See Table B-4) | | | | | | 182,300 |
| | | | Total Direct Construction Cost (TDCC) | | | 8,762,653 |
| | | | Contingency @20% of TDCC | | | 1,752,531 |
| | | | Engineering @5% of TDCC | | | 438,133 |
| | | | Legal and Administrative @ 2% of TDCC | | | 175,253 |
| | | | | Total Construction Cost | | 11,128,569 |

TABLE B-7

ALTERNATIVE 1 - NO ACTION

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| 1. Site Monitoring | | | |
| a. Visit Inspection & Report | 1 person<br>$60 /hr<br>40 hrs/yr | $2,400 | 1-30 |
| b. Ecological Survey & Sampling | 6 persons<br>$60 /hr<br>40 hrs/yr | $14,400 | 1-30 |
| c. Laboratory Analysis | 16 sediment samples<br>$400 /sample | $6,400 | 1-30 |
| | 16 water samples<br>$300 /sample | $4,800 | 1-30 |
| | 40 ecological samples<br>$200 /sample | $8,000 | 1-30 |
| d. Report | 2 persons<br>$60 /hr<br>40 hrs/yr | $4,800 | 1-30 |
| | SUBTOTAL | $40,800 | |
| 2. Public Information Seminar | 2 persons<br>$60 /hr<br>40 hrs/yr | $4,800 | 1-30 |
| 3. Maintenance | | | |
| a. Warning Signs | 10% of DCC | $1,500 | 1-30 |
| 4. Contingency | 5% of O&M Cost | $2,355 | 1-30 |
| TOTAL ANNUAL O&M COST | | $49,455 | 1-30 |

TABLE B-8

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/ OFF-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| A. Monitoring | | | |
| 1. Site Monitoring | | | |
| a. Visit Inspection & Report | 1 person<br>$60 /hr<br>40 hrs/yr | $2,400 | 4-33 |
| b. Laboratory Analysis | 16 sediment samples<br>$400 /sample | $6,400 | 4-33 |
| | 4 water samples<br>$300 /sample | $1,200 | 4-33 |
| c. Report | 1 person<br>$60 /hr<br>40 hrs/yr | $2,400 | 4-33 |
| 2. Monitoring Contingency | 5% of O&M Cost | $620 | 4-33 |
| TOTAL ANNUAL MONITORING O&M COST | | $13,020 | |
| B. Plant Operation | | | |
| 1. Chemicals | | | |
| a. Coagulant Alum | 0.99 tons<br>$425 /ton | $420 | 2-3 |
| b. Polymer | 0.02 tons<br>$4,000 /ton | $79 | 2-3 |
| c. Ferric Chloride | 0.99 tons<br>$860 /ton | $850 | 2-3 |
| d. K-20 LSC | 278,080 gal<br>$25 /gal | $6,951,990 | 2-3 |
| e. Activated Carbon | 3,708 tons<br>$1,600 /ton | $5,932,364 | 2-3 |
| f. Portland Cement | 33,370 tons<br>$70 /ton | $2,335,869 | 2-3 |
| g. Fly Ash | 11,123 tons<br>$50 /ton | $556,159 | 2-3 |
| | SUBTOTAL | $15,777,731 | 2-3 |

TABLE B-8 (Cont'd)

ALTERNATIVE 2A - DREDGING/EXCAVATION/THICKENING/FIXATION/ OFF-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| 2. Manpower | | | |
| a. Supervision | 1 person<br>$45 /hr<br>8 hrs/day<br>365 days/yr | $131,400 | 2-3 |
| b. Operators | 7 person<br>$30 /hr<br>8 hrs/day<br>365 days/yr | $613,200 | 2-3 |
| | SUBTOTAL | $744,600 | 2-3 |
| 3. Power | | | |
| a. Operating Equipment | 134 kw<br>24 hrs/day<br>365 days/yr<br>$0.10 /kwhr | $117,384 | 2-3 |
| b. Lighting and Trailers | 6 kw<br>24 hrs/day<br>365 days/yr<br>$0.10 /kwhr | $5,256 | 2-3 |
| | SUBTOTAL | $122,640 | 2-3 |
| 4. Maintenance | 8% of TCC excluding off-site disposal and backfill costs | $300,361 | 2-3 |
| 5. Plant Operation Contingency | 5% of O&M Cost | $847,267 | 2-3 |
| TOTAL ANNUAL PLANT OPERATING COST | | $17,792,599 | 2-3 |

TABLE B-9

ALTERNATIVE 2B - DREDGING/EXCAVATION/THICKENING/FIXATION/ ON-SITE NONHAZARDOUS LANDFILL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| A. Monitoring and Landfill Maintenance | | | |
| 1. Landfill Monitoring | | | |
| a. Visit Inspection | 2 persons<br>$30 /hr<br>8 hrs/visit<br>2 visits/yr | $960 | 4-33 |
| b. Laboratory Analysis | 4 leachate samples<br>$1,000 /sample<br>2 times/yr | $8,000 | 4-33 |
| c. Report | 1 person<br>$60 /hr<br>8 hrs<br>2 times/yr | $960 | 4-33 |
| | SUBTOTAL | $9,920 | 4-33 |
| 2. Landfill Maintenance | | | |
| a. Liner System | 2% of DCC | $28,069 | 4-33 |
| b. Cap & Site Repair | 2% of DCC | $27,785 | 4-33 |
| c. Drainage Ditch Repair | 2% of DCC | $9,119 | 4-33 |
| d. Leachate Disposal | 1,010 gal<br>$1.00 /gal | $1,010 | 4-33 |
| | SUBTOTAL | $65,983 | 4-33 |
| 3. Monitoring and Landfill Maintenance Contingency | 5% of O&M Cost | $3,795 | 4-33 |
| TOTAL ANNUAL MONITORING O&M COST | | $79,698 | 4-33 |
| B. Plant Operation | | | |
| | Same as Alt. 2A<br>See Table B-8 | | |
| TOTAL ANNUAL PLANT OPERATING COST | | $17,792,599 | 2-3 |

TABLE B-10

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| C. Monitoring | | | |
| | Same as Alt. 2A<br>See Table B-8 | | |
| TOTAL ANNUAL MONITORING O&M COST | | $13,020 | 2-3 |
| D. Plant Operation | | | |
| a. Polymer | 0.20 tons<br>$4,000 /ton | $802 | 2-3 |
| b. Ferric Chloride | 72.21 tons<br>$860 /ton | $62,100 | 2-3 |
| c. Hydrochloric Acid | 73.21 tons<br>$320 /ton | $23,428 | 2-3 |
| d. Potassium Permanganate | 11.28 tons<br>$2,800 /ton | $31,597 | 2-3 |
| e. Sodium Hydroxide | 79.79 tons<br>$540 /ton | $43,087 | 2-3 |
| | SUBTOTAL | $161,015 | 2-3 |

TABLE B-10 (Cont'd)

ALTERNATIVE 3A - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO OFF-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| 2. Manpower | Same as Alt. 2A See Table B-8 | | |
| | SUBTOTAL | $744,600 | 2-3 |
| 3. Power | | | |
| a. Operating Equipment | 164 kw<br>24 hrs/day<br>365 days/yr<br>$0.10 /kwhr | $143,664 | 2-3 |
| b. Lighting and Trailers | 6 kw<br>24 hrs/day<br>365 days/yr<br>$0.10 /kwhr | $5,256 | 2-3 |
| | SUBTOTAL | $148,920 | 2-3 |
| 4. Maintenance | 8% of TCC excluding off-site disposal and backfill costs | $459,637 | 2-3 |
| 5. Plant Operation Contingency | 5% of O&M Cost | $75,709 | 2-3 |
| TOTAL ANNUAL PLANT OPERATING COST | | $1,589,880 | 2-3 |

TABLE B-11

ALTERNATIVE 3B - DREDGING/EXCAVATION/EXTRACTION/SEDIMENTS TO/ ON-SITE NONHAZARDOUS LANDFILL/OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| A. Monitoring and Landfill Maintenance | | | |
| 1. Landfill Monitoring | Same as Alt. 2B See Table B-9 | $9,920 | 4-33 |
| 2. Landfill Maintenance | | | |
| a. Liner System | 2% of DCC | $17,823 | 4-33 |
| b. Cap & Site Repair | 2% of DCC | $17,284 | 4-33 |
| c. Drainage Ditch Repair | 2% of DCC | $6,217 | 4-33 |
| d. Leachate Disposal | 611 gal $1.00 /gal | $611 | 4-33 |
| | SUBTOTAL | $41,935 | 4-33 |
| 3. Monitoring and Landfill Maintenance Contingency | 5% of O&M Cost | $2,593 | 4-33 |
| TOTAL ANNUAL MONITORING O&M COST | | $54,448 | 4-33 |
| B. Plant Operation | Same as Alt. 3A See Table B-10 | | |
| TOTAL ANNUAL PLANT OPERATING COST | | $1,589,880 | 2-3 |

TABLE B-12

ALTERNATIVE 3C - DREDGING/EXCAVATION/EXTRACTION/
FLOODPLAIN REDEPOSITION OF SEDIMENTS/
SITE DEPOSITION OF RIVER SEDIMENTS/
OFF-SITE HAZARDOUS SLUDGE DISPOSAL

ANNUAL OPERATION AND MAINTENANCE COST ESTIMATES (1989 DOLLARS)

| COST COMPONENT | BASIS OF ESTIMATE | O&M COST ESTIMATE | YEAR |
|---|---|---|---|
| A. Monitoring | | | |
| | Same as Alt. 2A See Table B-8 | | |
| TOTAL ANNUAL MONITORING O&M COST | | $13,020 | 2-3 |
| B. Plant Operation | | | |
| | Same as Alt. 3A See Table B-10 | | |
| TOTAL ANNUAL PLANT OPERATING COST | | $1,589,880 | 2-3 |

# APPENDIX C

# METHODS FOR ESTIMATING CONTAMINATED SEDIMENT VOLUMES

Calculations were performed to estimate the volume of sediment in the Maurice River and The Blackwater Branch that contains arsenic concentrations that exceed the established cleanup level. The cleanup level for the exposed sediments in the Blackwater Branch and for the more accessible areas of the river is 20 mg/kg. In the less accessible areas of the river, the cleanup level is 120 mg/kg for the submerged contaminated sediments. During the remedial investigation, water depth and sediment depth measurements were taken to calculate stream flow rates and to develop stream and sediment cross sections for the Maurice River and the Blackwater Branch. In addition, sediment samples were collected from these areas to define the extent of contamination. At most sampling stations, two core samples were taken with samples obtained from 0-1, 1-2, and 2-3 feet (Ebasco 1988c). The cross sections showing the arsenic concentrations in each core sample are presented in Figures C-1 through C-20. Table C-1 presents descriptions of each of the samples taken as they appeared in the boring log book.

The estimated target cleanup level of 20 mg/kg was used as the basis for deter- mining which areas were contaminated with arsenic and the volume of contaminated sediment needing remediation in the exposed area of the Blackwater Branch floodplain. All sediments with arsenic concentrations greater than or equal to this value were to be removed for remediation. The same conditions applied to the submerged sediment in the more accessible areas of the Blackwater Branch and the Maurice River. As discussed in Section 2, the more accessible areas of the river include Almond Road Beach and the areas within 100 feet of either side of a river crossing. It should be noted that the cleanup level yielded cancer risks of $1 \times 10^{-5}$ and $2 \times 10^{-6}$ for exposed and submerged sediments, respectively, using the sediment exposure models.

The estimated target cleanup level of 120 mg/kg was used as the basis for determining which areas were contaminated with arsenic and the volume of contaminated sediment needing remediation in the less accessible areas of the Blackwater Branch, downstream of the North Mill Road bridge, and the river. All sediments with arsenic concentrations greater than or equal to this value were to be removed from remediation. This would result in a cancer risk level of $1 \times 10^{-5}$ in the submerged less accessible sediments.

Areas of submerged sediment requiring remediation were determined by first extrapolating the cross-sectional depths to contamination from the results of the sediment corings. The cross sections in this appendix depict arsenic concentration lines of 20 mg/kg and 120 mg/kg. Once this was completed, planimetry was used to determine the cross-sectional area of submerged sediments with an arsenic concentration of 120 mg/kg or greater between two river stations, using the river reach between the two. In

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areas of high accessibility, the cross-sectional area of sediments with an arsenic concentration of 20 mg/kg or greater at the nearest river station and the reach of the area (200 feet at river crossings and the length of Almond Road Beach) were used to determine the area of contamination greater than 20 mg/kg. It was assumed that during the remedial design phase, additional sampling would be performed to better define the extent of contamination. The original calculation sheets are included in this appendix.

Calculations were performed to estimate the volume of sediments in the Blackwater Branch Floodplain that require remediation. In November 1988, Ebasco sampled 23 locations at varying depths in the floodplain to better define the extent of contamination. Sampling locations are identified in Figure 4-3. Analysis of the samples indicated arsenic-contaminated sediments over the 20 mg/kg cleanup level across the entire region. The floodplain contamination extended to various depths; two-foot, four-foot, and six-foot depths of excavation were determined for remediating areas of the floodplain. A planimeter was used to measure the various areas of the contaminated floodplain. The respective depth of excavation was multiplied with the area to obtain the contaminated sediment volume. It was assumed for this area as well that additional sampling would be performed during the remedial design phase, to better define the extent of contamination.

Figures C-1 to C-20 depict the cross sections used for these calculations.



