CLOSURE PLAN

DOCK 2-B, BUILDING 45 AND BUILDING 49 AT THE FORMER TRW INC. TAPCO FACILITY

SUBMITTED TO

TRW

INCORPORATED

MODIFIED , SEPTEMBER, 1988

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DESIGN • RESEARCH • PLANNING
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SEPTEMBER 1988

Submitted by

ENGINEERING-SCIENCE
19101 Villaview Road - Suite 301
Cleveland, Ohio 44119

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CLOSURE PLAN

DOCK 2-B, BUILDING 45
and
BUILDING 49

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1. DESCRIPTION OF FACILITY

The TAPCO facility, formerly owned by TRW Incorporated, is located about two miles south of Lake Erie, in the City of Euclid, Cuyahoga County, Ohio. As shown in Figure 1.1, the property boundaries include more than 200 acres on both sides of Euclid Avenue. All of the buildings are located on the north side of Euclid Avenue.

Construction of the TAPCO facility was started in the 1940s by the then Thompson Aircraft Products Company, later TRW Incorporated. Over a period of more than forty years, numerous and varied manufacturing operations took place on the site, including forging, heat treatment, machining, metal finishing and electroplating. Additional activities, including aircraft engine and weapons testing, took place under contract to the Federal government.

TRW submitted a RCRA Part A Permit Application for the TAPCO facility on 17 November 1980. An Interim Status Permit was granted 14 May 1982. (The EPA Facility Identification Number for TAPCO is OHD004179-453). An application for revision, which was filed on 4 June 1984, was withdrawn 21 December 1984. TRW requested that the TAPCO facility be removed from the treatment, storage and disposal facility category, because it was only a 90-day generator. Appendix 1 includes a copy of the interim status permit.

In 1986, the TAPCO property and the manufacturing and contract testing facilities there were sold by TRW Incorporated. ARGO-TECH Inc. purchased the property and a portion of the manufacturing and testing facilities, effective 20 October 1986. Airfoil Forging Corporation (now, Airfoil Forging Textron) purchased other manufacturing facilities effective 29 August 1986.

Pursuant to the purchase agreements, TRW Incorporated will proceed with closure of those portions of the TAPCO facility which had been granted interim status. ARGO-TECH and Aircraft Forging Textron are generators of most of the same hazardous waste materials formerly generated by TRW, but they do not plan to store any hazardous waste materials on-site for periods longer than 90 days.

The sections that follow present the Closure Plan for the three hazardous waste management units on the TAPCO site which are to be closed. The units are Dock 2-B, Building 45 and Building 49. This Closure Plan represents a complete closure of all RCRA regulated units at the Tapco facility operated by TRW under interim status.

2. DESCRIPTION OF WASTE MANAGEMENT UNITS TO BE CLOSED

This Closure Plan represents a complete closure of all RCRA regulated units at the TAPCO facility operated by TRW under interim status.

Figure 1.1 shows the TAPCO site and the locations of the units to be closed. Dock 2-B, Building 45 and Building 49 are all in the northern portion of the property. Dock 2-B and Building 45 were used for storage up to 90 days of drummed hazardous wastes generated on-site. The Building 49 area includes a fenced compound used for torpedo testing. Torpedo fuel and liquid residues remaining after test firing were stored in drums and a 1000 gallon underground tank at Building 49. Accidental discharges of fuel residue and cyanides generated by test firing occurred onto a formerly swampy area to the south of the fenced compound.

The descriptions that follow are based in part on information included in the interim status RCRA permit and the application for revision (Appendix 1). Additional information from a sampling and laboratory analysis program at the units to be closed, which was undertaken in conjunction with preparation of this Closure Plan, is presented in Section 5.

2.1 Dock 2-B

Dock 2-B is the site of a hazardous waste storage area for 55 gallon drums. This 8100 sq.ft. area is located near the northwest corner of the TAPCO facility, adjoining Building 26. It consists of a concrete base covered by wood block flooring. When originally built, about 1950, this was a general purpose shipping and receiving dock serving the site.

Since about 1981, Dock 2-B has been used mainly for storage and subsequent shipment of hazardous wastes in drums. As shown in Figure 2.1, an area of about 1200 sq.ft. at the southeast corner of the Dock has been used for secured storage of hazardous wastes from all hazardous waste generating activities at the TAPCO facility. This area is enclosed by a metal cage about 9 ft high, with a locked sliding gate. In TRW's application for the interim status permit, Dock 2-B was marked as a "Drum Storage Area" in the sketch provided on Page 5. Its process design capacity was listed as

23,100 gallons (i.e., 420 drums) on Page 1 (See Appendix 1). The maximum inventories stored of each waste are listed in Table 2.1.

Effective 20 October 1986, ARGO-TECH, Inc. assumed responsibility for operation of this area. TRW Inc., pursuant to its purchase agreements with ARGO-TECH, plans to close the original Dock 2-B caged area and to provide a new storage area with facilities for spill containment and control. ARGO-TECH will continue to use Dock 2-B for storage of hazardous waste generated on-site for periods not exceeding 90 days.

A second caged area was added to the west of the original area. This new area is operated by Airfoil Forging Textron (AFT), specifically for hazardous waste generated by AFT manufacturing operations.

2.2 Building 45

Building 45 is located in the north-central portion of the TAPCO site. As shown in Figure 2.2, this long, narrow building adjoins Building 26 and extends about 450 ft northeastward into a fenced compound. It was constructed of concrete during the 1940s, specifically for rifle test firing ranges. A wall along the entire length of the building separates Range A, on the north side, from Range B.

The Target House near the eastern end is separated from the main building by a firing tunnel. It is provided with security doors, originally to prevent accidental entry during firing tests. A pit located to the east of the Target House, originally for recovery of spent bullets, and a target trench to the west, isolate the Target House floor.

The former Target House was put into use for storage of drummed hazardous waste prior to 1980 and continued through 1985. It was selected for this, partially on the basis of distance from plant operations and limited access. The Range A side provided about 315 sq.ft., and the Range B side provided an additional 420 sq.ft. In TRW's application for the interim status permit, the Building 45 Target House was marked as a "Drum Storage Area" in the sketch provided on Page 5. Its process design capacity was listed as 4,400 gallons (i.e., 80 drums) on Page 1 (See Appendix 1). The maximum inventories stored of each waste are listed in Table 2.1.

As noted in Figure 2.2, the concrete floor was built sloping downward to the east. Metal dike plates were installed along the eastern edge of

the floor and grouted, to prevent any spillage from leaking into the former water pit. The square concrete extensions of the Target House floor along the north and south walls each have a 55 gallon sump to collect spillage.

The Building 45 Target House Hazardous Waste Storage Area was removed from service, and the last 55 gallon drum containers of hazardous waste that had been stored there were removed prior to the sale of the property by TRW Incorporated. ARGO-TECH Inc., has no plans for further use of Building 45 as a hazardous waste storage area at present.

2.3 Building 49

Building 49 is located in the northeastern portion of the TAPCO facility, inside a fenced compound which isolated torpedo testing activities. Building 49 was built in 1965, originally containing one cell for test firings; a second cell was added later. The storage area for virgin fuel was located on the eastern side of the building. The other buildings within the compound include a locker room and laundry for torpedo test personnel (Building 48) and storage buildings (Buildings 42, 43, 50 and 51). See Figure 1.1.

Wastewater containing liquid fuel residue and cyanides is generated by the torpedo test firing. Until late 1985, the wastewater was discharged through a 1000 gallon underground steel separation tank. Liquid residues of unburned fuel were separated in the tank and stored there until hauled off-site for disposal by incineration within 90 days. See Figure 2.3 for details on the tank construction and installation.

In TRW's application for the interim status permit, the Building 49 Area was marked as a "Waste Fuel Storage Area" in the sketch provided on Page 5. The process design capacity for the storage tank there (S02) was listed as 1000 gallons on Page 1 (See Appendix 1). The maximum inventory of waste stored was 500 gallons, as listed in Table 2.1.

Unintentional discharges from the separator tank containing cyanides and liquid residues of unburned torpedo fuel were discovered in 1985 in a swampy area on the south side of the fence. The National Response Center was notified, and TRW authorized studies of the discharge area, to define the extent of the soil affected. The study report is enclosed as Attachment 2. The principal findings are summarized in Section 5.3. The volume

of contaminated soil and sediments to be removed is estimated to be 114.4 cu.yd. (See Sections 6.4 and 6.5 and Attachment 2).

Since the discovery of the discharge, overflows from the separator tank has been diverted to, and stored in three holding tanks on the west side of Building 49 until hauled for off-site disposal (See Figure 2.3). A new torpedo test facility has been built elsewhere on the TAPCO Site (Building 33), and all torpedo testing activities will be shifted to that location.

2.4 Topography and Soils

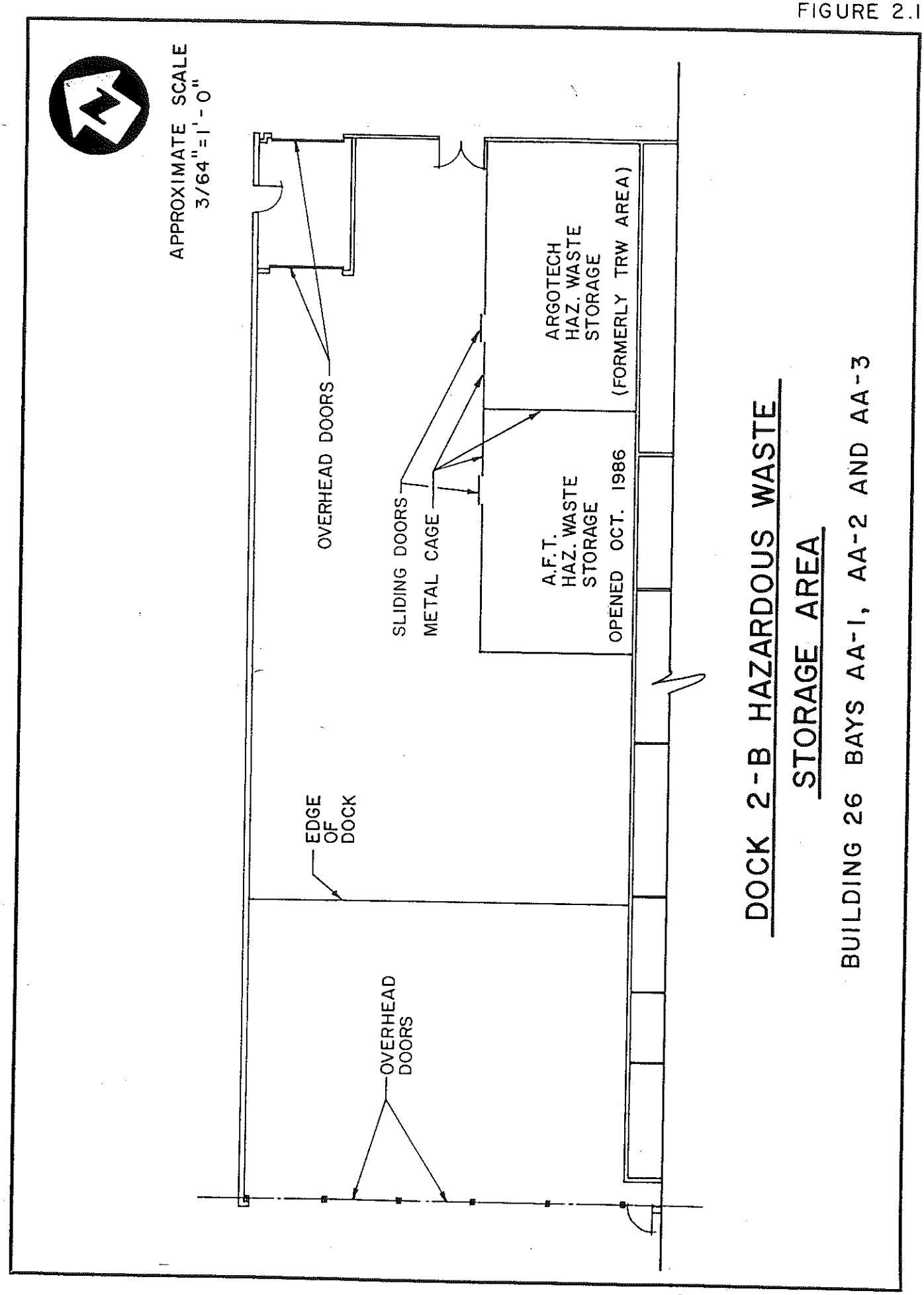
The hazardous waste management units to be closed lie in the lake plain, which resulted from deposition of clay, silt and fine sands during a stage of glacial lake inundation. The area is characterized as nearly level to gently sloping. The undisturbed vegetative cover would be thick grass, brush and trees. Drainage is poor, due in part to the flat topography and to the low permeability of the predominant silty soils.