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TABLE C-1
BORING LOGS FOR RIVER AREAS

| Station | Sample No. | Depth (ft) | Description |
|---|---|---|---|
| ER-0 | ER-0 A-0 | left bank, 0-1 | Light brown silt, some sand |
| | ER-0 A-1 | left bank, 1-2 | Some light brown silt, some dark brown clay |
| | ER-0 A-2 | left bank, 2-3 | Dark brown clay, some sand and organics |
| | ER-0 B-0 | right bank, 0-1 | Medium brown sand silt, some organics |
| | ER-0 B-1 | right bank, 1-2 | Dark brown clay, some sand and organics |
| | ER-0 B-2 | right bank, 2-3 | Dark brown clay, some sand and organics |
| ER-0A | ER-0A A-0 | left bank, 0-1 | Med brown fine sandy silt |
| | ER-0A A-1 | left bank, 1-2 | Med brown fine sandy silt |
| | ER-0A A-2 | left bank, 2-3 | Med brown silty fine sand |
| | ER-0A B-0 | right bank, 0-1 | Med brown fine sandy silt |
| | ER-0A B-1 | right bank, 1-2 | Med brown fine sandy silt |
| | ER-0A B-2 | right bank, 2-3 | Med brown fine silty sand |
| ER-0B | ER-0B A-0 | left bank, 0-1 | Dark brown silt, trace fine sand |
| | ER-0B A-1 | left bank, 1-2 | Brown silt and fine sand |
| | ER-0B A-2 | left bank, 2-3 | Brown silt and fine sand |
| | ER-0B B-0 | right bank, 0-1 | Dark brown silt, some organic material |
| | ER-0B B-1 | right bank, 1-2 | Brown silt and fine sand |
| | ER-0B B-2 | right bank, 2-3 | Brown fine sand, some silt |
| ER-1 | ER-1 A-0 | left bank, 0-1 | Dark brown silt, trace organic |
| | ER-1 A-1 | left bank, 1-2 | Dark brown silt, trace organic |
| | ER-1 A-2 | left bank, 2-3 | Brown fine sand, trace med sand, trace silt |
| | ER-1 B-0 | right bank, 0-1 | Dark brown silt, trace fine sand, some organic |
| | ER-1 B-1 | right bank, 1-2 | Dark brown silt, trace fine sand, some organic |
| | ER-1 B-2 | right bank, 2-3 | Dark brown silt, trace fine sand, some organic |
| ER-2 | ER-2 A-0 | left bank, 0-1 | Dark brown fine silt, some organic matter |
| | ER-2 A-1 | left bank, 1-2 | Dark brown fine silt, some organic matter |
| | ER-2 A-2 | left bank, 2-3 | Grey fine sand, some gravel |
| | ER-2 B-0 | right bank, 0-1 | Dark brown silt, some organic matter |
| | ER-2 B-1 | right bank, 1-2 | Dark brown silt, some organic trace grey fine sand |
| | ER-2 B-2 | right bank, 2-3 | Dark brown silt, some grey fine sand |
| ER-3A | ER-3A A-0 | left bank, 0-1 | Medium brown silty sand |
| | ER-3A A-1 | left bank, 1-2 | Dark brown silty sand |
| | ER-3A A-2 | left bank, 2-3 | Dark brown sand |
| | ER-3A B-0 | right bank, 0-1 | Dark brown sandy silt |
| | ER-3A B-1 | right bank, 1-2 | Dark brown silty sand |
| | ER-3A B-2 | right bank, 2-3 | Dark brown silty sand |

TABLE C-1
BORING LOGS FOR RIVER AREAS

| Station | Sample No. | Depth (ft) | Description |
|---|---|---|---|
| ER-4 | ER-4 A-0 | left bank, 0-1 | Dark brown sandy silt, some organic |
| | ER-4 A-1 | left bank, 1-2 | Dark brown sandy silt, some organic |
| | ER-4 A-2 | left bank, 2-3 | Dark brown sandy silt, some organic |
| | ER-4 B-0 | mid bank, 0-1 | Dark brown silty sand, some organic |
| | ER-4 B-1 | mid bank, 1-2 | Dark brown silty sand, some organic |
| | ER-4 B-2 | mid bank, 2-3 | Dark brown sandy silt, some organic |
| | ER-4 C-0 | right bank, 0-1 | Dark brown sandy silt, some organic |
| | ER-4 C-1 | right bank, 1-2 | Dark brown sandy silt, some organic |
| | ER-4 C-2 | right bank, 2-3 | Dark brown silty sand, some organic |
| ER-5 | ER-5 A-0 | left bank, 0-1 | Black very fine silt and organic material |
| | ER-5 A-1 | left bank, 1-2 | Black very fine silt and organic material |
| | ER-5 A-2 | left bank, 2-3 | Black very fine silt and organic material |
| | ER-5 B-0 | right bank, 0-1 | Black very fine silt and organic material |
| | ER-5 B-1 | right bank, 1-2 | Black very fine silt and organic material |
| | ER-5 B-2 | right bank, 2-3 | Black very fine silt and organic material last 1/2 ft, white fine sand |
| ER-6 | ER-6 A-0 | left bank, 0-1 | Dark brown silt of fine sand |
| | ER-6 A-1 | left bank, 1-2 | Brown fine sand, trace silt |
| | ER-6 A-2 | left bank, 2-3 | Dark brown silt of fine sand |
| | ER-6 B-0 | right bank, 0-1 | Brown fine sand, trace silt |
| | ER-6 B-1 | right bank, 1-2 | Brown fine sand, trace silt |
| | ER-6 B-2 | right bank, 2-3 | Light brown fine sand |
| ER-6A | ER-6A A-0 | left bank, 0-1 | Fine grey sand and brown silt |
| | ER-6A A-1 | left bank, 1-2 | Fine grey sand and brown silt |
| | ER-6A A-2 | left bank, 2-3 | Fine grey sand and brown silt |
| | ER-6A B-0 | right bank, 0-1 | Dark brown silt, trace fine grey sand |
| | ER-6A B-1 | right bank, 1-2 | Dark brown silt, trace fine grey sand |
| | ER-6A B-2 | right bank, 2-3 | Grey fine sand, some brown silt |
| ER-7 | ER-7 A-0 | left bank, 0-1 | Greyish-brown silty sand |
| | ER-7 A-1 | left bank, 1-2 | Med brown silty sand, some gravel |
| | ER-7 A-2 | left bank, 2-3 | Greyish-brown silty sand, some gravel |
| | ER-7 B-0 | mid bank, 0-1 | Med brown sandy silt |
| | ER-7 B-1 | mid bank, 1-2 | Med brown sandy silt |
| | ER-7 B-2 | mid bank, 2-3 | Med brown silty sand |
| | ER-7 C-0 | right bank, 0-1 | Med brown sandy silt |
| | ER-7 C-1 | right bank, 1-2 | Med brown sandy silt, some gravel |
| | ER-7 C-2 | right bank, 2-3 | Med brown sandy silt, some gravel |
| ER-8 | ER-8 A-0 | left bank, 0-1 | Brown fine sand, some silt |
| | ER-8 A-1 | left bank, 1-2 | Brown fine sand, some silt |
| | ER-8 A-2 | left bank, 2-3 | Brown fine sand, some silt |
| | ER-8 B-0 | right bank, 0-1 | Brown fine sand, some silt |
| | ER-8 B-1 | right bank, 1-2 | Brown fine sand, some silt |
| | ER-8 B-2 | right bank, 2-3 | Brown fine sand, some silt |

TABLE C-1
BORING LOGS FOR RIVER AREAS

| Station | Sample No. | Depth (ft) | Description |
|---|---|---|---|
| ER-9 | ER-9 A-0 | left bank, 0-1 | Brown medium fine sand, trace silt, organic |
| | ER-9 A-1 | left bank, 1-2 | Grey medium fine sand, trace silt, organic |
| | ER-9 A-2 | left bank, 2-3 | Grey medium fine sand, trace silt, organic |
| | ER-9 B-0 | right bank, 0-1 | Brown medium fine sand, trace fine gravel and silt |
| | ER-9 B-1 | right bank, 1-2 | Brown medium fine sand, trace fine gravel and silt |
| | ER-9 B-2 | right bank, 2-3 | Brown medium fine sand, trace fine gravel and silt |
| ER-9A | ER-9A A-0 | left bank, 0-1 | Dark brown silt, some organic |
| | ER-9A A-1 | left bank, 1-2 | Dark brown silt, some organic |
| | ER-9A A-2 | left bank, 2-3 | Dark brown silt, some organic, some sand |
| | ER-9A B-0 | left bank, 0-1 | Brown silty sand |
| | ER-9A B-1 | left bank, 1-2 | Brown silty sand |
| | ER-9A B-2 | left bank, 2-3 | Brown Silty sand |
| | ER-9A C-0 | mid-stream, 0-1 | Brown sand |
| | ER-9A C-1 | mid-stream, 1-2 | Brown sand |
| | ER-9A C-2 | mid-stream, 2-3 | Brown sand, some fine gravel |
| | ER-9A D-0 | right bank, 0-1 | Brown sand, some fine gravel |
| | ER-9A D-1 | right bank, 1-2 | Brown sand, some fine gravel |
| | ER-9A D-2 | right bank, 2-3 | Brown sand, some fine gravel |
| | ER-9A E-0 | right bank, 0-1 | Dark brown silt, some organic |
| | ER-9A E-1 | right bank, 1-2 | Dark brown silt, some organic |
| | ER-9A E-2 | right bank, 2-3 | Dark brown silt, some brown sand |
| ER-9C | ER-9C A-0 | left bank, 0-1 | Medium brown silty coarse sand, some gravel |
| | ER-9C A-1 | left bank, 1-2 | Medium brown silty coarse sand, some gravel |
| | ER-9C A-2 | left bank, 2-3 | Medium brown fine sand |
| | ER-9C B-0 | left bank, 0-1 | Medium-light brown silty coarse sand, some gravel |
| | ER-9C B-1 | left bank, 1-2 | Medium-light brown silty coarse sand, some gravel |
| | ER-9C B-2 | left bank, 2-3 | Medium-light brown silty coarse sand, some gravel |
| | ER-9C C-0 | mid bank, 0-1 | Light brown coarse sand, some gravel |
| | ER-9C C-1 | mid bank, 1-2 | Light brown coarse sand, some gravel |
| | ER-9C D-0 | right bank, 0-1 | Greyish-brown silty coarse sand, some gravel |
| | ER-9C D-1 | right bank, 1-2 | Greyish-brown silty coarse sand, some gravel |
| | ER-9C D-2 | right bank, 2-3 | Greyish-brown silty coarse sand, some gravel |
| | ER-9C E-0 | right bank, 0-1 | Dark brown silt, some fine sand |
| | ER-9C E-1 | right bank, 1-2 | Dark brown silt, some fine sand |
| | ER-9C E-2 | right bank, 2-3 | Greyish brown coarse sand |
| ER-9D | ER-9D A-0 | left bank, 0-1 | Dark brown silt, trace sand, some organic |
| | ER-9D A-1 | left bank, 1-2 | Brown silty fine sand |
| | ER-9D A-2 | left bank, 2-3 | Brown fine sand, trace med sand, trace silt |
| | ER-9D B-0 | right bank, 0-1 | Dark brown silty fine sand, some organic material |
| | ER-9D B-1 | right bank, 1-2 | Brown fine sand, trace silt |
| | ER-9D B-2 | right bank, 2-3 | Brown fine sand, trace silt |

TABLE C-1
BORING LOGS FOR RIVER AREAS

| Station | Sample No. | Depth (ft) | Description |
|---|---|---|---|
| ER-9E | ER-9E A-0 | left bank, 0-1 | Medium brown sandy silt |
| | ER-9E A-1 | left bank, 1-2 | Medium brown silty sand |
| | ER-9E A-2 | left bank, 2-3 | Medium brown silty sand |
| | ER-9E B-0 | left bank, 0-1 | Light brown silty sand |
| | ER-9E B-1 | left bank, 1-2 | Light brown silty sand |
| | ER-9E B-2 | left bank, 2-3 | Light brown silty sand |
| | ER-9E C-0 | mid bank, 0-1 | Light brown sand, some gravel |
| | ER-9E D-0 | right bank, 0-1 | Medium brown sand, some gravel |
| | ER-9E D-1 | right bank, 1-2 | Med-light brown sand, some gravel |
| | ER-9E D-2 | right bank, 2-3 | Med-light brown sand, some gravel |
| | ER-9E E-0 | right bank, 0-1 | Med brown silty sand, some gravel |
| | ER-9E E-1 | right bank, 1-2 | Med brown silty sand, some gravel |
| | ER-9E E-2 | right bank, 2-3 | Med brown silty sand, some gravel |
| ER-9F | ER-9F A-0 | left bank, 0-1 | Brown silt, trace organic |
| | ER-9F A-1 | left bank, 1-2 | Brown silt, trace organic |
| | ER-9F A-2 | left bank, 2-3 | Brown silt, brown fine sand |
| | ER-9F B-0 | left bank, 0-1 | Brown silt, brown fine sand |
| | ER-9F B-1 | left bank, 1-2 | Brown silt, brown fine sand |
| | ER-9F C-0 | left bank, 0-1 | Brown fine sand, trace silt |
| | ER-9F C-1 | left bank, 1-2 | Brown fine sand, trace silt |
| | ER-9F C-2 | left bank, 2-3 | Brown fine sand, some fine gravel |
| | ER-9F D-0 | mid-stream, 0-1 | Brown fine sand, some fine gravel |
| | ER-9F D-1 | mid-stream, 1-2 | Brown fine sand, some fine gravel |
| | ER-9F D-2 | mid-stream, 2-3 | Brown fine sand, some fine gravel |
| | ER-9F E-0 | right bank, 0-1 | Brown fine sand, some fine gravel |
| | ER-9F E-1 | right bank, 1-2 | Brown fine sand, some silt |
| | ER-9F F-0 | right bank, 0-1 | Brown fine sand, some silt |
| | ER-9F F-1 | right bank, 1-2 | Brown fine sand, some silt |
| | ER-9F F-2 | right bank, 2-3 | Brown fine sand, some silt |
| | ER-9F G-0 | right bank, 0-1 | Brown fine sand |
| | ER-9F G-1 | right bank, 1-2 | Dark brown silt, some sand |
| | ER-9F G-2 | right bank, 2-3 | Brown silty sand |
| ER-10 | ER-10 A-0 | | Dark brown silt, some fine sand |
| | ER-10 A-1 | | Dark brown silt, some fine sand |
| | ER-10 A-2 | | Brown silty sand, some gravel |
| | ER-10 B-0 | | Dark brown silt, some fine sand |
| | ER-10 B-1 | | Dark brown silt, some fine sand |
| | ER-10 B-2 | | Brown silty sand, some gravel |
| | ER-10 B-2 Dup | | Brown silty sand, some gravel |
| ER-10A | ER-10A A-0 | left bank, 0-1 | Dark Brown silt, some sand, some organic |
| | ER-10A A-1 | left bank, 1-2 | Dark Brown silt, some sand, some organic |
| | ER-10A A-2 | left bank, 2-3 | Dark Brown sand, trace silt |
| | ER-10A B-0 | left bank, 0-1 | Dark Brown silty sand, some organic |
| | ER-10A B-1 | left bank, 1-2 | Dark Brown silty sand, some organic |
| | ER-10A B-2 | left bank, 2-3 | Brown sand, some fine gravel |

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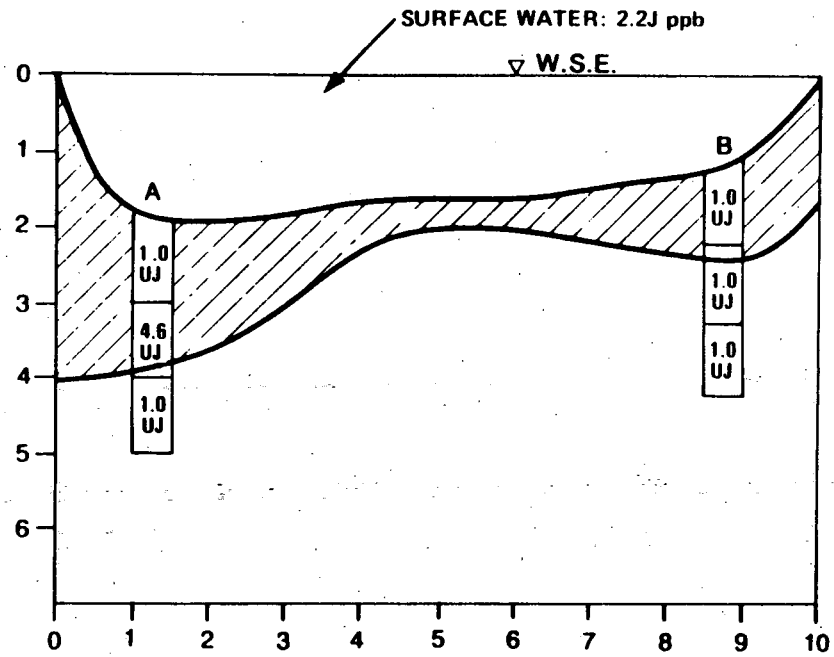
TABLE C-1
BORING LOGS FOR RIVER AREAS

| Station | Sample No. | Depth (ft) | Description |
|---|---|---|---|
| ER-10A | ER-10A C-0 | left bank, 0-1 | Brown sand, and gravel |
| | ER-10A C-1 | left bank, 1-2 | Brown sand, and gravel |
| | ER-10A D-0 | left bank, 0-1 | Brown sand, and gravel |
| | ER-10A E-0 | mid-stream, 0-1 | Brown sand, and gravel |
| | ER-10A F-0 | right bank, 0-1 | Brown sand, and gravel |
| | ER-10A G-0 | right bank, 0-1 | Brown sand, trace silt |
| | ER-10A G-1 | right bank, 1-2 | Brown sand, trace silt |
| | ER-10A G-2 | right bank, 2-3 | Brown sand and gravel |
| | ER-10A H-0 | right bank, 0-1 | Brown silty sand |
| | ER-10A H-1 | right bank, 1-2 | Fine brown sand, trace gravel |
| | ER-10A H-2 | right bank, 2-3 | Brown sand and gravel |
| | ER-10A H-2 Dup | right bank, 2-3 | Brown sand and gravel |
| | ER-10A I-0 | right bank, 0-1 | Dark Brown sandy silt, some organic |
| | ER-10A I-1 | right bank, 1-2 | Dark Brown sandy silt, some organic |
| | ER-10A I-2 | right bank, 2-3 | Brown silty sand |
| ER-11 | ER-11 A-0 | left bank, 0-1 | Black silty fine sand, some organic material |
| | ER-11 A-1 | left bank, 1-2 | Black silty fine sand, some organic material |
| | ER-11 A-2 | left bank, 2-3 | Black silty fine sand, some organic material |
| | ER-11 B-0 | right bank, 0-1 | Black silty fine sand, some organic material |
| | ER-11 B-1 | right bank, 1-2 | Black silty fine sand, some organic material |
| | ER-11 B-2 | right bank, 2-3 | Black silty fine sand, some organic material |

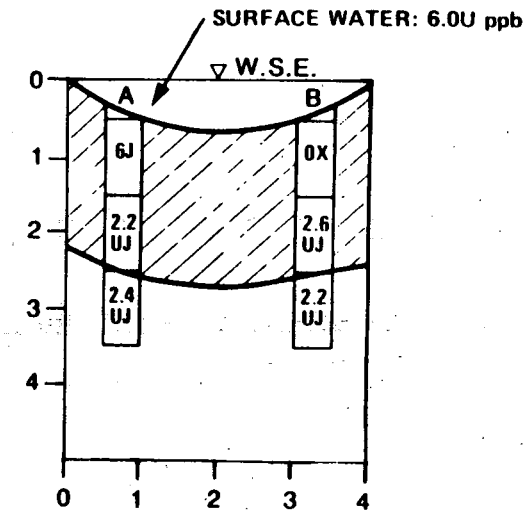
STATION ER-OA (BLACKWATER BRANCH)




SCALE:

(STAGNANT; Q=0)

*STATION ER-0B (PINE BRANCH)




*NOTE: ASSUME WATER DEPTH AT EACH pt.. NO FLOW CALCULATIONS.

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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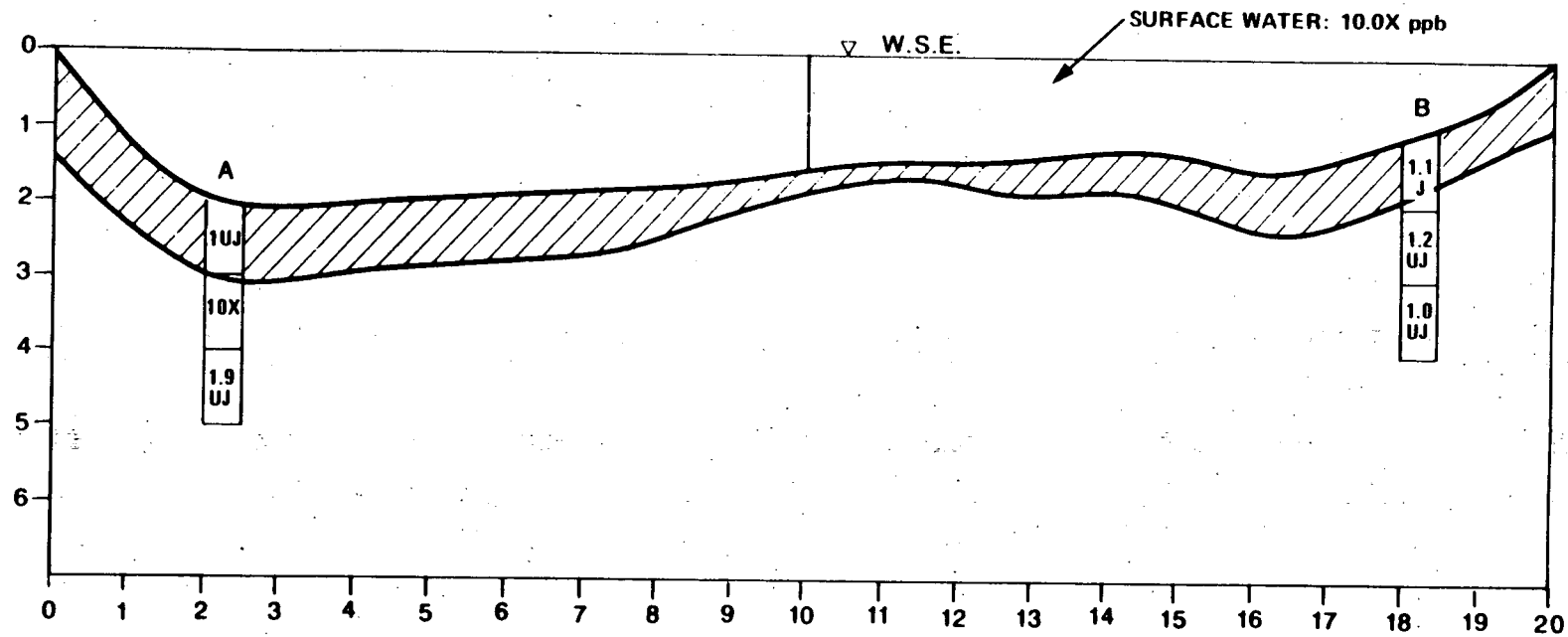
VINELAND CHEMICAL COMPANY SITE

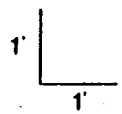
FIGURE C-1

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATIONS ER-0A (BLACKWATER BRANCH) AND ER-0B (PINE BRANCH)

EBASCO SERVICES INCORPORATED




SCALE:




KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA
= SEDIMENT IN STREAM BED

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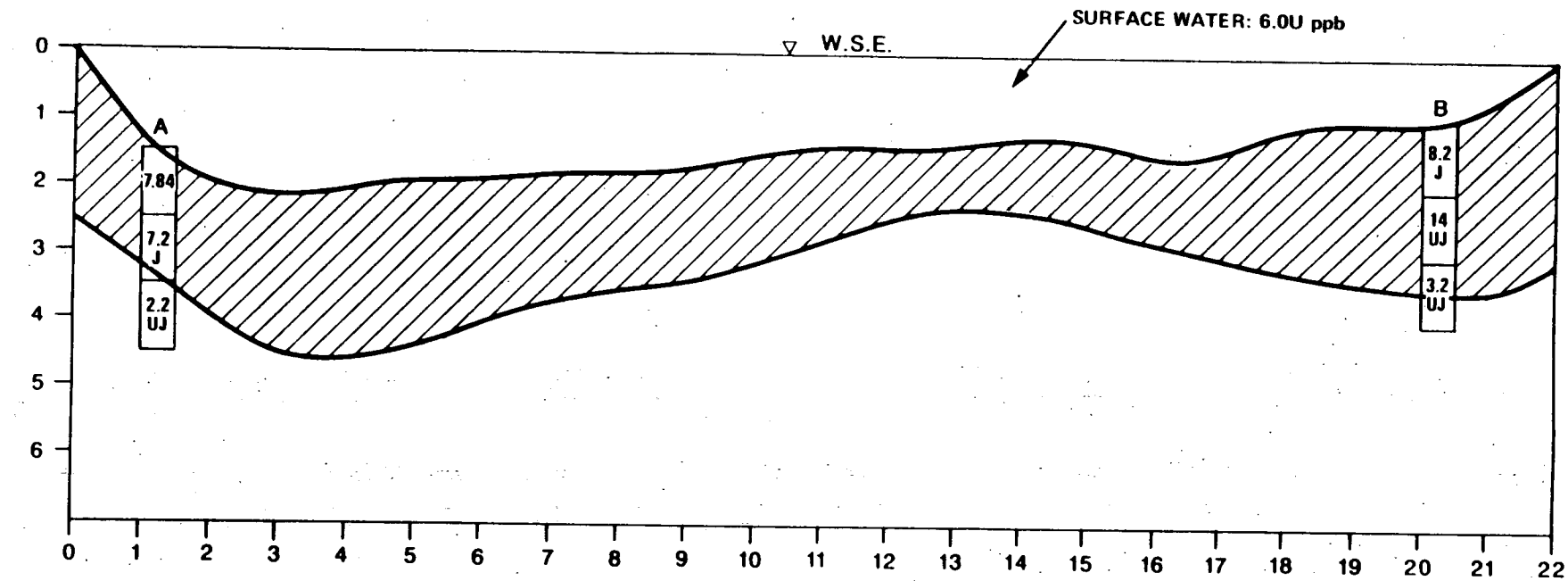
VINELAND CHEMICAL COMPANY SITE

FIGURE C–2

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-0 (BLACKWATER BRANCH)

EBASCO SERVICES INCORPORATED




SCALE: 1' 1'

NOTE: ASSUMED THAT STREAM CROSS-SECTION IS SIMILAR TO STATION ER-0

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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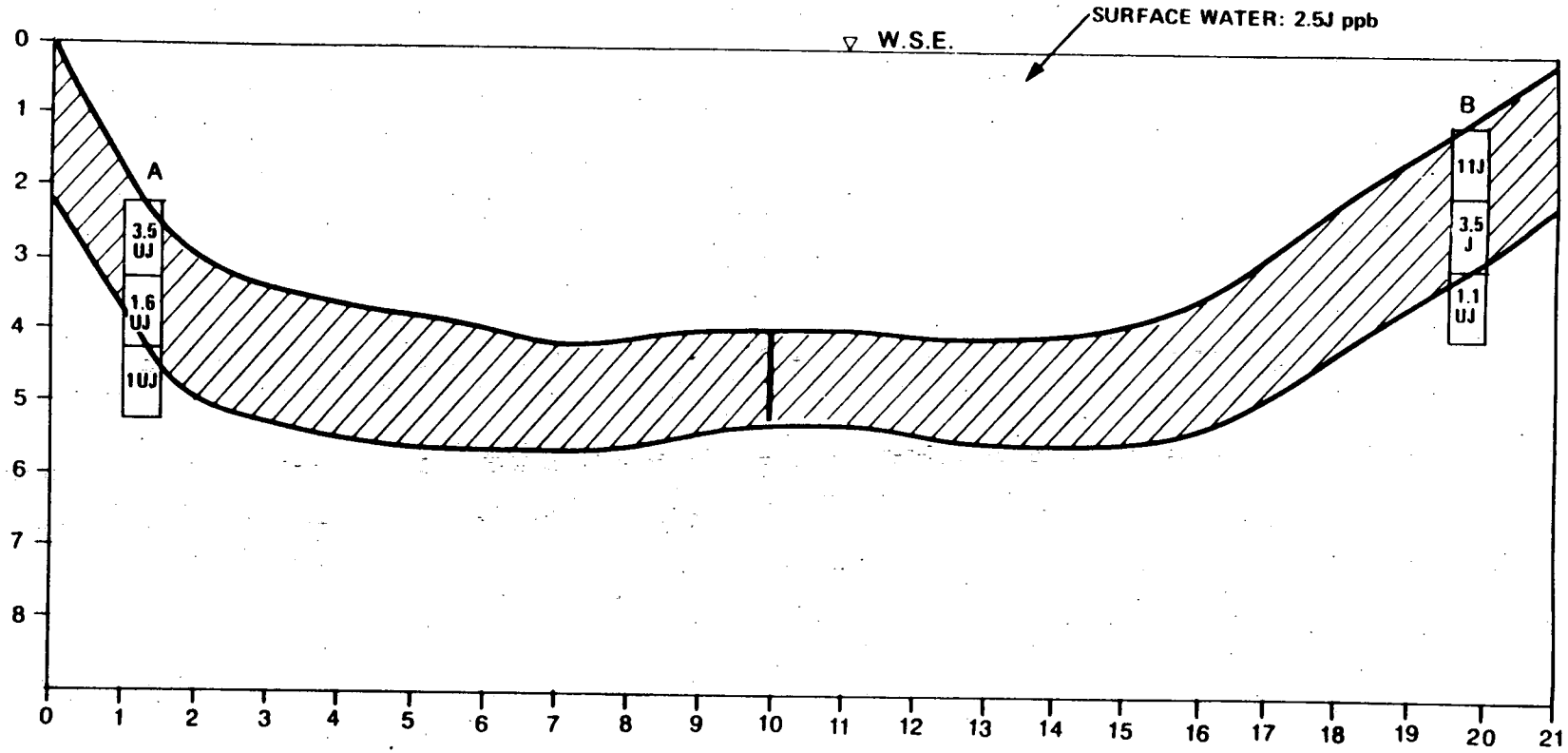
VINELAND CHEMICAL COMPANY SITE