The surface soils in the lake plain are generally derived from very fine silt and clay sediments deposited from past higher lake stages, except where beach sand remnants remain. These lacustrine (lake) surface deposits are typically about 10 feet in thickness. These surface soils are generally considered to be very poor sources of ground water supply. Most of the soil at the former TAPCO site is classified as urban land, since a large proportion of the surface is covered by buildings and asphalt or concrete pavement.

Underlying the surface soils is a variable thickness of tight glacial till composed of hard clayey to sandy silt with angular gravel and rock fragments. The consolidated deposits underlying the former TAPCO site consist of a series of shale formations of low permeability, together more than 800 ft thick. These shales are of Mississippian and Devonian age. The formations are not considered to be productive for ground water supply.

Appendix 2 provides a more detailed description of the regional and site topography. Details on the surface drainage and the surface and subsurface soils at the former Building 49 discharge area also are found in Attachments 2 (the Building 49 Study Report, Sections 3 and 4).

FIGURE 2.1


APPROXIMATE SCALE
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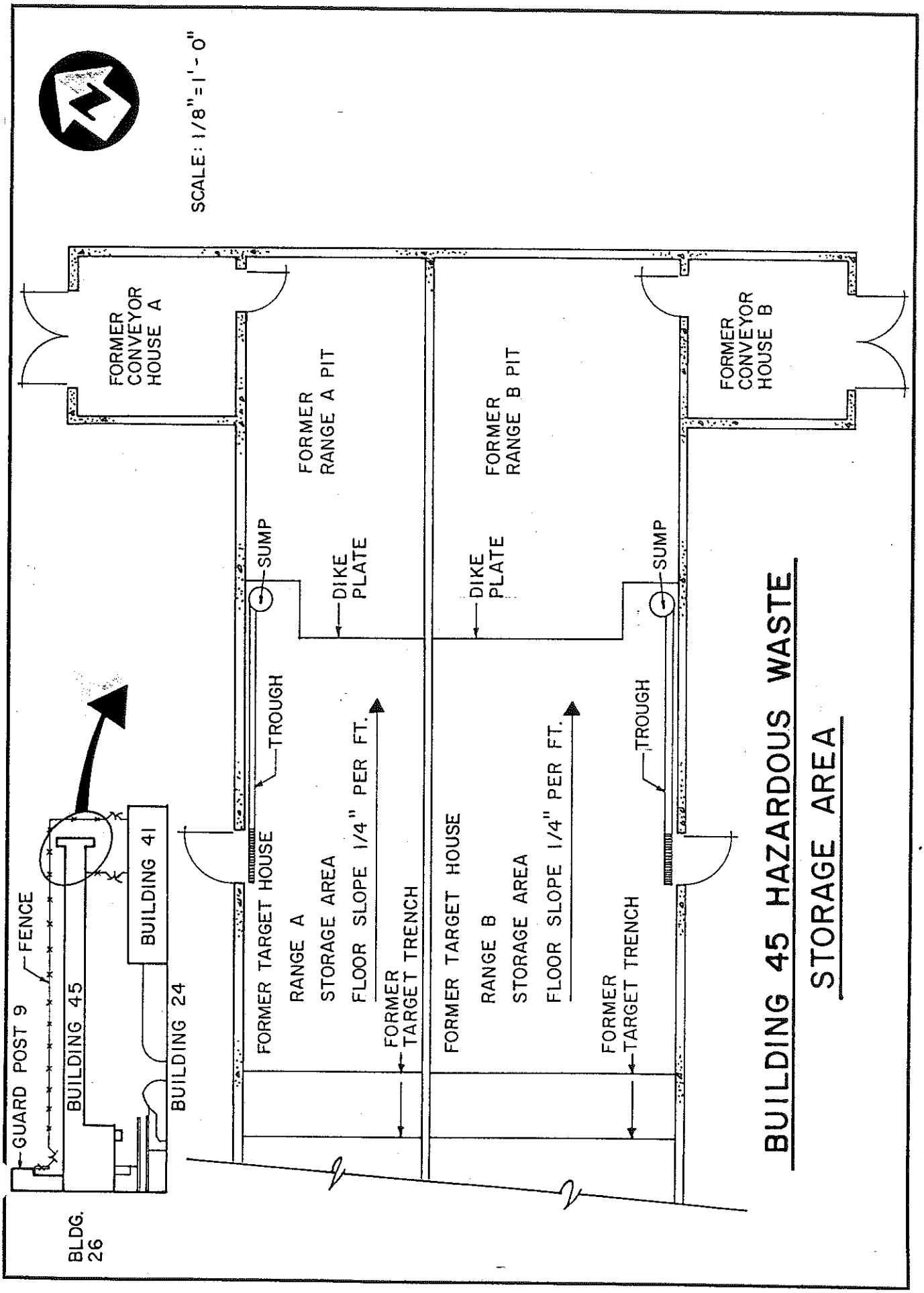
ARGOTECH
HAZ. WASTE
STORAGE
(FORMERLY TRW AREA)
A.F.T.
HAZ. WASTE
STORAGE
OPENED OCT. 1986
EDGE
OF
DOCK
OVERHEAD
DOORS
DOCK 2-B HAZARDOUS WASTE
STORAGE AREA
BUILDING 26 BAYS AA-1, AA-2 AND AA-3

FIGURE 2.2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FORMER CONVEYOR HOUSE A
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FORMER CONVEYOR HOUSE B
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DIKE PLATE
DIKE PLATE
SUMP
TROUGH
TROUGH
FORMER TARGET HOUSE
RANGE A
STORAGE AREA
FLOOR SLOPE 1/4" PER FT.
FORMER TARGET TRENCH
FORMER TARGET HOUSE
RANGE B
STORAGE AREA
FLOOR SLOPE 1/4" PER FT.
FORMER TARGET TRENCH
BUILDING 41
BUILDING 24
BUILDING 45
FENCE
GUARD POST 9
BLDG. 26
BUILDING 45 HAZARDOUS WASTE
STORAGE AREA

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TABLE 2.1

MAXIMUM INVENTORIES OF WASTES STORED AT RCRA FACILITIES
Basis: Operational Records and Manifest Files

Dock 2-B (former TRW caged area)

F001	Freon Degreasing Residue	6 drums (300 gallons)
F001	Spent Trichloroethylene	22 drums (1,100 gallons)
F001	Spent Tetrachloroethylene	8 drums (400 gallons)
F002	Trichloroethane Recovery Still Bottoms	11 drums (550 gallons)
F005	Spent Methyl Ethyl Ketone (MEK)	2 drums (100 gallons)
F005	Spent Dioxane/MEK mixed solvent	1 drum (50 gallons)
D008	Waste Ceramic Slip	57 drums (28,000 lbs)
D002	Corrosive Solid	78 drums (39,000 lbs)

Building 45

F003	Spent Xylene	1 drum (50 gallons)
F008 D007	Sludges from Chromium Electroplating Bath	4 drums (2,000 lbs)

Building 49

D003	Torpedo Fuel Residue	(500 gallons)

3. MAPS OF FACILITY

FIGURE 1.1 - Tapco Site: Areas To Be Closed

FIGURE 3.1 - Topographic Map of the Tapco Facility (Aerial Photo Base)
Scale 1" = 200'

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4. DETAILED DRAWINGS OF THE UNITS TO BE CLOSED

FIGURE 2.1 - Dock 2-B Hazardous Waste Storage Area

FIGURE 2.2 - Building 45 Hazardous Waste Storage Area

FIGURE 2.3 - Building 49 Plans and 1,000 Gallon Separator Tank - Details (TAPCO Drawing M-1177)

5. LIST OF HAZARDOUS WASTES HANDLED

According to the RCRA Interim Status Permit and the Application for Revision, the wastes stored in Building 45 and Dock 2-B included (F002) trichloroethane recovery still bottoms and (F006) wastewater treatment sludges from electroplating operations, containing cyanides and metal hydroxides. The torpedo fuel residues at Building 49 were listed as reactive (in their virgin state) (See Appendix 1). See Table 2.1 for the maximum inventories stored.

In the course of preparing this Closure Plan, sampling and chemical analysis were undertaken, to define further the characteristics of hazardous wastes and residues which may be involved in the Closure. A copy of the laboratory reports is provided as Attachment 1. The results are discussed in the paragraphs that follow.

5.1 Dock 2-B

The uncaged area flooring was sampled on 28 May 1987, by removal of wood blocks at the centers of eight randomly selected areas defined by the 10 ft spacing grid shown in Figure 5.1 and scraping the wood surfaces with a chisel. A composite sample of the scrapings was submitted for laboratory analysis to determine priority pollutants and RCRA Hazard Characteristics. The wood blocks in the caged former TRW storage area can be expected to have similar characteristics. Since hazardous waste was stored in this area and spilled materials may have been absorbed, these blocks will be removed. (However, the wood blocks outside this area are still serving their original purpose and will not be removed, unless they are found to have become contaminated due to spilled hazardous waste. Sampling and analysis during the closure will determine that, as discussed in Section 6.11).

The results, as summarized in Table 5.1, show characteristics which would require that any flooring removed from the former TRW Hazardous Waste Storage Area during closure must be disposed of as a hazardous waste. A spectrum of priority pollutant organics was detected. These organics, which include both volatile organics and polynuclear aromatics (base/

neutral extractable semi-volatiles), are believed to be preservative chemicals which were applied to the wood blocks by the manufacturer.

However, those were the only characteristics which would be considered to be hazardous. The TCLP (Toxicity Characteristic Leaching Procedure) extraction did not yield detectable concentrations of any regulated PCBs, pesticides or herbicides. None of the regulated heavy metals was present at a concentration which would render the flooring material EP Toxic. Cyanide was detected at a low concentration, but corrosivity and sulfide reactivity tests were both negative. The cyanide is believed to be a preservative chemical residue, since operations records for Dock 2B indicate that no hazardous wastes containing cyanides have ever been stored there.

5.2 Building 45

The Target House flooring was sampled on 29 May 1987, by scraping the concrete flooring surfaces with a chisel at the centers of eight randomly selected areas defined by the 5 ft spacing grid shown in Figure 5.2. A composited sample of the scrapings was submitted for laboratory analysis to determine priority pollutants and RCRA Hazard Characteristics.

The results, as summarized in Table 5.1, show characteristics which would require that any concrete flooring removed from the Target House during closure must be disposed of as a hazardous waste. The scrapings are EP Toxic, due to the presence of high TCLP extraction chromium concentrations.

However, the other characteristics would not be considered hazardous. The tests of corrosivity, ignitability and sulfide reactivity were negative. No priority pollutant organics, PCBs or TCLP extraction herbicides and pesticides were present at detectable concentrations.

5.3 Building 49

In 1985, an unintentional discharge into the swampy area to the south of Building 49 was found. The National Response Center was notified, and TRW authorized studies of the discharge area, to define the extent of the soil affected. The study report is enclosed as Attachment 2. The principal findings in that study are as follows (See Figure 5.3):

- An irregularly shaped 300 sq.ft. area around the former discharge pipe was found to contain detectable concentrations of Propylene

Glycol Dinitrate (PGDN), the principal component of the torpedo fuel. The average PGDN concentration for the top 1 ft of soil in this area was 1900 mg/kg. Overlapping this was a larger area, about 600 sq.ft. of soil containing detectable cyanides, with an average concentration of 10 mg/kg for the top 1 ft of soil. (The detection limits were, respectively, 25 mg/kg for PGDN and 0.25 mg/kg for total cyanides.)

- Migration of the chemical residues away from the soils near the former discharge pipe was attributed principally to erosion of soil particles at times of high stormwater flow. Two isolated samples of sediments from the 120 ft long runoff stream were found to contain 240 and 80 mg/kg of PGDN in the top 1 ft. Sediment cyanide concentrations along the runoff stream averaged 6 mg/kg in the top 1 ft. There also has been migration of cyanides by solubilization and transport into the runoff stream; observed cyanide concentrations in the runoff stream water ranged from 0.3 to 1.2 mg/L (PGDN, which is not miscible with water, would not migrate by that mechanism).

- A narrow belt of soil containing cyanide at concentrations 0.5 to 2 mg/kg in the top 1 ft was found encircling Building 49, at distance of 100 to 300 ft from former discharge area. The cyanides in this belt are believed not to have originated from the discharges, but from downwash of exhaust gases vented during torpedo tests (See Figure 5.4).

Additional soil sampling and laboratory analysis for cyanides was undertaken in conjunction with the preparation of this Closure Plan, to further define the extent of soils containing cyanides and to determine characteristics of the soil in the vicinity of Building 49, for purposes of treatment and disposal. The results are summarized in Table 5.2 (See Attachment 2, the Building 49 Study Report, for details).

The soil at the former discharge pipe is considered hazardous because of the presence of PGDN and cyanides. However, the RCRA characteristics tests for ignitability, corrosivity, sulfide reactivity and EP Toxicity

were negative. Priority pollutant organics and PCBs were not present at detectable concentrations.

Additional characteristics were determined for the recommended treatment of soil excavated from the former discharge area by incineration (to be followed by ultimate disposal of the resultant ash by landfilling). The observed high flash point, low net heating value, high ash content and high solids content in discharge area samples were essentially the same as those of the background area samples.

FIGURE 5.1

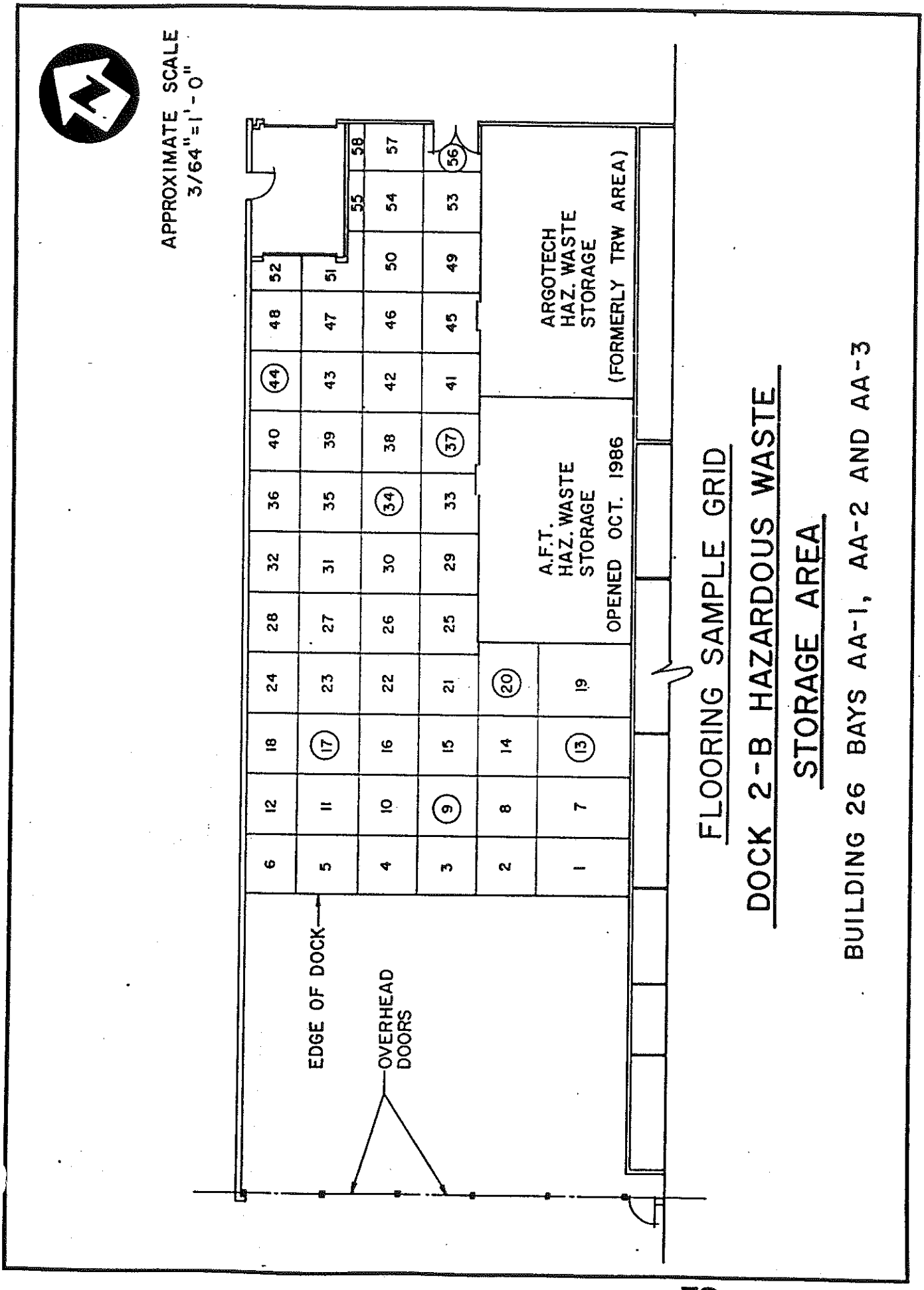

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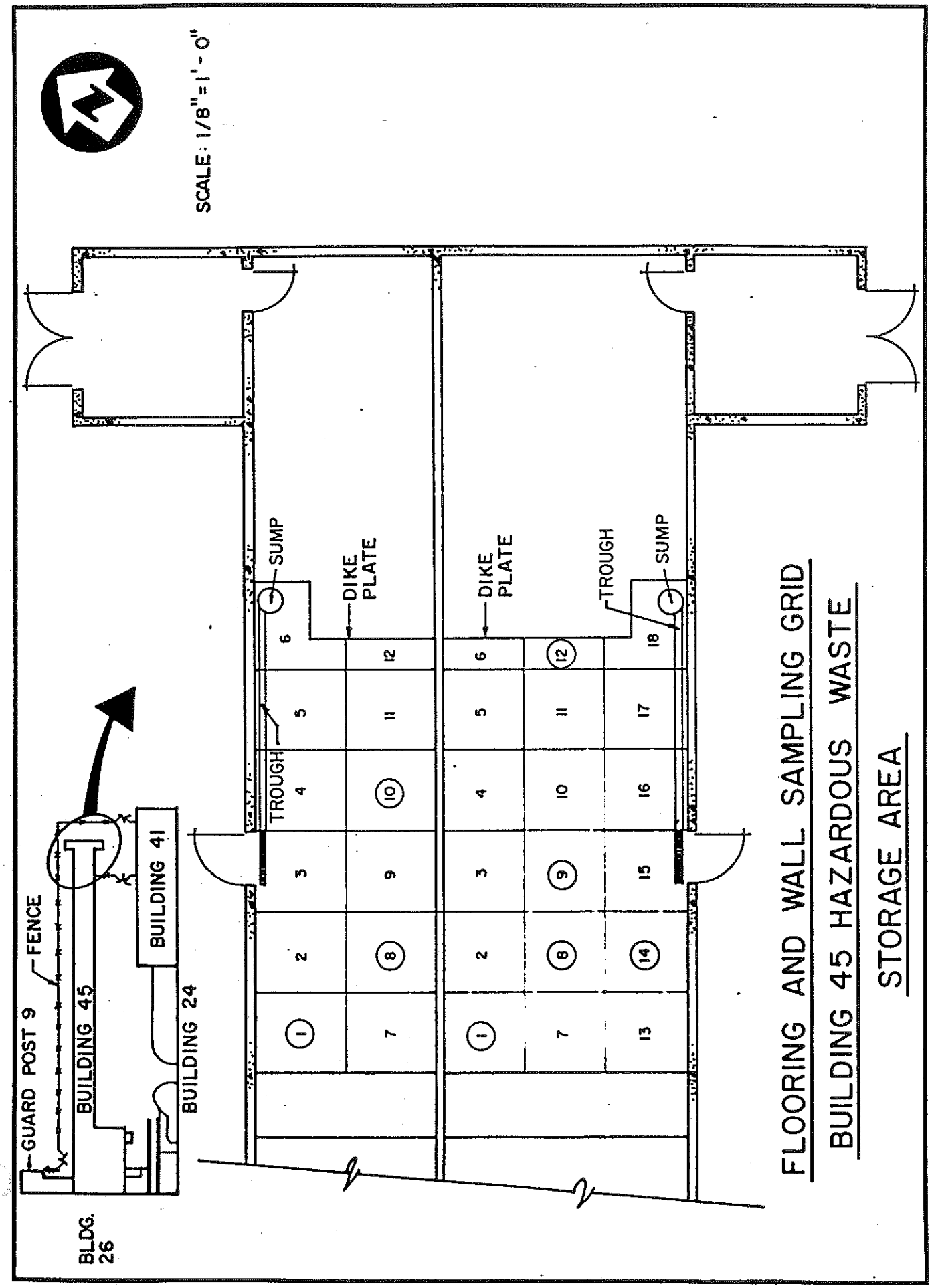
FIGURE 5.2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15
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8
2
8
14
1
7
1
7
13
GUARD POST 9
FENCE
BUILDING 45
BUILDING 41
BUILDING 24
BLDG. 26
FLOORING AND WALL SAMPLING GRID
BUILDING 45 HAZARDOUS WASTE
STORAGE AREA