FIGURE C–3

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-1 (BLACKWATER BRANCH)

EBASCO SERVICES INCORPORATED




SCALE:

1'

1'

NOTE: ASSUMED THAT CROSS-SECTION IS SIMILAR TO STATION ER-4

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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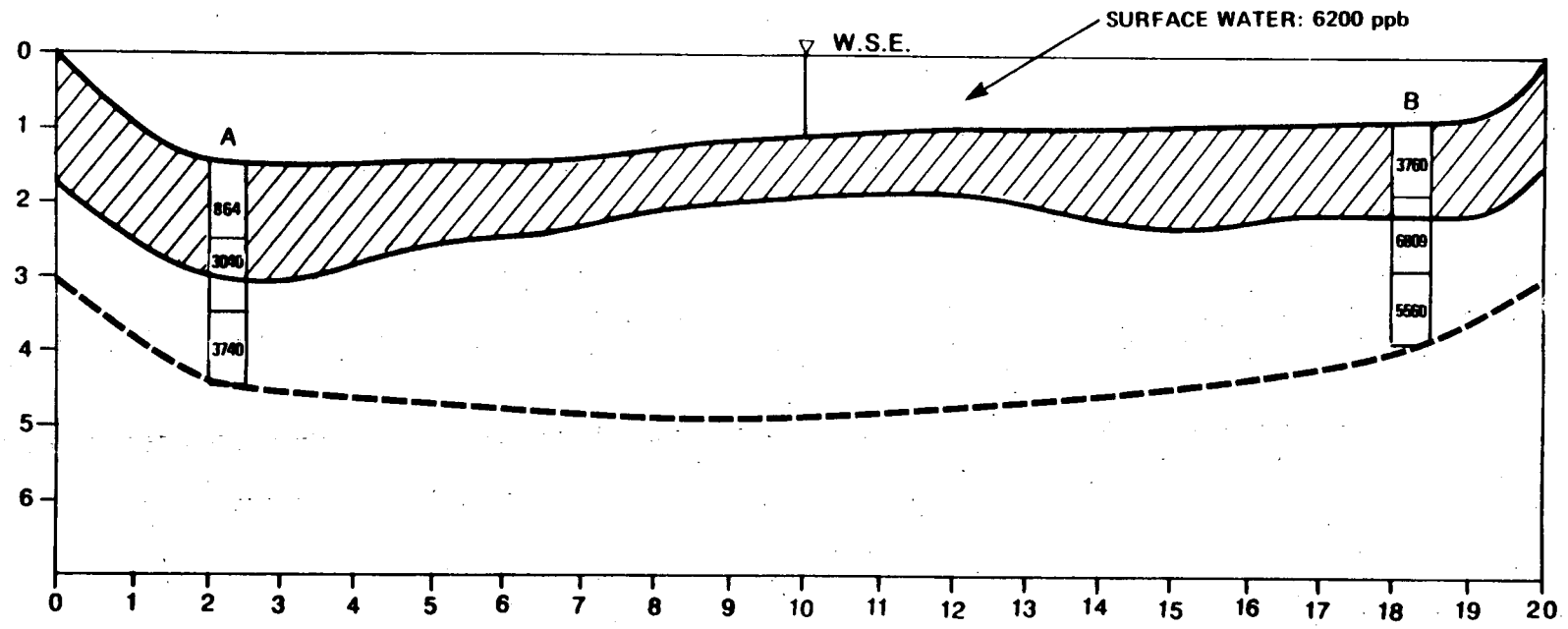
FIGURE C–4

SURFACE WATER AND SEDIMENT ARSENIC RESULTS STATION ER-2 (BLACKWATER BRANCH)

EBASCO SERVICES INCORPORATED




SCALE:

1'

1'

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA
= SEDIMENT IN STREAM BED
20 ppm

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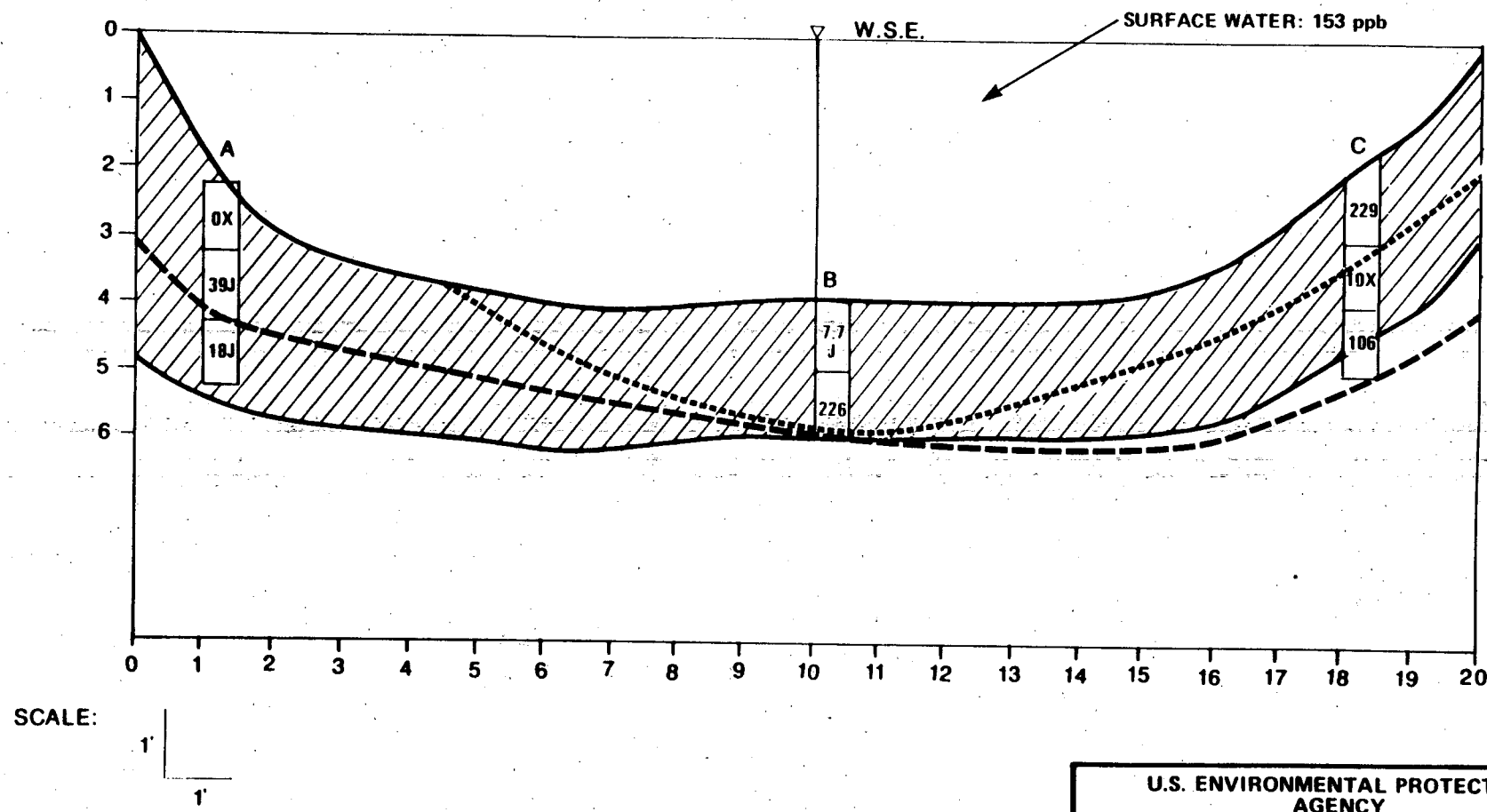
VINELAND CHEMICAL COMPANY SITE

FIGURE C–5

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-3A (BLACKWATER BRANCH)

EBASCO SERVICES INCORPORATED




KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

SEDIMENT IN STREAM BED
20 ppm ----- 120 ppm

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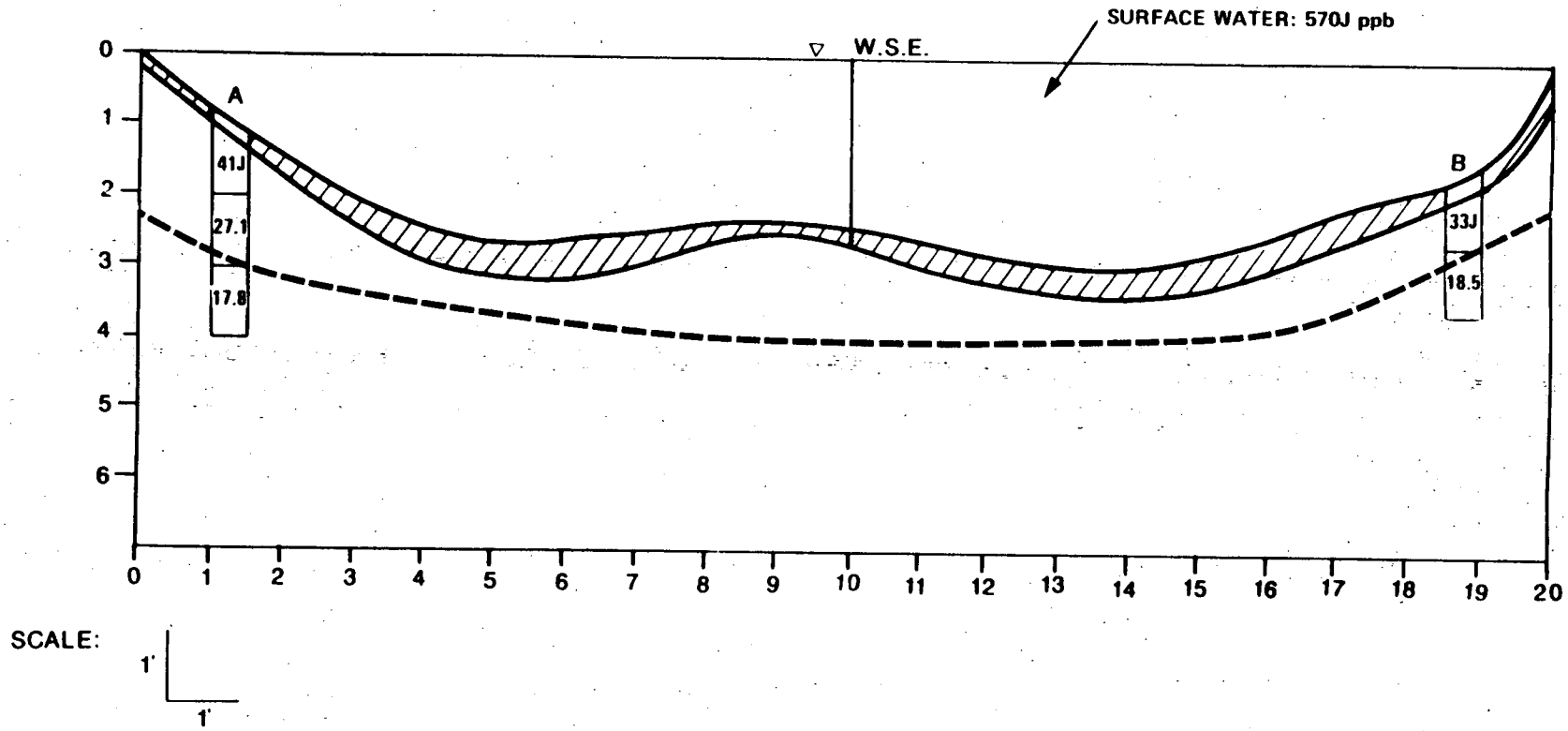
FIGURE C–6

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-4 (BLACKWATER BRANCH)

EBASCO SERVICES INCORPORATED




KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA
= SEDIMENT IN STREAM BED
20 ppm

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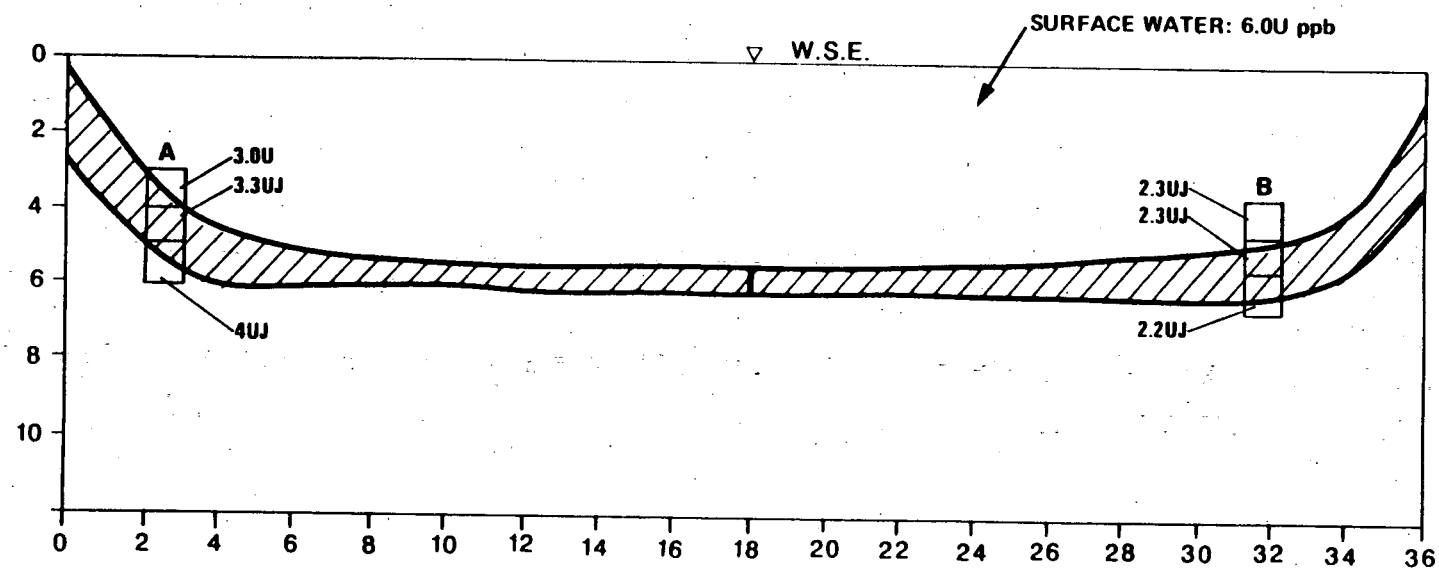
VINELAND CHEMICAL COMPANY SITE