FIGURE 5.3

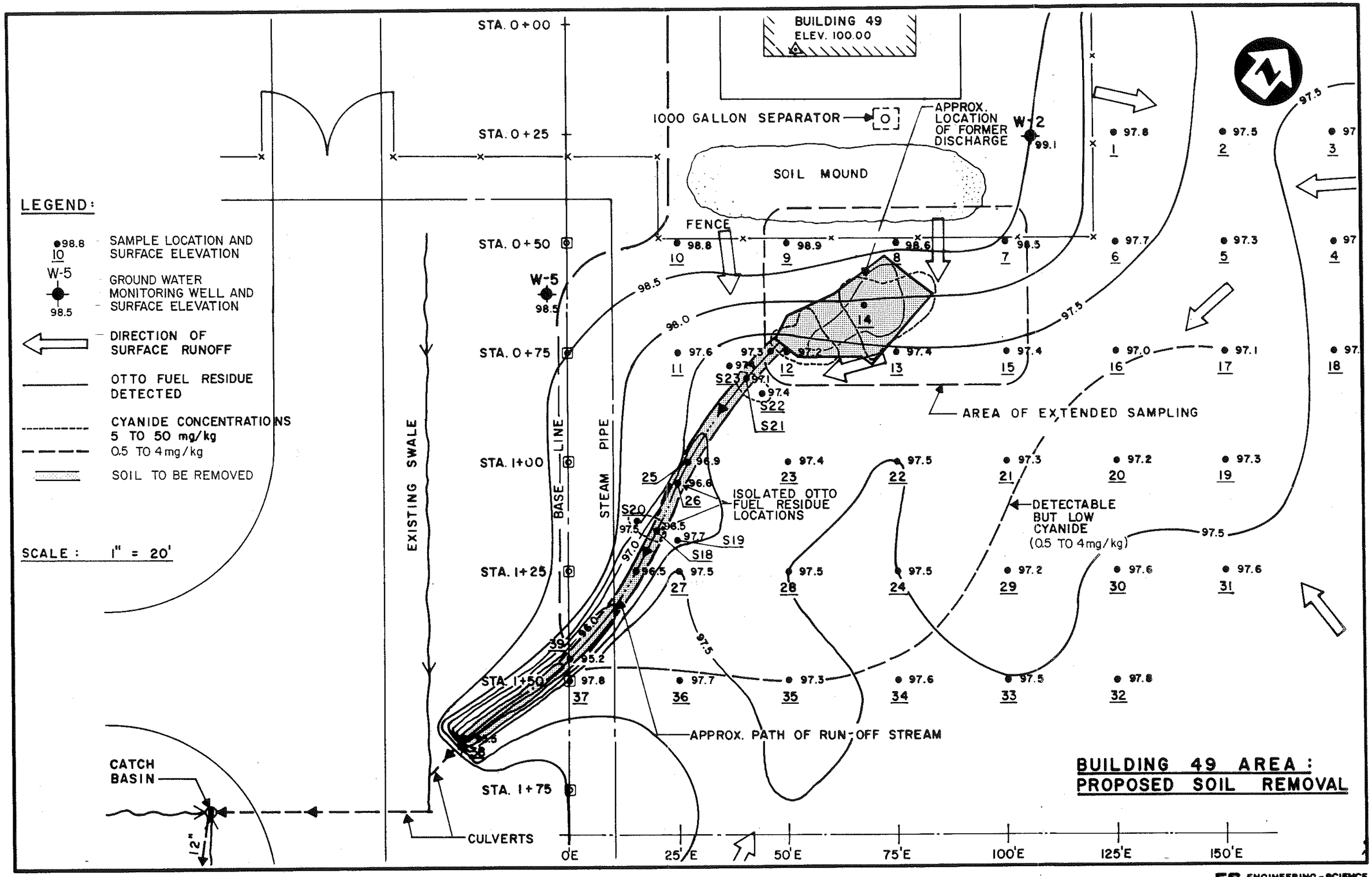

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TABLE 5.1

ANALYTICAL CHARACTERIZATION OF DOCK 2-B AND BUILDING 45 FLOORING

Laboratory-Composited Samples

Parameters	Method	Units	Concentrations Bldg. 45	Concentrations Dock 2-B	Regulatory Limit
Volatile Organic Compounds	8240				
Priority Pollutants		mg/kg	ND	ND	--
Semi-Volatile Organics	8270				
Polynuclear Aromatics		mg/kg	ND	8250#	--
Acid Extractables		mg/kg	ND	ND	--
Other Regulated Semi-Volatiles		mg/kg	ND	ND	--
Pesticides/Herbicides	TCLP	mg/kg	ND	ND	--
PCBs	8080	mg/kg	ND	ND	--
Total Cyanides	9010	mg/kg	<0.1	1.04	BDT
Leachate Heavy Metals	TCLP				
Silver		mg/L	BDT	BDT	5.0
Arsenic		mg/L	BDT	0.07	5.0
Barium		mg/L	0.3	0.4	100
Cadmium		mg/L	BDT	0.09	1.0
Chromium		mg/L	13	0.5	5.0
Lead		mg/L	BDT	1.0	5.0
Mercury		mg/L	BDT	BDT	0.2
Nickel		mg/L	BDT	0.16	--
RCRA Characteristics					
Corrosivity	pH	S.U.	11.0	7.4	2-12
Reactivity (sulfide)	Sulfide	mg/kg	<0.1	<0.1	BDT

NOTE:
BDT = Below Detection Limit
ND = All compounds in this category BDT
-- = No Limit at Present

#Fifteen (15) Regulated Base/Neutral Compounds Detected

TABLE 5.2

ANALYTICAL CHARACTERIZATION OF SOIL SAMPLES NEAR BUILDING 49
Laboratory-Composited Samples (except as noted below)

Parameters	Method	Units	Concentrations Back-ground Area	Dis-charge Area	Regula-tory Limit
Volatile Organic Compounds	8240				
Priority Pollutants		mg/kg	ND	ND	--
Semi-Volatile Organics	8270				
Polynuclear Aromatics		mg/kg	ND	NA	--
Other Regulated Semi-Volatiles		mg/kg	ND	NA	--
Pesticides/Herbicides	TCLP	mg/kg	ND	ND	--
PCBs	8080	mg/kg	ND	ND	--
Total Cyanides*	9010	mg/kg	0.7	17	BDT
PGDN (Torpedo Fuel)*	Gas Chrom.+	mg/kg	NA	543	--
Leachate Heavy Metals	TCLP				
Silver		mg/L	BDT	BDT	5.0
Arsenic		mg/L	BDT	BDT	5.0
Barium		mg/L	1.5	1.2	100
Cadmium		mg/L	BDT	BDT	1.0
Chromium		mg/L	0.04	0.05	5.0
Lead		mg/L	0.54	0.16	5.0
Mercury		mg/L	BDT	BDT	0.2
Nickel		mg/L	0.49	BDT	--
RCRA Characteristics					
Ignitability	Flash Pt.	°F	>180	>180	>140
Corrosivity	pH	S.U.	NA	NA	2-12
Reactivity (sulfide)	Sulfide	mg/kg	60	50	BDT
Incineration Characteristics					
% Solids			70%	73%	>30%
% Ash			NA	72%	--
Heating Value		BTU/lb	NA	<1000	--

NOTE:
BDT = Below Detection Limit
NA = Analysis Not Required
ND = All compounds in this category BDT
* = Averages for 3-4 Samples
-- = No Limit at Present
+ = See Appendix 3 for details

APPENDIX 3

LABORATORY ANALYSIS METHOD FOR PROPYLENE GLYCOL DINITRATE

1938-1988
50 YEARS
WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing, mobile labs
4101 Shuffel Drive N.W. / North Canton, Ohio 44720

RECEIVED
SEP 19 1988
CLEVELAND ES

September 16, 1988

Engineering Science LTD.
19101 Villaview Rd.
Suite 301
Cleveland, Ohio 44119

Attention: Richard Prober

Dear Richard,

In response to your question concerning the method used to analyze the Otto fuel component propylene glycol dinitrate, I am submitting the following summary:

Propylene Glycol Dinitrate Analytical Summary

Extraction was performed using a soxhlet extractor for 18 hours with methylene chloride as the solvent. This extraction is similar to Method 3540 without the addition of any surrogate standards. Extracts were concentrated to 10 ml. for analysis.

The analysis was performed using a gas chromatograph equipped with a flame ionization detector. The column was a 30 meter DB-1 megabore, 0.53 mm with nitrogen carrier gas. A temperature was programmed from 60° to 120°C.

External standards were used to quantify results. The sample extract was initially analyzed and quantified against a single point calibration. If the initial analysis was outside a 50-200% limit of the prepared standard, the sample extract was diluted or concentrated to meet this criteria. A standard was rerun every 3-5 runs to assure consistent response. The standard was derived from a sample of Otto fuel supplied by TRW and was assumed to be 76% propylene glycol dinitrate (PGDN) as described in its specifications. Because of the nature of the standard no further standardization was performed.

CORPORATE AND LABORATORY: North Canton, Ohio (216) 497-9396
LABORATORY: Cleveland, Ohio (216) 642-9151
LABORATORY: Bartow, Florida (813) 533-2150
SOUTHEAST REGIONAL OFFICE: Lexington, South Carolina (803) 957-6590
24-HOUR ALERT LINE (216) 497-9338

1938-1988
50 YEARS
WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing, mobile labs
4101 Shuffel Drive N.W. / North Canton, Ohio 44720

Samples were periodically spiked with the "standard" PGDN to determine extraction efficiency and analytical accuracy. The quantitation limit was set at 20% of a standard giving a half scale response. Blanks were also analyzed and were determined to be clean if no quantifiable PGDN was present.

This should suffice as a summary of the method. If you have any questions feel free to cam me.

Sincerely,

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph.D.
Vice President
Corporate Technical Director

MWS:pjh

CORPORATE AND LABORATORY: North Canton, Ohio (216) 497-9396
LABORATORY: Cleveland, Ohio (216) 642-9151
LABORATORY: Bartow, Florida (813) 533-2150
SOUTHEAST REGIONAL OFFICE: Lexington, South Carolina (803) 957-6590
24-HOUR ALERT LINE: (216) 497-9338

6. SCHEDULE FOR CLOSURE

Closure of the Hazardous Waste Management Facilities at the TAPCO site will consist of the following:

In the Building 49 Area (the Torpedo Test Compound):

- o Site work, as necessary for equipment access,
- o Excavation of contaminated soil from the Spill Area and dredging of the runoff stream, and removal for off-site incineration,
- o Soil sampling to ensure that the soil that remains does not contain detectable PGDN and/or cyanides at concentrations exceeding 10 mg/kg,
- o Removal and decontamination of the 1,000 gallon underground Separator Tank and auxiliary piping, and
- o Backfilling and final grading of the area of soil excavation.

At the former TRW Hazardous Waste Storage Area at Dock 2-B:

- o Removal and off-site incineration of wood flooring blocks, and
- o Cleaning of the underlying concrete and analysis of rinseates to verify that hazardous waste residues have been removed.

At the Building 45 Target House:

- o Cleaning of the concrete flooring and analysis of rinseates to verify that hazardous waste residues have been removed.

If necessary, demolition of concrete flooring at Building 45 and/or Dock 2-B; off-site disposal of the rubble; and soil sampling to verify that no hazardous waste residues remain.

Figure 6.1 shows the schedule in bar-chart form, based on days elapsed after approval of the Closure Plan by the Director of Ohio EPA. The Closure Plan activities can be completed within the required 180 days. In the event that approval occurs in the autumn, it may be necessary to extend closure activities beyond 180 calendar days, due to the onset of winter conditions hampering outside work at Building 49 and access to the other areas undergoing closure.

Figures 6.2, 6.3 and 6.4, respectively, show the layout of closure facilities and activities at Dock 2-B, Building 45 and Building 49. The paragraphs that follow briefly describe the Closure activities. Additional details on closure activities and contingency planning are provided on Air Emissions Control during closure (Section 7); Personnel Safety and Fire Protection (Section 8); Decontamination Efforts for tanks and piping to be removed during closure (Section 9); Criteria for Soil Contamination (Section 10); Sampling Plan for Soil (Section 11); Description of Removal Efforts (Section 12); and Description of Closure Equipment Cleaning (Section 14).

The activities comprising closure are as follows:

6.1 Notification of Approval of the Closure Plan by the Ohio EPA received by TRW. The schedule allows for delays in delivery of this notice up to a full work week (7 days).

6.2 The Hazardous Waste Management Units at Dock 2-B and Building 49 are vacated by ARGO-TECH. The new facilities for Torpedo Testing at Building 33 are partially in use as of 1 August 1987. It is assumed that construction there will have been completed on or before the notification date above, so that ARGO-TECH will have ceased Torpedo Testing activities and removed all stored torpedo fuel at Building 49 within five weeks (35 calendar days) thereafter. It is also assumed that all hazardous waste stored by ARGO-TECH at Dock 2-B can be removed within the same time limit for off-site treatment and disposal, or transferred to a new area to be provided by TRW.

6.3 Selection of Contractors by TRW and mobilization of equipment is scheduled to take place in the five work weeks (35 calendar days) following Receipt of Approval of the Closure Plan.

6.4 Site Work at Building 49 for equipment access is required before any other closure activities can begin there (See Figure 6.4). The fence on the southeast side of the Torpedo Test complex must be removed. Decontamination facilities will be set up during this time. A gravel or slag roadway, 12 ft wide x about 150 linear ft., will be installed

about 10 ft south of the soil to be excavated, for access by the heavy equipment which otherwise may be mired in the soil after rains. This activity can start as soon as possible, weather permitting. Once started, it will take about two work weeks (14 calendar days) to complete, allowing for possible delays due to adverse weather.

6.5 Excavation of Contaminated Soil from the Building 49 Spill Area will require a Gradall or Clamshell. Soil will be excavated from the approximately 625 sq.ft. polygon area shown in Figure 2.5, to a depth of 1 ft below the interface of competent clay. Sections through the polygon area ae shown in Figures 6.5 and 6.6. Assuming that the excavation averages about 4 ft depth, it will amount to about 95 cu.yd. This activity can begin immediately after completion of the roadway, and will take about one work week, weather permitting. As soon as the excavation has been completed, soil sampling can begin (See Subsection 6.9).

6.6 Dredging of the Runoff Stream will also require the Gradall or Clamshell unit. Sediments will be removed from the approximately 120 ft length of the stream, to a depth of 2 ft. A profile section along the stream is shown in Figure 6.7. Assuming a bucket width of 2 ft, the sediments removed would amount to about 18 cu.yd. An additional 1.4 cu.yd. of sediments will be removed from the first culvert (at the south end of the runoff stream) by hand shoveling. The dredging can begin after completion of the excavation of contaminated soil, and will take about one work week, weather permitting. Soil sampling can begin along the runoff stream bed as soon as the sediment dredging activity has been completed (See Subsection 6.9).

6.7 Off-Site Disposal of the Soil and Sediments. The two preceding activities will generate about 130 cu.yd. of soil and sediments, assuming about 10% expansion. This material will be transferred to containers, covered with plastic sheets to keep out rainwater and hauled off-site for disposal by incineration. (In the event that an alternative treatment technology becomes available before approval of the Closure Plan, TRW will investigate its feasibility.) A 25 ft.x 25

ft. container staging area to the north of Building 49 will be protected from contamination by a 20 mil plastic sheet. This activity will follow the soil and sediment removal, as quickly as practicable. Upon completion of this activity, the plastic sheet will be inspected for damage, to determine whether soil sampling would be required.

6.8 Removal and Decontamination of the 1,000 Gallon Underground Separator Tank, the Three Overflow Holding Tanks and Auxiliary Piping can occur at any time following the excavation of contaminated soil. The auxiliary piping will be removed first, about 40 ft. of 6" VT pipe from the former discharge area to the separator tank outlet, about 10 ft. of 6" VT from the separator tank inlet to the connection with the torpedo test cell drains, and about 60 ft. of 6" VT pipe from the separator tank outlet to the overflow holding tanks. Any free liquid in the tanks will be pumped out and retained for off-site disposal, if necessary, pending analysis for PGDN and total cyanides. The tanks will then be exhumed.

This activity will require a backhoe to unearth the underground facilities, which lie at typical depths up to about 4 ft. It can be completed within two work weeks, weather permitting. Decontamination of the tanks and piping are described in Section 9.

6.9 Soil Sampling at Building 49 and Subsequent Laboratory Analysis of the Soil Samples will begin upon completion of the excavation, removal or demolition activities above. A maximum of five weeks (35 calendar days) will be required for the laboratory results to be reported. A grid sampling strategy will be followed in the Polygon area to ensure that no contaminated soil remains. The proposed sampling grid and other details of the soil sampling are discussed in Section 11.

Soil samples will be taken at four locations formerly under the separator tank, four locations under the overflow holding tanks and at 5 ft. intervals along the former piping. Samples also will be taken at all pipe connections and any other locations appearing to have suffered leakage.

A Soil Boring rig will be used to take the soil samples at Building 49. The soil samples will be collected in Shelby Tubes representing 1 ft intervals of depth below the surface (after excavation) down to the bedrock shale.

The Shelby Tubes or cores will be capped, marked with identifying numbers and delivered to a certified laboratory for chemical analysis. Chain-of-Custody documentation and other quality control procedures are discussed in Section 11. The analysis will be only for PGDN and Total Cyanide.

Contingent on the soil sampling results, additional soil removal and/or dredging may be required to ensure that all hazardous waste and contaminated soil have had proper disposal. Soils found to contain higher than 10 mg/kg total cyanides or detectable PGDN will be removed for off-site disposal, pending laboratory analysis results for the soil samples. See Section 11.1 and the Risk Assessment (Attachment 2, the Building 49 Study Report, Appendix C) for details on Soil Sampling and acceptable cyanide levels.

Any equipment used in this task will have to be decontaminated before it can be allowed to leave the site (See Section 6.15).

6.10 Backfilling and Final Grading of the Soil Removal Area will use clean borrow material. Soil from the former shrapnel barrier mound to the south of Building 49 will be used for this. It does not contain detectable concentrations of cyanides, based on analysis of a composite sample which was collected during the preparation of this Closure Plan. This activity can begin after analytical laboratory tests confirm that the remaining soil is free of PGDN (torpedo fuel) and has acceptable cyanide concentrations (not exceeding 10 mg/kg). It can be completed within one work week, weather permitting.

6.11 Removal of Wood Flooring Blocks must precede the other closure activities at the Dock 2-B former TRW Hazardous Waste Storage Area. Wood blocks along the periphery of this area will be sampled, as indicated on Figure 6.2 and analyzed by GC/MS (Method 8240) for the spent solvents that were stored at the Dock, including TCE (trichloroethylene), PCE (tetrachloroethylene), TCA (trichloroethene), MEK (Methyl ethyl ketone), and dioxane (See Table 2.1), to identify wood blocks that may have been contaminated by spills. (Note that operational records indicate no spills.) Any peripheral blocks found to be contaminated will be removed, and additional samples further away from the former TRW area will be required to define the affected area.

6.12 Decontamination of Concrete Flooring at Dock 2-B and Building 45. The underlying concrete flooring at Dock 2-B will be decontaminated using three pressurized water rinses and scrubbing or scraping at areas showing visible residues. The rinseates will be analyzed for the solvents once stored at the dock (including TCE, PCE, TCA, MEK and dioxane) from spill residues that may have penetrated through the blocks. If any of the solvents is present at 1 mg/L or higher concentrations in the third rinseate, samples will be taken of the concrete at the selected areas defined on the 5 ft. grid spacing shown in Figure 6.8 in order to identify the contaminated areas.

The concrete flooring in the Building 45 Target House will be decontaminated using three pressurized water rinses and scrubbing or scraping at areas showing visible residues. The rinseates will be analyzed for xylene (GC, Method 8020) once stored there, total chromium (once stored there and detected in preliminary tests, Section 5.2) and total lead (residue from pre-RCRA use). If the third rinse contains 1 mg/L or higher of xylene or any of the suspected metals at a concentration exceeding those in the cleaning water, the concrete will be sampled in order to identify the specific areas contaminated. The samples will be taken by scraping the concrete at the selected areas defined by the 5 ft. grid spacing shown in Figure 6.9, which will extend the sampling to include the sumps and the pits adjoining the Target House on the east and west.

The rinseates will be retained for off-site disposal, pending the laboratory analysis results. Disposal as a RCRA waste will be required for rinseates containing 1 mg/L or higher of a regulated organic, or a metal at higher than EP toxic concentrations.

This activity can start after the wood flooring blocks have been removed. An estimated four weeks (28 calendar days) will be required for the laboratory results to be available.

6.13 Contingent Demolition of Concrete Flooring in the Dock 2-B former TRW Hazardous Waste Storage Area and in the Building 45 Target House is a contingent activity, to be carried out at either or both of the locations, only at the specific areas of the concrete flooring identified as containing hazardous waste residues. Level B personnel protection (impervious clothing and supplied air respiration) will be required in Building 45; Level C (air filtration) will suffice at Dock 2-B. A crew of two will work in each area, one operating the hammer and the other assisting with dust control. This activity will take about two weeks (14 calendar days) for a single crew. The dust control water spray will be collected for off-site disposal.

The soil underlying the concrete removed by demolition will be inspected visually for evidence of hazardous waste penetration through the now removed concrete flooring. If necessary, sampling and analysis and subsequent soil removal will be carried out.

All concrete flooring removed by demolition from both Dock 2-B and Building 49 will be replaced by patching. At Dock 2-B, additional concrete will be applied on top of the existing flooring (patched as necessary). This surface will be sealed by coating with coal-tar epoxy, to provide a suitable flooring service for future Argo-Tech use of the area for 90 day storage of hazardous materials.