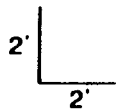
FIGURE C–7

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-5 (BLACKWATER BRANCH)

EBASCO SERVICES INCORPORATED




SCALE:




KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA
= SEDIMENT IN STREAM BED

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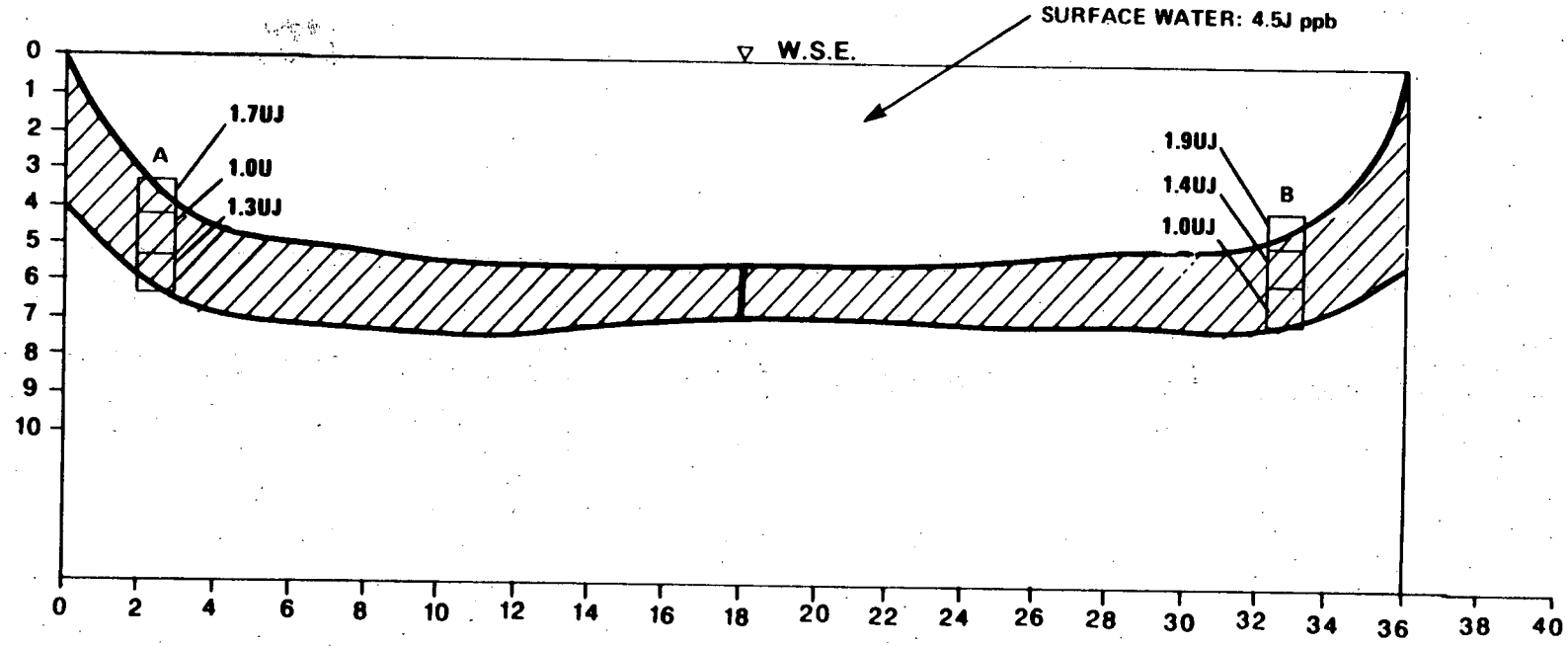
FIGURE C–8

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-6 (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:

2'

2'

KEY:

SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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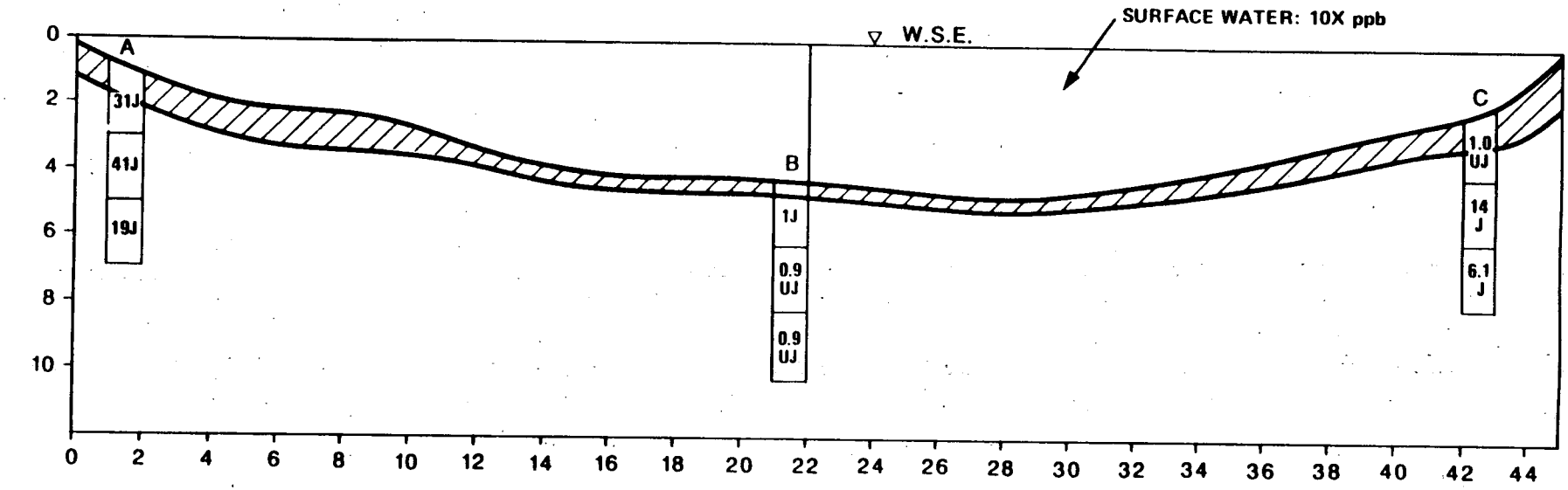
FIGURE C–9

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-6A (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:

2'

2'

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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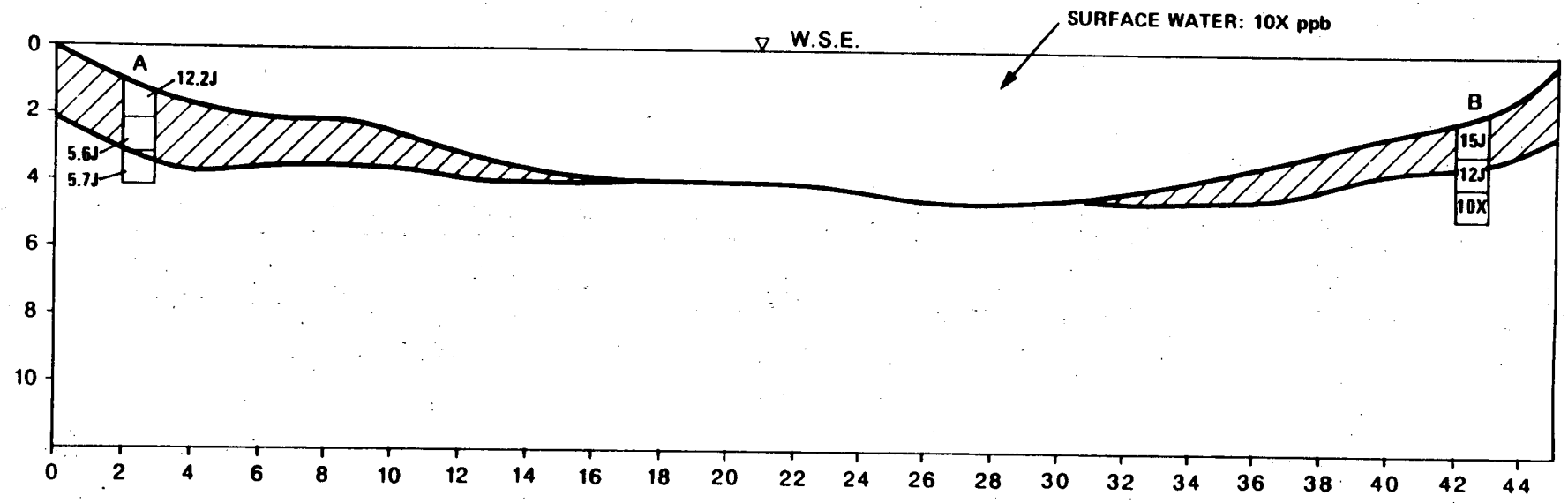
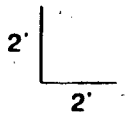
FIGURE C–10

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-7 (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:




NOTE: ASSUMED THAT STREAM X-SECTION IS SIMILAR TO STATION ER-7

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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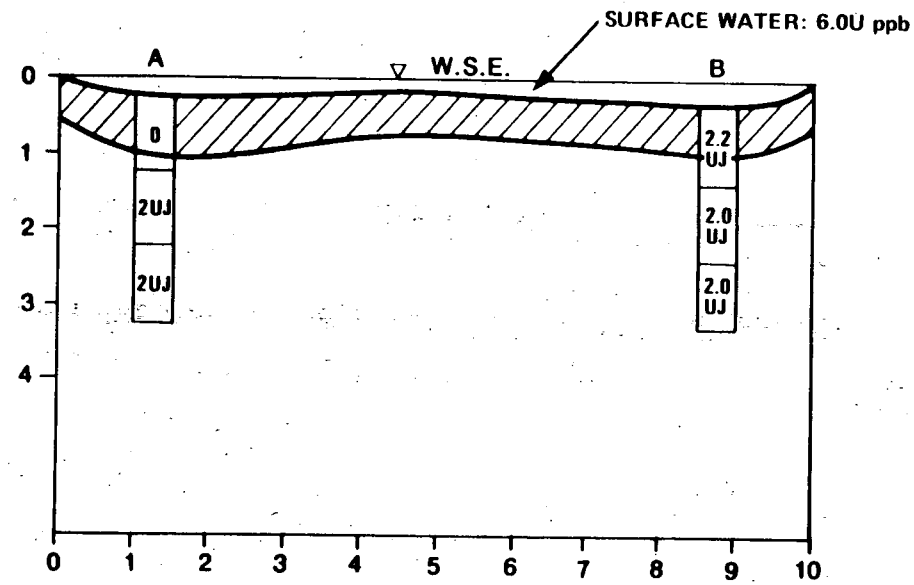
FIGURE C–11

SURFACE WATER AND SEDIMENT ARSENIC RESULTS STATION ER-8 (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:

1'

1'

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

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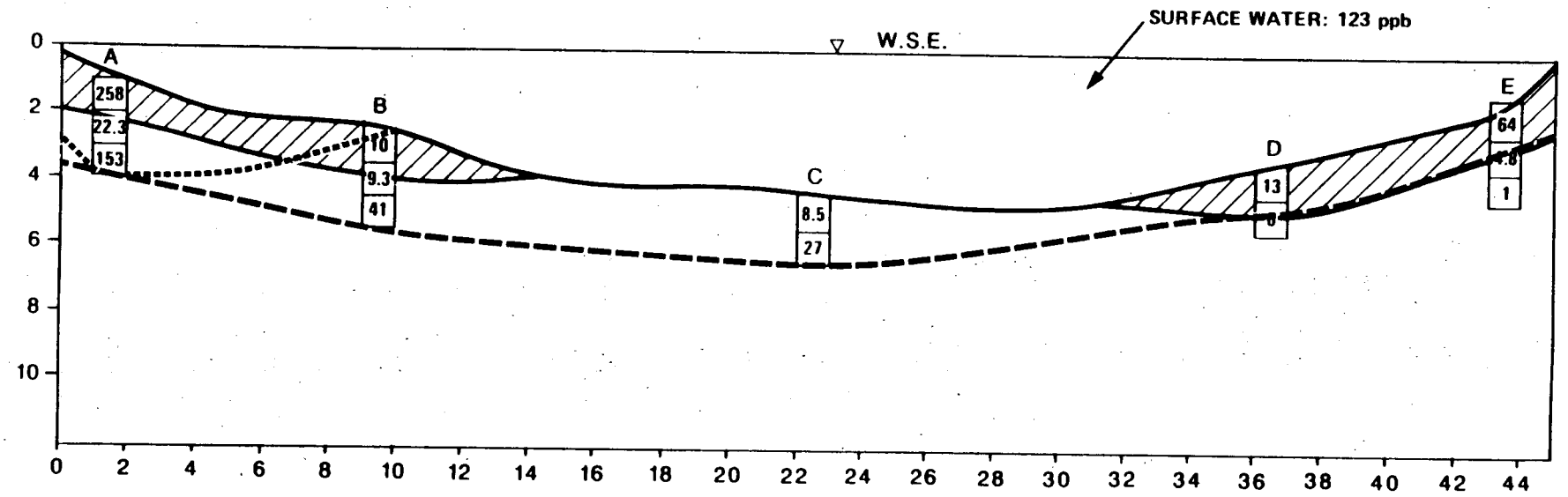
FIGURE C–12

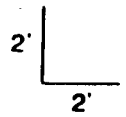
SURFACE WATER AND SEDIMENT
ARSENIC RESULTS
STATION ER-9 (LITTLE ROBIN BRANCH)

EBASCO SERVICES INCORPORATED

0b h.1




SCALE:




NOTE: ASSUMED THAT STREAM CROSS-SECTION IS SIMILAR TO STATION ER-7

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

20 ppm ------ 120 ppm

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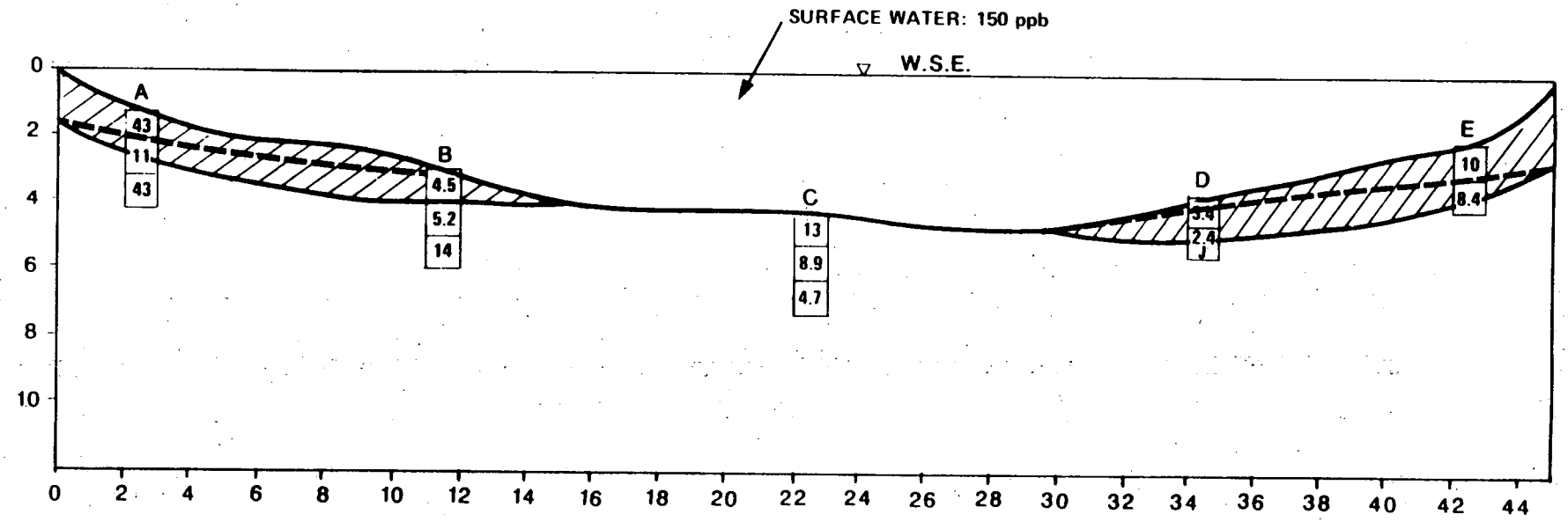
VINELAND CHEMICAL COMPANY SITE

FIGURE C–13

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-9A (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:

2'

2'

NOTE: ASSUMED THAT STREAM CROSS-SECTION IS SIMILAR TO STATION ER-7

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

20 ppm

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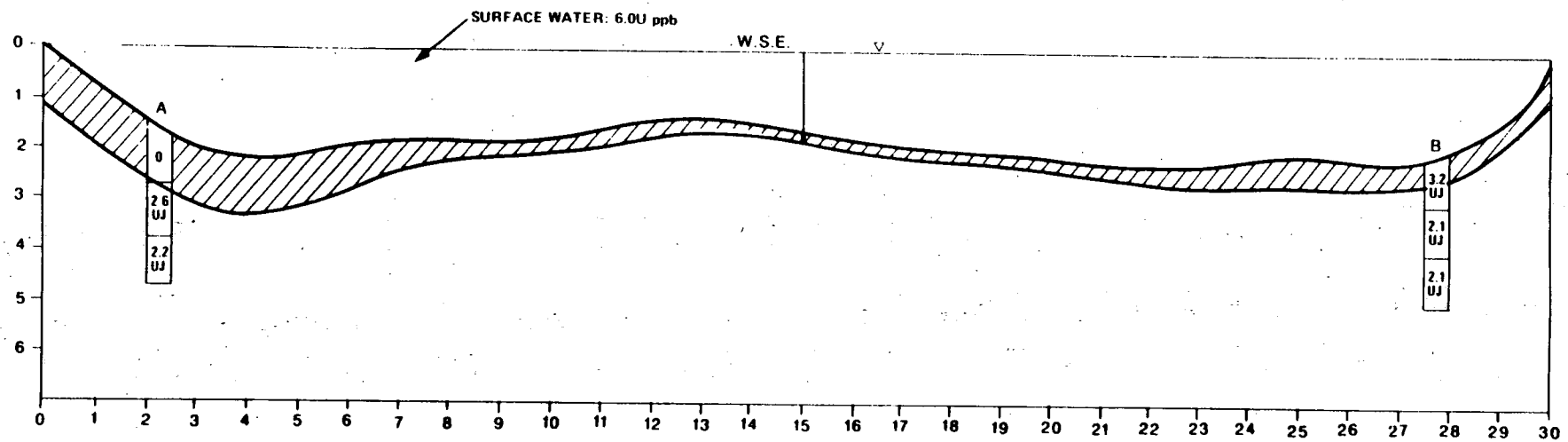
VINELAND CHEMICAL COMPANY SITE

FIGURE C–14

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-9C (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE: 1' 1'

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

▨ = SEDIMENT IN STREAM BED

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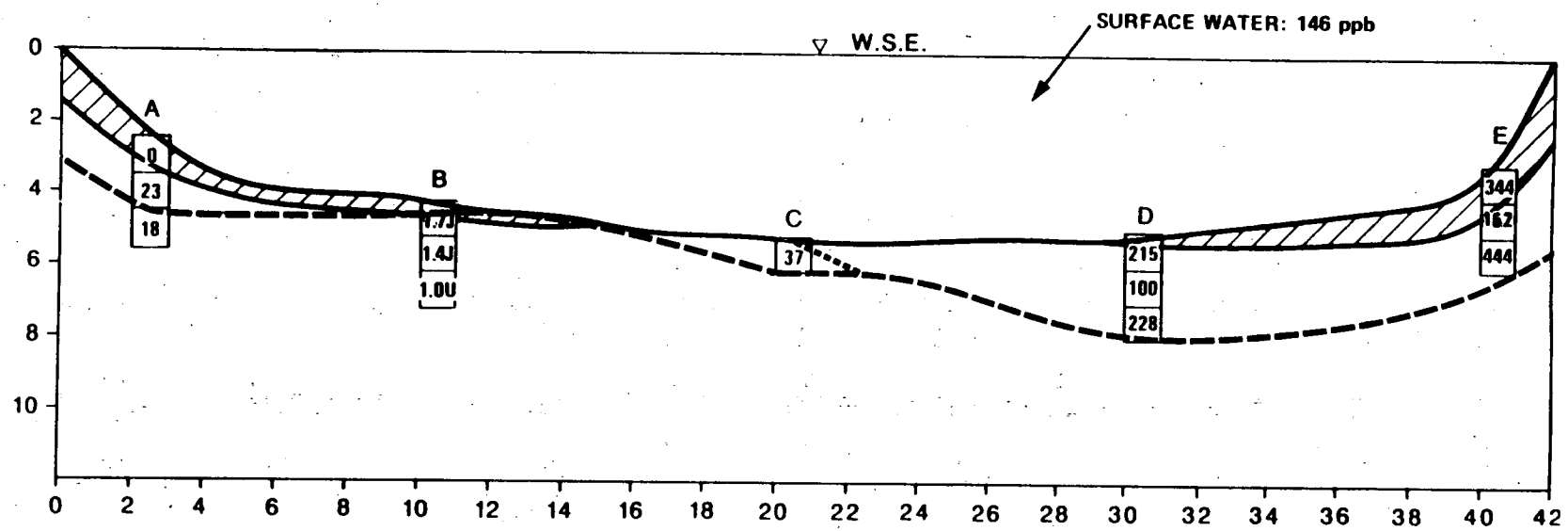
VINELAND CHEMICAL COMPANY SITE

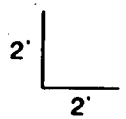
**FIGURE C–15**

SURFACE WATER AND SEDIMENT ARSENIC RESULTS STATION ER-9D (MUDDY RUN)

EBASCO SERVICES INCORPORATED




SCALE:




NOTE: ASSUMED THAT STREAM CROSS-SECTION IS SIMILAR TO STATION ER-10

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED
20 ppm ----- 120 ppm

U.S. ENVIRONMENTAL PROTECTION AGENCY

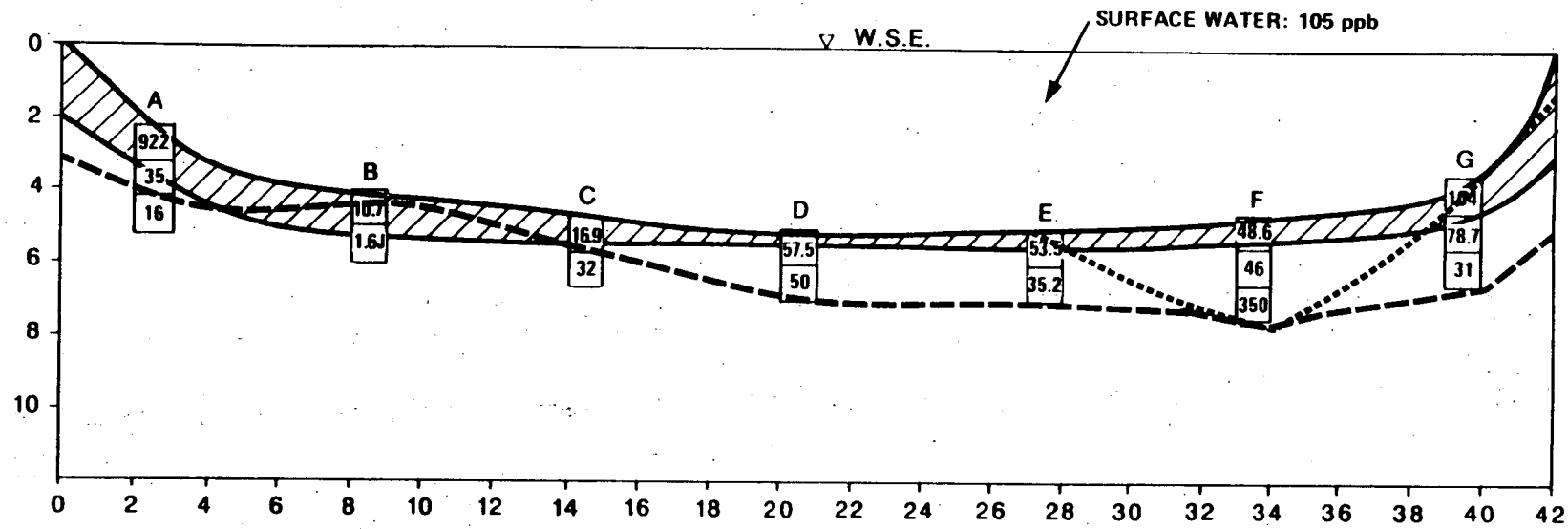
VINELAND CHEMICAL COMPANY SITE

FIGURE C–16

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-9E (MAURICE RIVER)

EBASCO SERVICES INCORPORATED

5671




SCALE:

2'

2'

NOTE: ASSUMED THAT STREAM CROSS-SECTION IS SIMILAR TO STATION ER-10

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA
= SEDIMENT IN STREAM BED
20 ppm ••••• 120 ppm

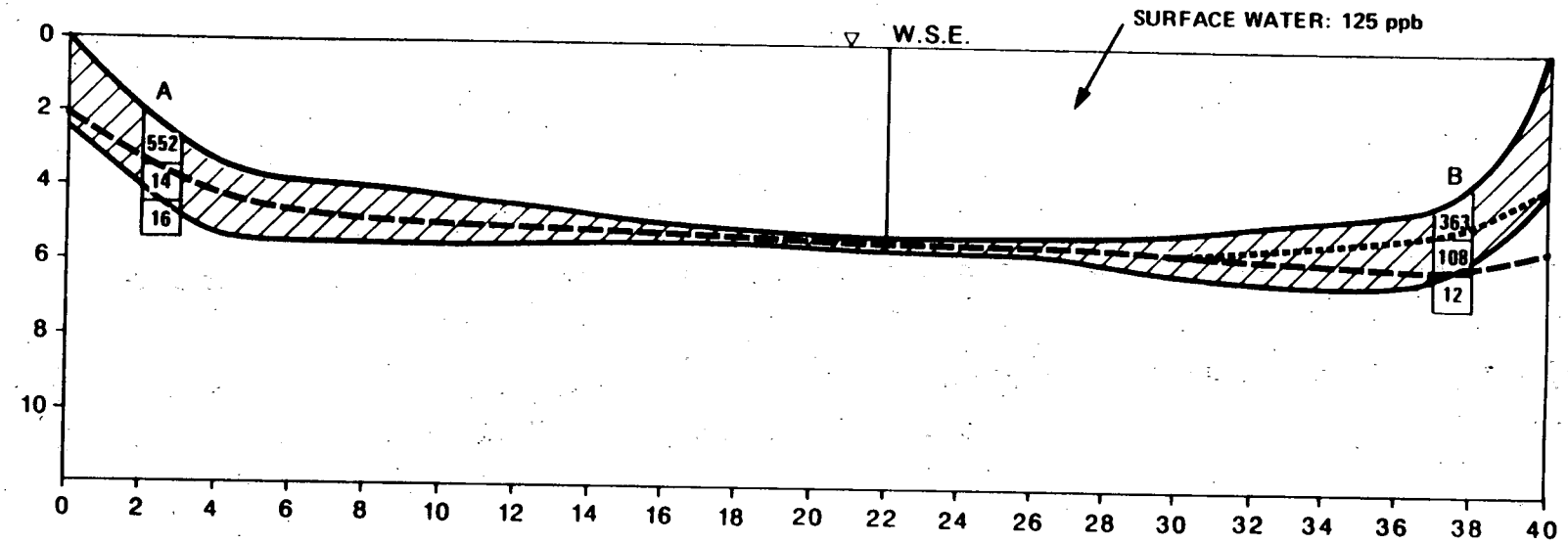
U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE C–17

SURFACE WATER AND SEDIMENT ARSENIC RESULTS STATION ER-9F (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:

2'

2'

KEY:

SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

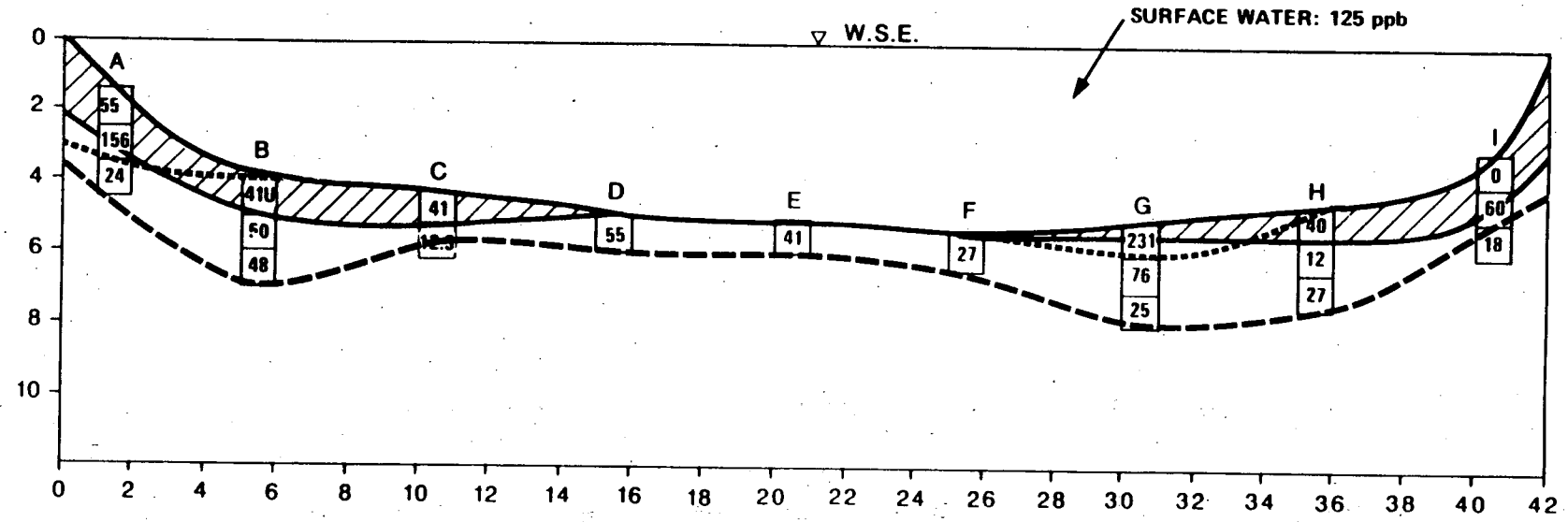
20 ppm 120 ppm

U.S. ENVIRONMENTAL PROTECTION AGENCY

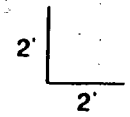
VINELAND CHEMICAL COMPANY SITE

FIGURE C–18
SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-10 (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:




NOTE: ASSUMED THAT STREAM CROSS-SECTION IS SIMILAR TO STATION ER-10

KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

20 ppm ------ 120 ppm

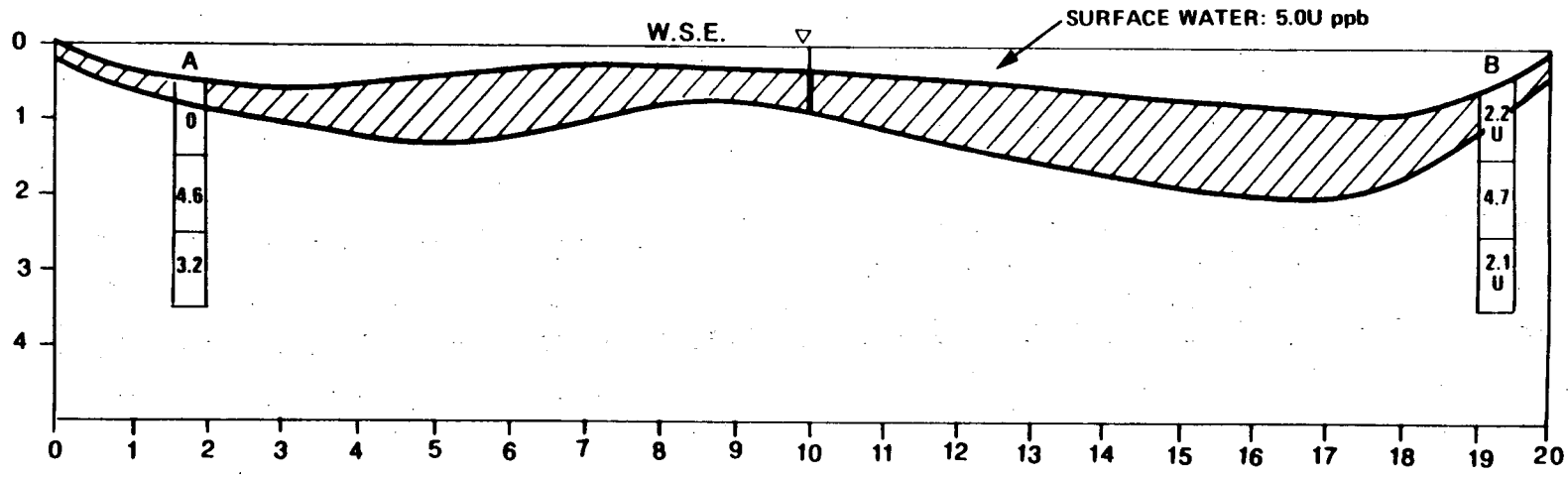
U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

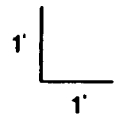
FIGURE C–19

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-10A (MAURICE RIVER)

EBASCO SERVICES INCORPORATED




SCALE:




KEY:
SURFACE SEDIMENT [AS]: ppm
SURFACE WATER [AS]: ppb
U = UNDETECTED
[ ] = ESTIMATED VALUE
J = VALUE BETWEEN CRDL AND IDL
X = REJECTED DATA

= SEDIMENT IN STREAM BED

U.S. ENVIRONMENTAL PROTECTION AGENCY

VINELAND CHEMICAL COMPANY SITE

FIGURE C–20

SURFACE WATER AND SEDIMENT ARSENIC RESULTS
STATION ER-11 (TARKILIN BRANCH)

EBASCO SERVICES INCORPORATED

8641

**EBASCO SERVICES INCORPORATED**

BY SW DATE 5-22-89 SHEET 1 OF 5

CHKD. BY SRO DATE 5-23-89 OFS NO. _____ DEPT. NO. _____

CLIENT USEPA

PROJECT Vineland ES

SUBJECT Contaminated Sediment Volume, River Area

Discussion: A determination of preferred action levels in the river area warrants a recalculation of the contaminated sediment volume. For areas not adjacent to residences, the cleanup level is now 120 ppm. In areas adjacent to homes (i.e. Mill Rd. bridges), the cleanup level is 20 ppm. Calculations by SER, dated 12-6-88, and F. Saghafi, dated 8-29-88, will be used to combine quantities estimated for 120 ppm and 20 ppm, respectively.

Assumptions: Each bridge that serves as a public access point will warrant a 100-foot reduction zone both upstream and downstream. Thus, the volume of sediment calculated for 120 ppm will be subtracted over a 200 ft stretch of river with the bridge as the center. The volume of sediment calculated for 20 ppm over the 200 ft section of river will be added on to arrive at the total volume of sediment requiring remediation.

Calculations:

1. Station ER-4 to Station ER-5

River reach length: 5,150 ft.

Cross sectional area for sediments @ 120 ppm = 11.17 ft² (Avg.)

" " " " " @ 20 ppm = 41.6 ft² (ER-4) } Avg = 35.55

" " " " " @ 20 ppm = 29.5 ft² (ER-5)

Bridge for Mill Rd. is a public access point, ∴ 100' downstream must be remediated to 20 ppm

5,150 − 100 = 5,050 ft (for 120 ppm @ avg. cross sectional area)

100' × 41.6 ft² = 4,160 ft³ (20 ppm) ✓

Bridge @ ER-5 is a public access point, ∴ 100' upstream must be remediated to 20 ppm

5,050 − 100 = 4,950 ft × 11.17 ft² = 55,292 ft³ (120 ppm) ✓

100 ft × 29.5 ft² = 2,950 ft³ (20 ppm) ✓

1495

**EBASCO SERVICES INCORPORATED**

BY SW DATE 5-23-89 SHEET 2 OF 5

CHKD. BY SRO DATE 5-23-89 OFS NO. DEPT. NO.

CLIENT USEPA

PROJECT Vineland FS

SUBJECT Contaminated Sediment Volume - River Area (cont'd)

2. Station ER-5 to Station ER-7

River reach length = 4000 ft ✓

Cross sectional area @ 120 ppm = 0 (Avg.)

" " " " 20 ppm = 29.5 ft² (ER-5) > Avg = 40.35 ft²

" " " " 20 ppm = 51.2 ft² (ER-7)

Bridge @ ER-5 is a public access point ∴ 100' downstream must be remediated to 20 ppm

4,000 - 100 = 3,900 ft (for 120 ppm @ avg cross sectional area) = 0

100 ft × 29.5 ft² = 2,950 ft³ (20 ppm) ✓

Almond Rd. Bridge @ ER-7 is a public beach ∴ 100' upstream must be remediated to 20 ppm

3,900 - 100 = 3,800 ft × 0 = 0 ft³ (120 ppm)

100 ft × 51.2 ft² = 5,120 ft³ (20 ppm)

3. Station ER-7 to Station ER-8

River reach length = 2,600 ft ✓

Cross sectional area @ 120 ppm = 0 (Avg)

" " " " 20 ppm = 51.2 ft² (ER-7) > Avg = 25.6

" " " " 20 ppm = 0 (ER-8)

Almond Rd. Bridge @ ER-7 is a public beach ∴ 100' downstream must be remediated to 20 ppm

2,600 - 100 = 2,500 ft (for 120 ppm @ avg cross sectional area) = 0

100 ft × 51.2 ft² = 5,120 ft³ (20 ppm)

Lindas Ave. Bridge @ ER-8 is a public access point, ∴ 100' upstream must be remediated to 20 ppm

2,500 - 100 = 2,400 ft × 0 ft² = 0 (120 ppm)

100 ft × 0 ft² = 0 (20 ppm

**EBASCO SERVICES INCORPORATED**

BY SW DATE 5-23-89 SHEET 3 OF 5

CHKD. BY SRO DATE 5-23-89 OFS NO. _____ DEPT. NO. _____

CLIENT USEPA

PROJECT Vineland FS

SUBJECT Contaminated Sediment Volume in River Reach (cont'd)

4. Station ER-8 to Station ER-9A
River reach length = 5,700 ft
Cross sectional area @ 120 ppm = 9.36 ft²
" " " " 20 ppm = 0 (ER-8) > Avg = 45.6
" " " " 20 ppm = 91.2 (ER-9A)

There are no public access points between these two stations, ∴ remediation is only performed to 120 ppm.
5,700 ft × 9.36 ft² = 53,352 ft³ ✓

5. Station ER-9A to Station ER-9C
River reach length = 2,300 ft
Cross sectional area @ 120 ppm = 14.72 ft² (Avg)
" " " " 20 ppm = 91.2 ft² (ER-9A) > Avg = 55.47
" " " " 20 ppm = 19.73 ft² (ER-9C)

There are no public access points between these two stations, ∴ remediation is only performed to 120 ppm
2,300 ft × 14.72 ft² = 33,856 ft³ (120 ppm) ✓

6. Station ER-9C to Station ER-9E
River reach length = 4,000 ft
Cross sectional area @ 120 ppm = 29.68 ft² (Avg)
" " " " 20 ppm = 19.73 ft² (ER-9C) > Avg = 43.2
" " " " 20 ppm = 66.67 ft² (ER-9E)

There are no public access points between these two stations, ∴ remediation is only performed to 120 ppm
4,000 ft × 29.68 ft² = 118,720 ft³ (120 ppm) ✓

**EBASCO SERVICES INCORPORATED**

BY SW DATE 5-23-89 SHEET 4 OF 5

CHKD. BY SRO DATE 5-23-89 OFS NO. _____ DEPT. NO. _____

CLIENT USEPA

PROJECT Vineland FS

SUBJECT Contaminated Sediment Volumes in River Areas (cont'd)

7. Station ER-9E to Station ER-9F

River reach length = 1,850 ft

Cross sectional area @ 120 ppm = 37.28 ft² (Avg)

" " " 20 ppm = 66.67 ft² (ER-9E) → Avg = 77.5

" " " 20 ppm = 82.67 ft² (ER-9F)

There are no public access points between the two stations, so remediation is only performed to 120 ppm

1,850 ft × 37.28 ft² = 68,968 ft³ (120 ppm) ✓

8. Station ER-9F to Station ER-10

River reach length = 850 ft

Cross sectional area @ 120 ppm = 27.28 ft² (Avg)

" " " 20 ppm = 82.67 ft² (ER-9F) → Avg = 64.27

" " " " 20 ppm = 45.87 ft² (ER-10)

Bridge @ Sherman Ave is a public access point, so upstream must be remediated to 20 ppm.

850 - 100 = 750 ft × 27.28 ft² = 20,460 ft³ (120 ppm) ✓

100 ft × 45.87 ft² = 4,587 ft³ (20 ppm) ✓

9. Station ER-10 to Station ER-10F

River reach length = 1,700 ft

Cross sectional area @ 120 ppm = 22.56 ft² (Avg)

" " " 20 ppm = 45.87 ft² (ER-10) → Avg = 67.3

" " " 20 ppm = 88.53 ft² (ER-10F)

Bridge @ Sherman Ave is a public access point, so upstream must be remediated to 20 ppm.

1,700 - 100 = 1,600 ft × 22.56 ft² = 36,096 ft³ (120 ppm) ✓

100 ft × 45.87 ft² = 4,587 ft³ (20 ppm) ✓

1-02

**EBASCO SERVICES INCORPORATED**

BY SW DATE 5-23-89 SHEET 5 OF 5

CHKD. BY SRO DATE 5-23-89 OFS NO. DEPT. NO.