6.14 Off-Site Disposal of Rubble from Dock 2-B and Building 45 will generate an estimated 5 tons of wood blocks, assuming a wood block thickness of 1.5 inches. The concrete demolished in the two buildings is estimated to amount to 20 cu.yd., assuming a concrete thickness of 1 ft and 75% expansion. The rubble will be accumulated at each location in separate covered containers. These activities will follow the demolition as quickly as practicable.

The wood blocks from Dock 2-B will be collected in fibre drums for off-site treatment by incineration, and the resultant ash will then be disposed of by landfilling. The concrete rubble resulting from demolition, if any, would have to be disposed of at a landfill certified for hazardous wastes.

6.15 Decontamination of Equipment Used in the Closure is scheduled upon completion of the activities above. A portable steam generator or a high pressure water sprayer will be set up near the work areas. Enclosures will be set up to collect the condensate or washwater, for off-site disposal (See Section 14). This will ensure that all particles of hazardous waste and/or contaminated soil adhering to the equipment are dislodged and disposed of. Decontamination of the equipment should be done as quickly as possible after the last use of each item.

6.16 Certification is the final task. The independent registered Professional Engineer retained by TRW will have been present on-site during all of the activities enumerated above. Upon completion of all required site work and after review of the soil sampling laboratory data, the Engineer shall submit his report which will certify that all closure activities have been carried out in compliance with the Closure Plan. Further details on Certification are in Section 15.

This activity should have been completed within two weeks (14 days) after completion of the Final Closure field activity.

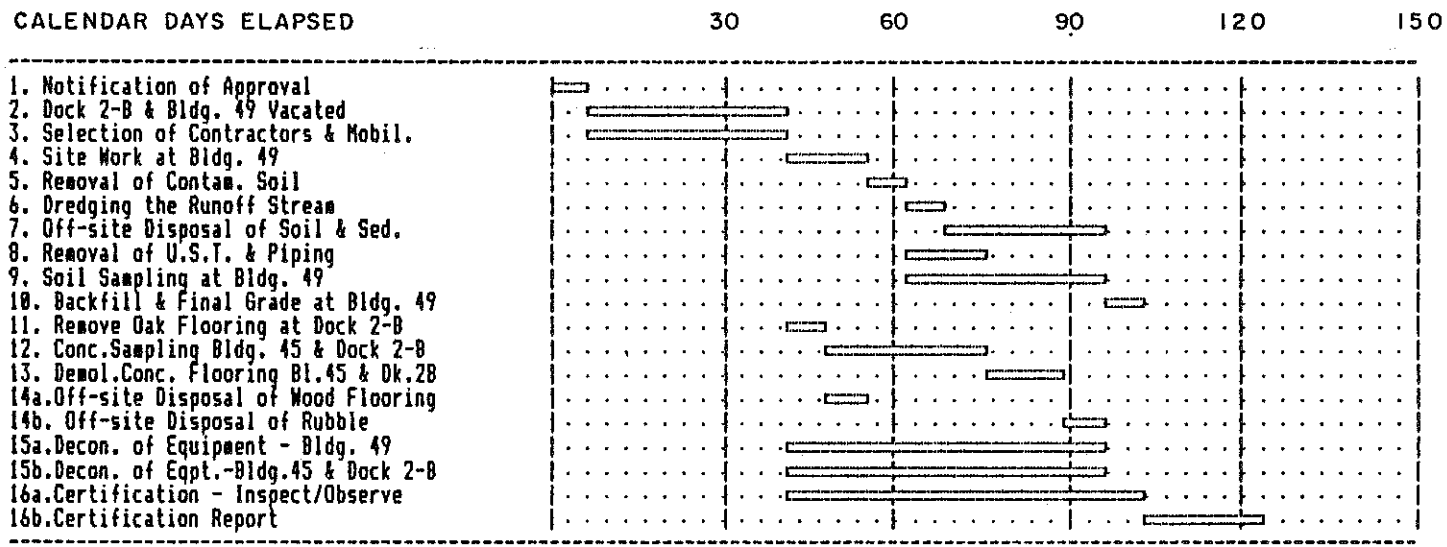
PROJECT SCHEDULE

TRW, Incorporated

TAPCO SITE CLOSURE
CL065.01
Project Mgr:A. L. Resetar

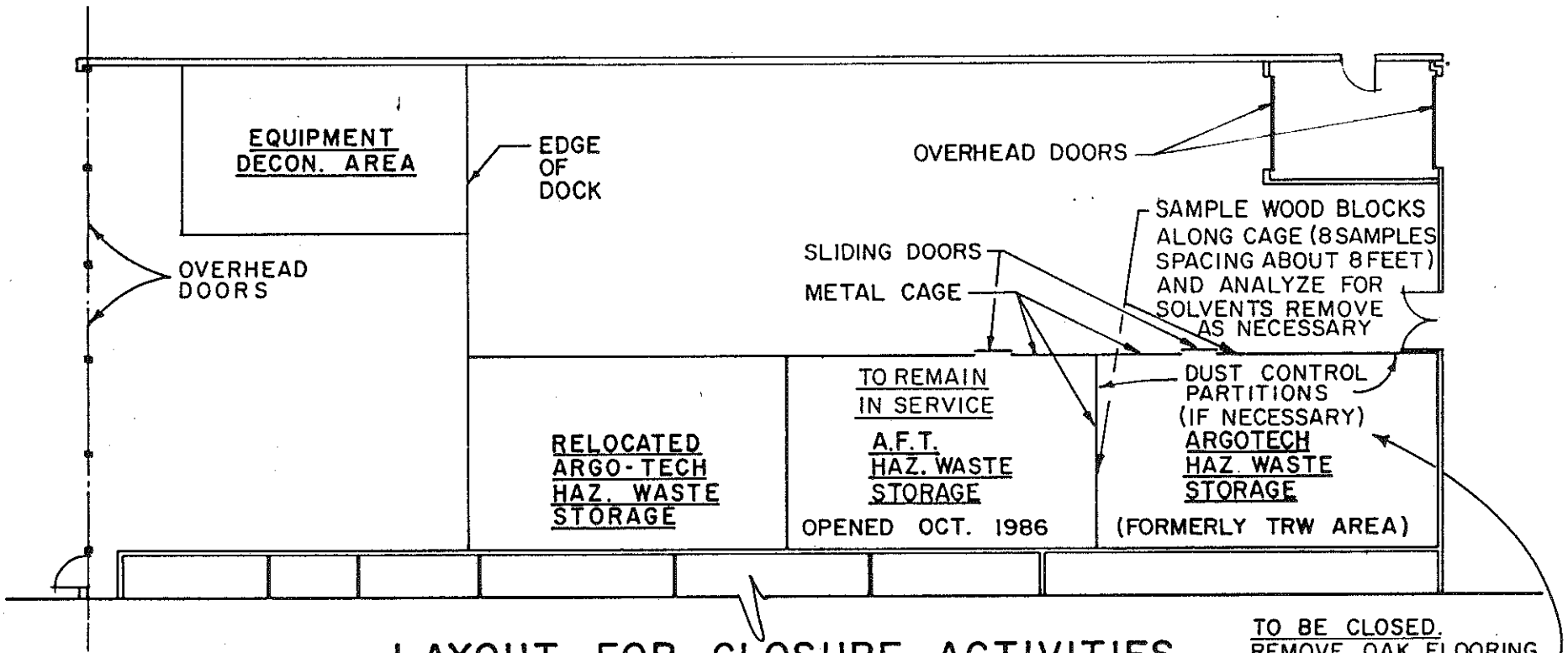
run time > >14:34:53 ** 11-03-1987

page 1



ES ENGINEERING-SCIENCE

FIGURE 6.1



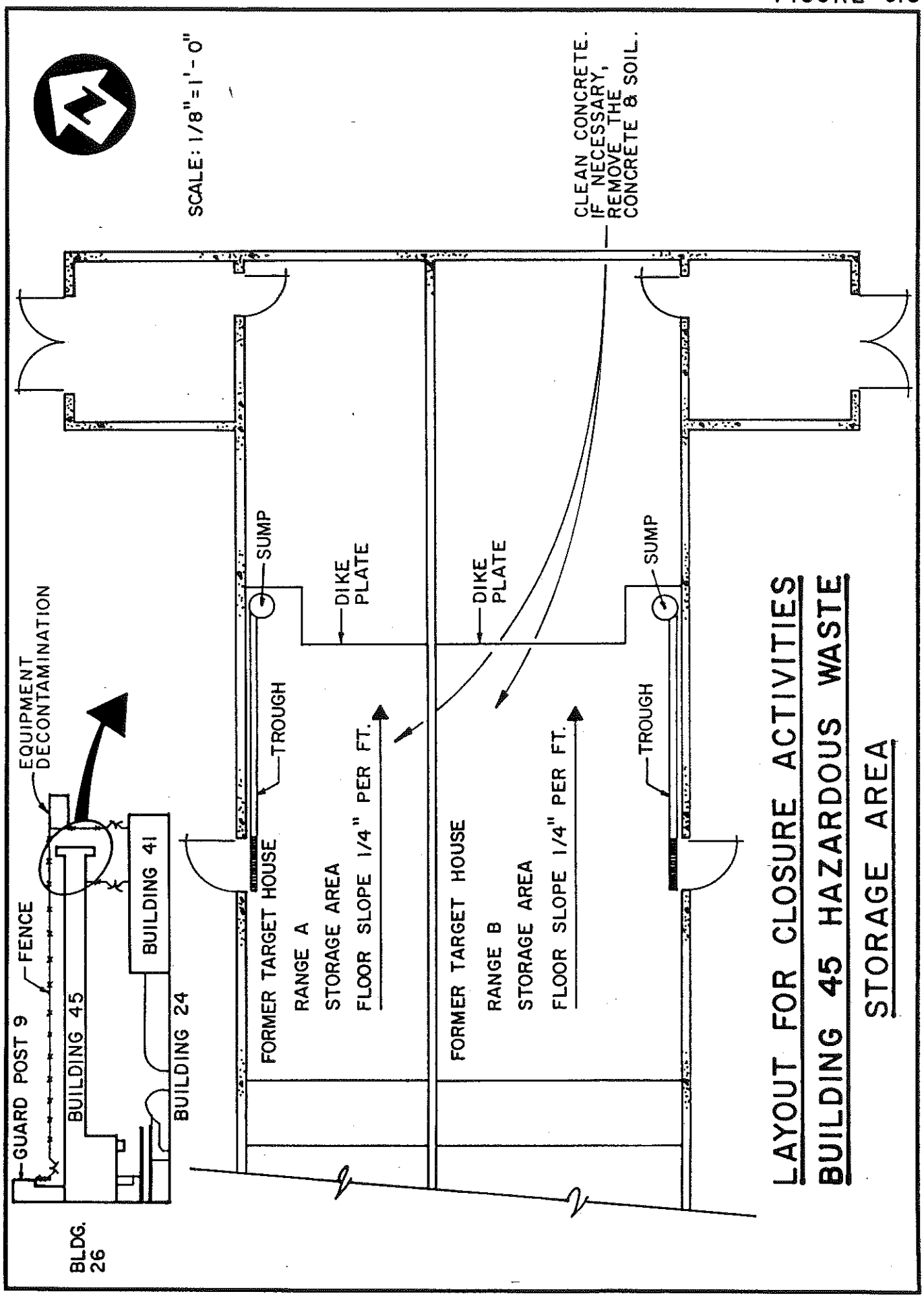
TO BE CLOSED.
REMOVE OAK FLOORING.
WASH CONCRETE.
REMOVE CONCRETE AND SOIL, IF NECESSARY, AND RESTORE.