CLIENT USEPA

PROJECT Vineland FS

SUBJECT Contaminated Sediment - Volume - Rio Grande (cont'd)

Total contaminated sediment @ 120 ppm =

55,292 + 53,352 + 33,856 + 118,720 + 68,968 + 20,460 + 36,096 = 386,744 ft³

= 14,324 cy

Total contaminated sediment @ 20 ppm =

4,160 + 2,950 + 2,950 + 5,120 + 5,120 + 4,587 + 4,587 = 29,474 ft³

= 1,092 cy

Total sediment to be dredged from Maurice River = 14,324 + 1,092

= 15,416 cy

In Blackwater Branch:

Total Excavated Volume = 56,170 cy

Volume to be dredged = 6,411 cy

New Totals for First Areas:

Excavated Volume = 56,170 cy

Dredged Volume = 15,416 cy + 6,411 cy = 21,827 cy

1502

581 2-88

**EBASCO SERVICES INCORPORATED**

BY SFR DATE 12-6-88

CHKD. BY Sm DATE 1-19-89

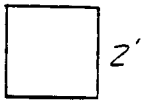
SHEET 1 OF 3

OFS NO. _____ DEPT. NO. _____

CLIENT EPA

PROJECT Loveland

SUBJECT Volume of River Sediments >120 PPM




(0.025 + 0.025 + 0.024)/3 = 0.025

4 (2 ft²) = 0.025

ER-5 0

ER-7 0

ER-8 0

ER-9A (0.116 + 0.113 + 0.120)/3 = 0.117

ER-9C (0.070 + 0.064 + 0.066)/3 = 0.067

ER-9E (0.304 + 0.305 + 0.303)/3 = 0.304

ER-9F (0.116 + 0.113 + 0.119)/3 = 0.116

(0.006 + 0.008 + 0.007)/3 = 0.007

(0.035 + 0.039 + 0.039)/3 = 0.038

0.161

ER-10 (0.097 + 0.096 + 0.097)/3 = 0.097

(0.080 + 0.081 + 0.082)/3 = 0.081

0.178

ER-10A (0.042 + 0.041 + 0.044)/3 = 0.042

(0.061 + 0.060 + 0.062)/3 = 0.061

0.103

150A

581 2-88

EBASCO SERVICES INCORPORATED

BY SER DATE 12-7-88 SHEET 2 OF 3

CHKD. BY _____ DATE 1-14-89 OFS NO. _____ DEPT. NO. _____

CLIENT EPA

PROJECT Vineland

SUBJECT Volume of River Sediments >120 PPM

Check

| | | |
|---|---|---|
| ER-9A | 0.117 | 1 - 0.883 = 0.117 |
| ER-9C | 0.067 | 1 - 0.932 = 0.068 ⇒ 0.067 |
| ER-9E | 0.304 | 1 - 0.696 = 0.304 |
| ER-9F | 0.117 | 1 - 0.883 = 0.117 |
| | 0.007 | 1 - 0.994 = 0.007 |
| | 0.039 | 1 - 0.963 = 0.037 → 0.038 |
| ER-10 | 0.082 | 1 - 0.917 = 0.083 → 0.083 |
| | 0.097 | 1 - 0.903 = 0.097 |
| ER-10A | 0.040 | 1 - 0.956 = 0.044 → 0.042 |
| | 0.060 | 1 - 0.940 = 0.060 |

Average preliminary values & checked values

| | | | |
|---|---|---|---|
| ER-5 | 0 | | |
| ER-7 | 0 | | |
| ER-8 | 0 | | |
| ER-9A | (0.117 + 0.117)/2 = 0.117 | ⇒ | 18.72 ft² |
| ER-9C | (0.067 + 0.067)/2 = 0.067 | ⇒ | 10.72 ft² |
| ER-9E | (0.304 + 0.304)/2 = 0.304 | ⇒ | 48.64 ft² |
| ER-9F | (0.161 + 0.162)/2 = 0.162 | ⇒ | 25.92 ft² |
| ER-10 | (0.178 + 0.180)/2 = 0.179 | ⇒ | 28.64 ft² |
| ER-10A | (0.103 + 0.102)/2 = 0.103 | ⇒ | 16.48 ft² |

1505

581 2-88

EBASCO SERVICES INCORPORATED

BY SER DATE 12-7-88

CHKD. BY _____ DATE 1-11-89

SHEET 3 OF 3

OFS NO. _____ DEPT. NO. _____

CLIENT EPL

PROJECT Vineland

SUBJECT Volume of River Sediments >120 PPM

| Station | X-Sectional Area ($ft^2$) | Avg Area ($ft^2$) | Reach Length (ft) | Volume ($ft^3$) |
|---|---|---|---|---|
| ER-5 | 0 | | | |
| | | 0 | 4000 | 0 |
| ER-7 | 0 | | | |
| | | 0 | 2600 | 0 |
| ER-8 | 0 | | | |
| | | 9.36 | 5700 | 53,352 |
| ER-9A | 18.72 | | | |
| | | 14.72 | 2300 | 33,856 |
| ER-9C | 10.72 | | | |
| | | 29.68 | 4000 | 118,720 |
| ER-9E | 48.64 | | | |
| | | 37.28 | 1850 | 68,968 |
| ER-9F | 25.92 | | | |
| | | 27.28 | 850 | 23,188 |
| ER-10 | 28.64 | | | |
| | | 22.56 | 1700 | 38,352 |
| ER-10A | 16.48 | | | |
| | | | | 336,436 |

Volume = 336,436 $ft^3$ $\frac{1\ cy^3}{27\ ft^3}$ = 12,460 CY

1506

581 2-88

EBASCO SERVICES INCORPORATED

BY F. Saghafi DATE 8/29/88 SHEET ____ OF ____

CHKD. BY SW DATE 10-3-88 OFS NO. ____ DEPT. NO. ____

CLIENT EPA

PROJECT Vineland Chemical - Maurice River

SUBJECT Sediment volumes to dredge

Volume of Sediments to be dredged @:

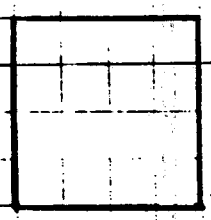
Rich level: $1 \times 10^{-4} \Rightarrow 1160$ ppm As

ER-3A: 16.1, 16.4, 16.3 $\Rightarrow 16.27/0.25 = 65.07 ft^2$

| Station | Sectional Area ($ft^2$) | Avg Area ($ft^2$) | Reach length (ft) | Volume ($ft^3$) |
|---|---|---|---|---|
| ER-3A | 65.07 | 32.54 | 850 | 27655 |
| ER-4 | 0 | | | |
| | | | | 27,655 $ft^3$ |

$$27{,}655\ ft^3 \times \frac{1\ cy}{27\ ft^3} = 1024.26 \simeq 1050\ cy$$

Calibration:



1" = 2' scale = $1 in^2 = 4 ft^2$

1" = 4' scale = $1 in^2 = 16 ft^2$

$\left(\text{or } \frac{1}{0.25 ft^2} \text{ \& } \frac{1}{0.0625 ft^2}\right)$

564

EBASCO SERVICES INCORPORATED

BY F. Soghafi DATE 8/29/88 SHEET ____ OF ____

CHKD. BY JW DATE 10-3-88 OFS NO. ____ DEPT. NO. ____

CLIENT EPA

PROJECT Vineland Chemical - Maurice River

SUBJECT Sediment volumes to dredge

Summary of different risk levels:

| Risk level | As Conc. (ppm) | Dredging Volume (cy) |
|---|---|---|
| $1 \times 10^{-6}$ | 11.6 (12) | 84890.67 ≃ 85,000 |
| $1.7 \times 10^{-6} \sim 2 \times 10^{-6}$ | 20 | 53,256.2 ≃ 53,300 |
| $1 \times 10^{-5}$ | 116 (120) | 19,831.33 ≃ 20,000 |
| $1 \times 10^{-4}$ | 1160 (1200) | 1024.26 ≃ 1050 |

Area to be dredged or excavated = 71,322 $yd^2$

Average depth to be dredged:

12.6 ppm ⟹ $\frac{85,000}{71,322} = 1.192\ yd = 3.57\ ft$

20 ppm ⟹ $\frac{53,300}{71,322} = 0.75\ yd = 2.25\ ft$

116 ppm ⟹ $\frac{20,000}{71,322} = 0.28\ yd = 0.84\ ft$

1160 ppm ⟹ $\frac{1050}{71,322} = 0.015\ yd = 0.05\ ft$

EBASCO SERVICES INCORPORATED

SHEET ____ OF ____

DEPT. NO. ____

OFS NO. ____

T. Dagofi DATE 8/29/88

KD. BY SW DATE 10-3-88

ENT EPA

OJECT Vineland Chemical - Maurice River

BJECT Sediments volume to dredge

Volume of sediments to dredge @:

Risk level: $1 \times 10^{-5}$ ⇒ 116 ppm As

calibration factor from map

ER-3A: 16.1, 16.4, 16.3 ⇒ 16.27 / 0.25 = 65.07 ft²
ER-4: 5.6, 5.6, 5.55 ⇒ 5.58 / 0.25 = 22.33 ft²
ER-9A: 1.5, 1.8, 1.7 ⇒ 1.67 / 0.0625 = 26.67 ft²
ER-9C: 0.8, 0.8, 0.8 ⇒ 0.8 / 0.0625 = 12.8 ft²
ER-9E: 3.8, 3.7, 3.6 ⇒ 3.7 / 0.0625 = 59.2 ft²
ER-9F: 2.8, 2.8, 2.9 ⇒ 2.83 / 0.0625 = 45.33 ft²
ER-10: 2, 2.1, 2.1 ⇒ 2.07 / 0.0625 = 33.07 ft²
ER-10A: 1.3, 1.2, 1.3 ⇒ 1.3 / 0.0625 ⇒ 20.3 ft²

| Station | Cross sectional area (ft²) | Avg. area (ft²) | Reach length (ft) (Dip) | Volume (ft³) |
|---|---|---|---|---|
| ER-3A | 65.07 | 43.7 | 3A-4 850 | 37145 |
| ER-4 | 22.33 | 11.17 | 4-5 5150 | 57525 |
| ER-5 | 0 | 0 | 5-7 4000 | 0 |
| ER-7 | 0 | 0 | 7-8 2600 | 0 |
| ER-8 | 0 | 13.33 | 8-9A 5700 | 75981 |
| ER-9A | 26.67 | 19.74 | 9A-9C 2300 | 45402 |
| ER-9C | 12.8 | 36 | 9C-9E 4000 | 144000 |
| ER-9E | 59.2 | 52.27 | 9E-9F 1850 | 96700 |
| ER-9F | 45.33 | 39.2 | 9F-10 850 | 33320 |
| ER-10 | 33.07 | 26.69 | 10-10A 1700 | 45373 |
| ER-10A | 20.3 | | | |
| | | | | 535,446 ft³ |

$535{,}446\ ft^3 \times \frac{1\ cy}{27\ ft^3} = 19{,}831.33 \approx 20{,}000\ cy$

16325

8051

EBASCO SERVICES INCORPORATED

BY L. Sofrafi DATE 3/29/88 SHEET ____ OF ____

OFS NO. ____ DEPT. NO. ____

CHKD. BY SW DATE 10-3-88

CLIENT EPA

PROJECT Vineland Chemical - Maurice River

SUBJECT Volume of sediments to dredge

Volume of Sediments to be dredged @:

Risk level: $1.7 \times 10^{-6} \simeq 2 \times 10^{-6} \Rightarrow$ 20 ppm As

ER-3A: 16.1, 16.4, 16.3 ⇒ 16.27/0.25 = 65.07 ft²
ER-4: 10.3, 10.5, 10.4 ⇒ 10.4/0.25 = 41.6 ft²
ER-5: 7.4, 7.3, 7.4 ⇒ 7.37/0.25 = 29.5 ft²
ER-7: 3.15, 3.25, 3.2 ⇒ 3.2/0.0625 = 51.2 ft²
ER-9A: 5.8, 5.7, 5.6 ⇒ 5.7/0.0625 = 91.2 ft²
ER-9C: 1.2, 1.25, 1.25 ⇒ 1.23/0.0625 = 19.73 ft²
ER-9E: 4.15, 4.15, 4.2 ⇒ 4.17/0.0625 = 66.67 ft²
ER-9F: 5.2, 5.1, 5.2 ⇒ 5.17/0.0625 = 82.67 ft²
ER-10: 2.8, 2.9, 2.9 ⇒ 2.87/0.0625 = 45.87 ft²
ER-10A: 5.8, 5.5, 5.5 ⇒ 5.53/0.0625 = 88.53 ft²

| Station | Sectional Area (ft²) | Avg. Area (ft²) | Reach length (ft) | Volume (ft³) |
|---|---|---|---|---|
| ER-3A | 65.07 | 53.335 | 850 | 45335 |
| ER-4 | 41.6 | 35.55 | 5150 | 183083 |
| ER-5 | 29.5 | 40.35 | 4000 | 161400 |
| ER-7 | 51.2 | 25.6 | 2600 | 66560 |
| ER-8 | 0 | 45.6 | 5700 | 259920 |
| ER-9A | 91.2 | 55.465 | 2300 | 127570 |
| ER-9C | 19.73 | 43.2 | 4000 | 172800 |
| ER-9E | 66.67 | 74.67 | 1850 | 138145 |
| ER-9F | 82.67 | 64.27 | 850 | 54629 |
| ER-10 | 45.87 | 67.2 | 1700 | 114240 |
| ER-10A | 88.53 | | | |

~~228480~~

~~1437917~~ ft³

49.025

~~53.580~~

1323677

EBASCO SERVICES INCORPORATED

BY K. Dogafi DATE 8/29/88 SHEET ____ OF ____

CHKD. BY SW DATE 10-3-88 OFS NO. ____ DEPT. NO. ____

CLIENT EPA

PROJECT Vineland Chemical - Maurice River

SUBJECT Sediment volumes to dredge

Volume of Sediments to be dredged @:

Risk level: $1 \times 10^{-6}$ ⟹ 11.6 ppm As

ER-1: 3.3, 3.4, 3.3 ⟹ 3.33/0.25 = 13.33 $ft^2$
ER-3A: 16.1, 16.4, 16.3 ⟹ 16.27/0.25 = 65.07 $ft^2$
ER-4: 11.95, 12.05, 12.15 ⟹ 12.05/0.25 = 48.2 $ft^2$
ER-5: 11.3, 11.5, 11.5 ⟹ 11.43/0.25 = 45.73 $ft^2$
ER-7: 7.9, 7.5, 7.5 ⟹ 7.63/0.0625 = 122.13 $ft^2$
ER-8: 2.6, 2.5, 2.6 ⟹ 2.57/0.0625 = 41.07 $ft^2$
ER-9A: 5.8, 5.7, 5.6 ⟹ 5.7/0.0625 = 91.2 $ft^2$
ER-9C: 3.8, 3.9, 3.6 ⟹ 3.77/0.0625 = 60.27 $ft^2$
ER-9E: 5.3, 5.2 ⟹ 5.17/0.0625 = 82.67 $ft^2$
ER-9F: 5.9, 5.7, 5.8 ⟹ 5.7/0.0625 = 91.2 $ft^2$
ER-10: 6.2, 6.2, 6.3 ⟹ 6.23/0.0625 = 99.73 $ft^2$
ER-10A: 6.5, 6.5, 6.5 ⟹ 6.5/0.0625 = 104 $ft^2$

| Station | Sectional Area ($ft^2$) | Avg Area ($ft^2$) | Reach length (ft) | Volume ($ft^3$) |
|---|---|---|---|---|
| ER-1 | 13.33 | 39.2 | 5150 | 201880 |
| ER-3A | 65.07 | 56.64 | 850 | 48144 |
| ER-4 | 48.2 | 46.97 | 5150 | 241896 |
| ER-5 | 45.73 | 83.93 | 4000 | 335720 |
| ER-7 | 122.13 | 81.6 | 2600 | 212160 |
| ER-8 | 41.07 | 66.14 | 5700 | 376998 |
| ER-9A | 91.2 | 75.74 | 2300 | 174202 |
| ER-9C | 60.27 | 71.47 | 4000 | 285880 |
| ER-9E | 82.67 | 86.94 | 1850 | 160839 |
| ER-9F | 91.2 | 93.47 | 850 | 81150 |
| ER-10 | 99.73 | 101.81 | 1700 | 173179 |
| ER-10A | 104 | | | |

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VIN 002 1702 1