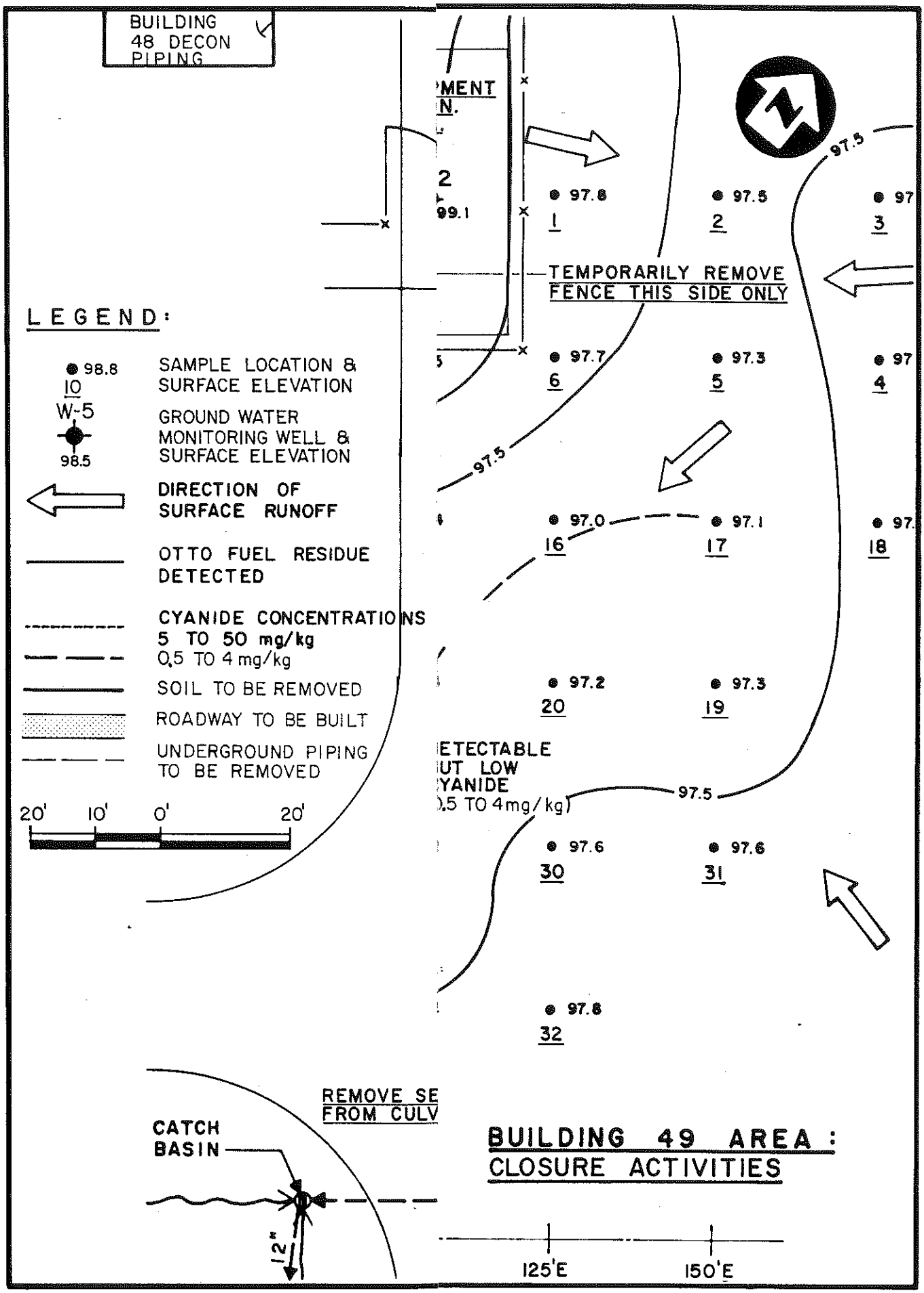
LAYOUT FOR CLOSURE ACTIVITIES
DOCK 2-B HAZARDOUS WASTE STORAGE AREA

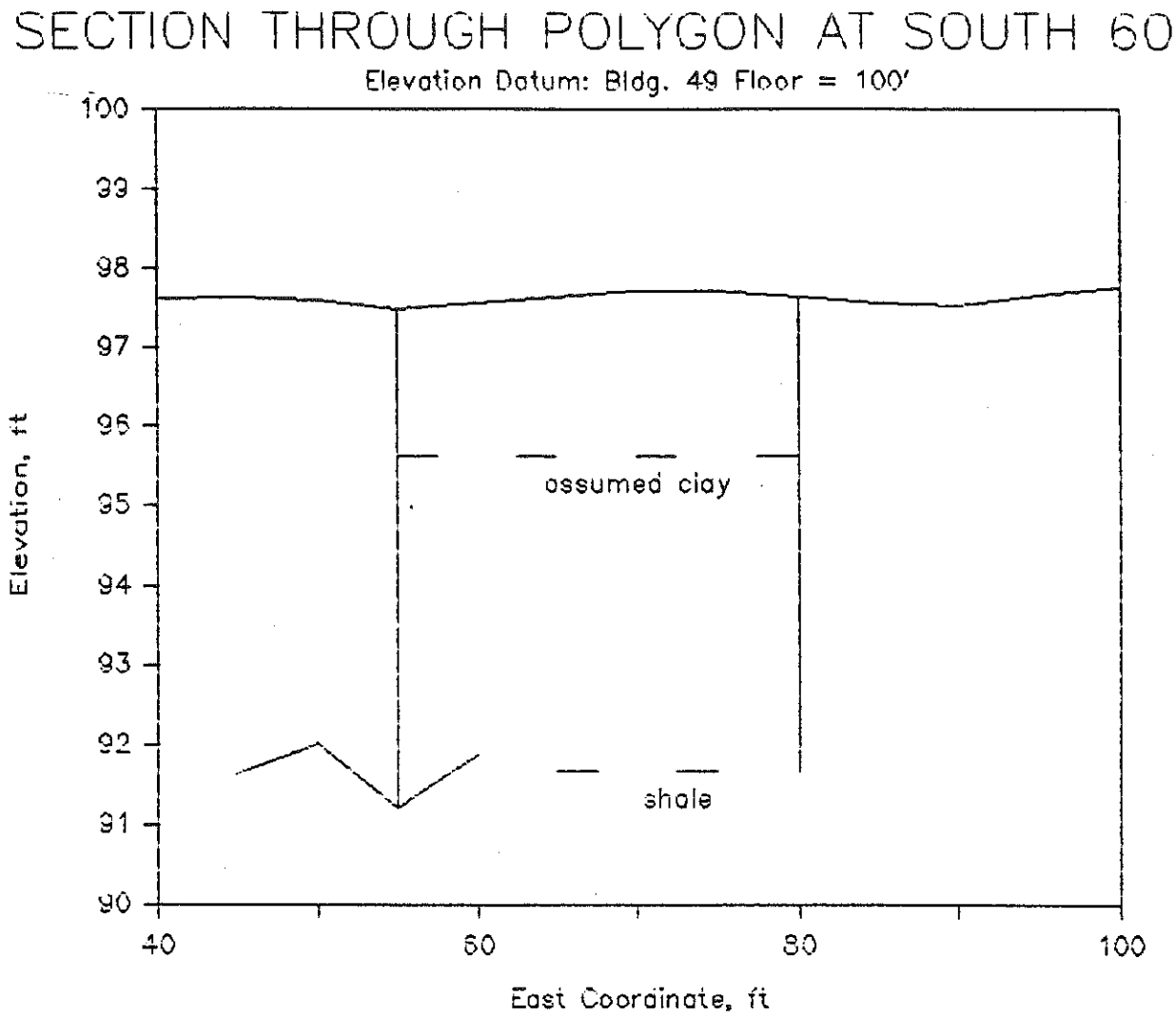
BUILDING 26 BAYS AA-1, AA-2 AND AA-3

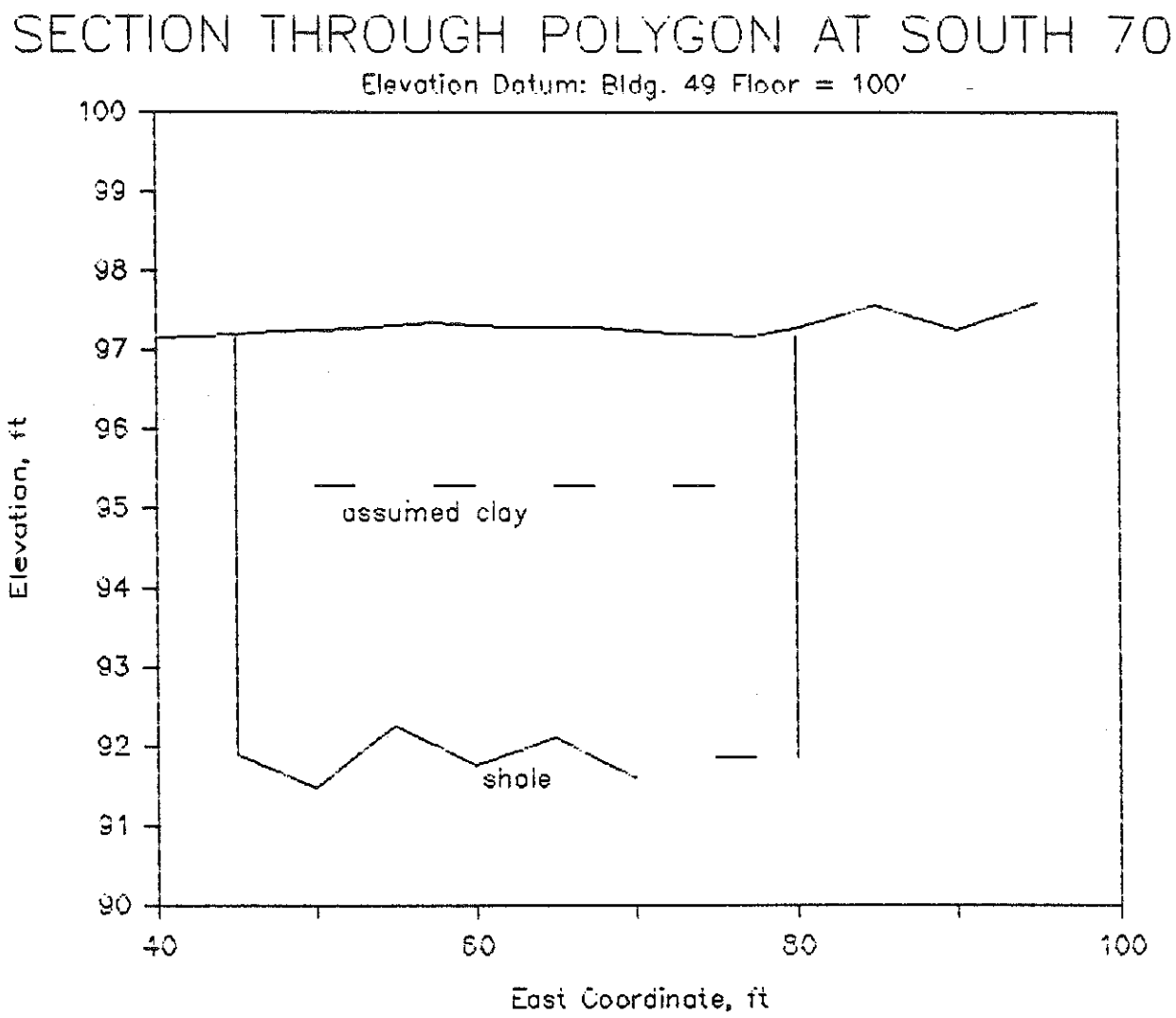
FIGURE 6.2

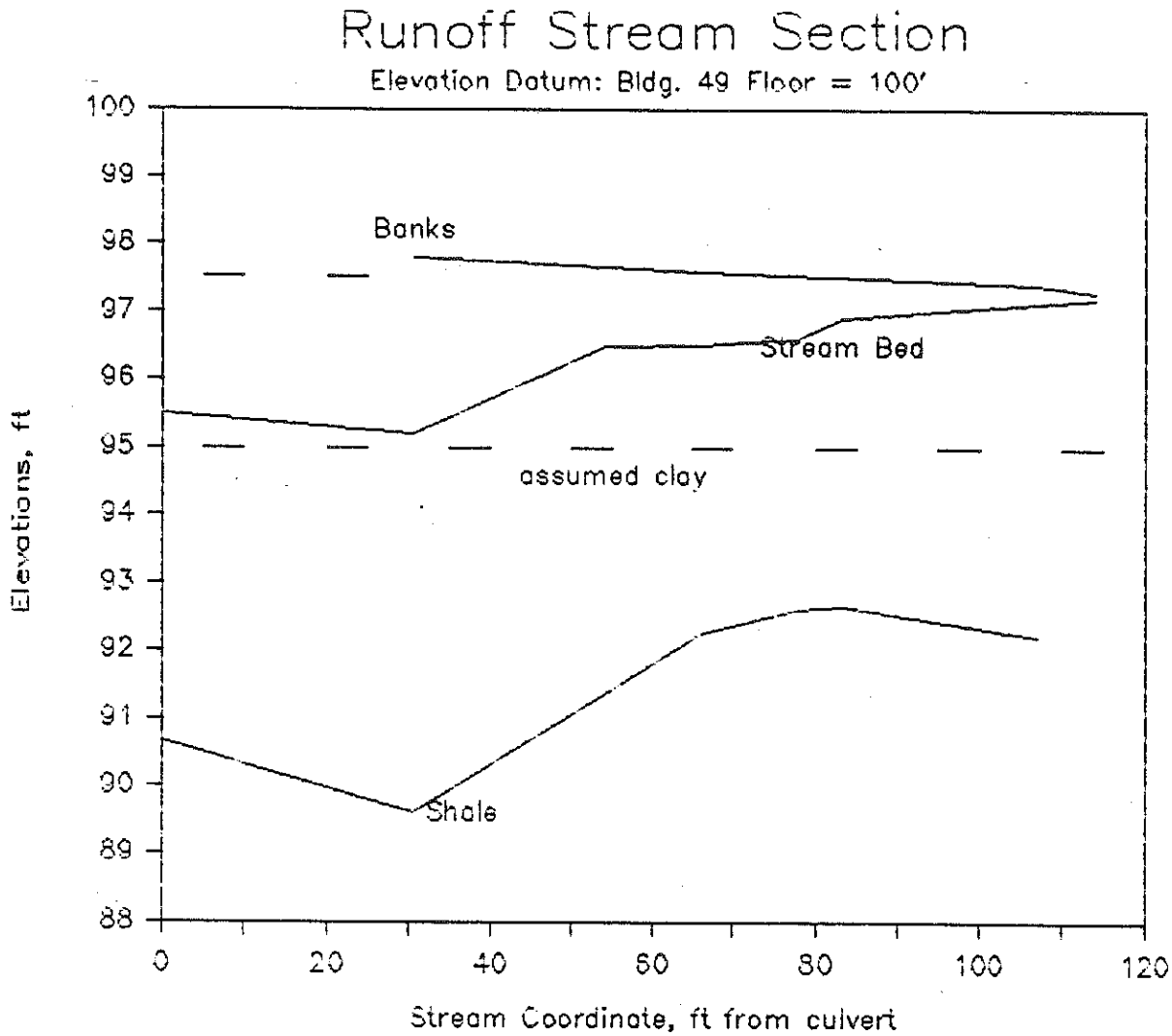
FIGURE 6.3

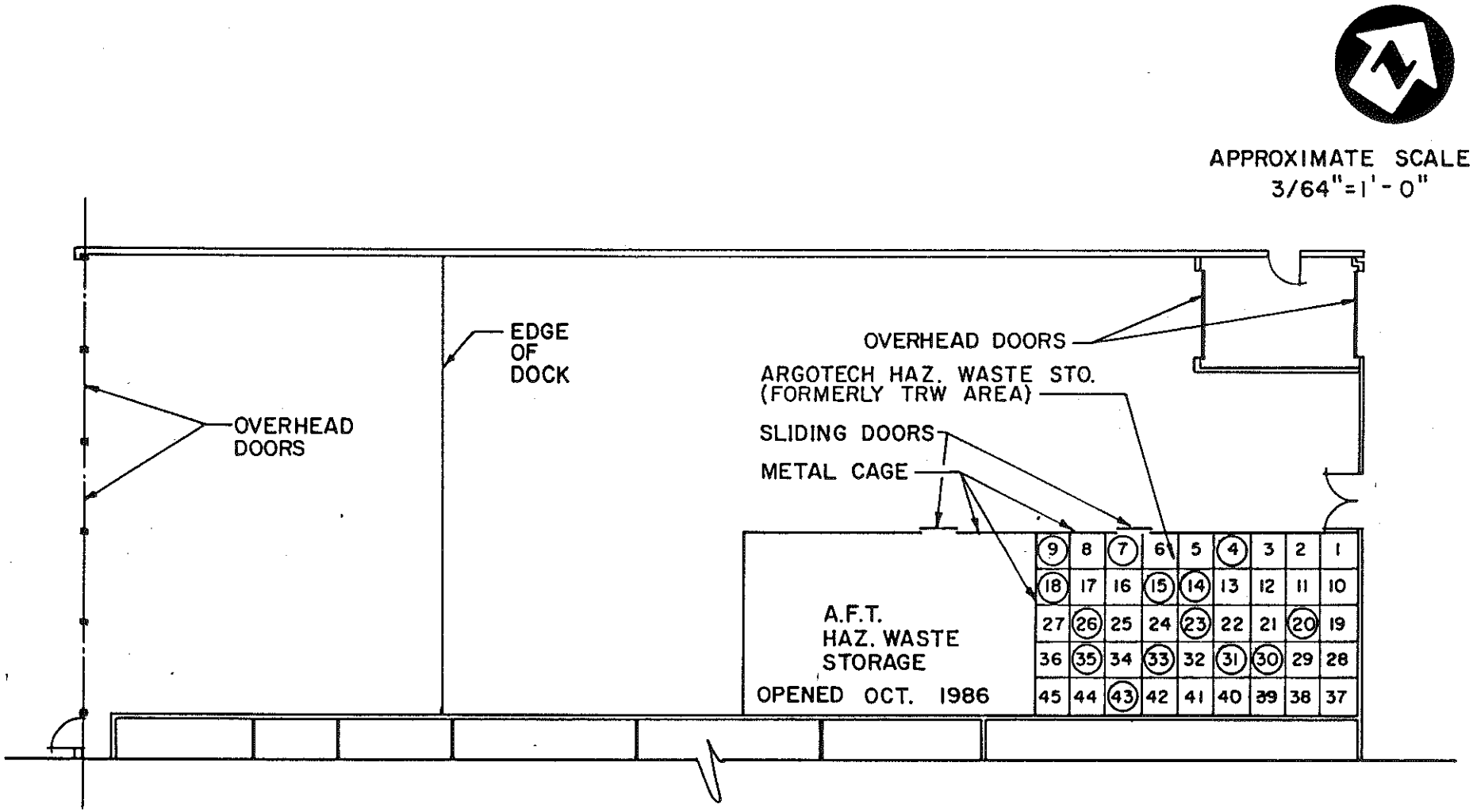

SCALE: 1/8" = 1'-0"
CLEAN CONCRETE. IF NECESSARY, REMOVE THE CONCRETE & SOIL.
SUMP
DIKE PLATE
DIKE PLATE
SUMP
EQUIPMENT DECONTAMINATION
TROUGH
TROUGH
FORMER TARGET HOUSE
RANGE A
STORAGE AREA
FLOOR SLOPE 1/4" PER FT.
FORMER TARGET HOUSE
RANGE B
STORAGE AREA
FLOOR SLOPE 1/4" PER FT.
BUILDING 41
FENCE
GUARD POST 9
BUILDING 45
BUILDING 24
BLDG. 26
LAYOUT FOR CLOSURE ACTIVITIES
BUILDING 45 HAZARDOUS WASTE
STORAGE AREA


BUILDING 48 DECON PIPING
MENT
N.
2
99.1
97.8
1
97.5
2
97
3
TEMPORARILY REMOVE FENCE THIS SIDE ONLY
97.5
97.7
6
97.3
5
97
4
97.5
97.0
16
97.1
17
97.
18
97.2
20
97.3
19
ETECTABLE
UT LOW
YANIDE
.5 TO 4mg/kg)
97.5
97.6
30
97.6
31
97.8
32
LEGEND:
98.8
10
SAMPLE LOCATION & SURFACE ELEVATION
W-5
98.5
GROUND WATER MONITORING WELL & SURFACE ELEVATION
DIRECTION OF SURFACE RUNOFF
OTTO FUEL RESIDUE DETECTED
CYANIDE CONCENTRATIONS
5 TO 50 mg/kg
0.5 TO 4 mg/kg
SOIL TO BE REMOVED
ROADWAY TO BE BUILT
UNDERGROUND PIPING TO BE REMOVED
20' 10' 0' 20'
REMOVE SE
FROM CULV
CATCH BASIN
12"
125'E
150'E
BUILDING 49 AREA:
CLOSURE ACTIVITIES


SECTION THROUGH POLYGON AT SOUTH 60
Elevation Datum: Bldg. 49 Floor = 100'
100
99
98
97
96
95
94
93
92
91
90
Elevation, ft
assumed clay
shale
40
60
80
100
East Coordinate, ft


SECTION THROUGH POLYGON AT SOUTH 70
Elevation Datum: Bldg. 49 Floor = 100'
100
99
98
97
96
95
94
93
92
91
90
Elevation, ft
assumed clay
shale
40
60
80
100
East Coordinate, ft

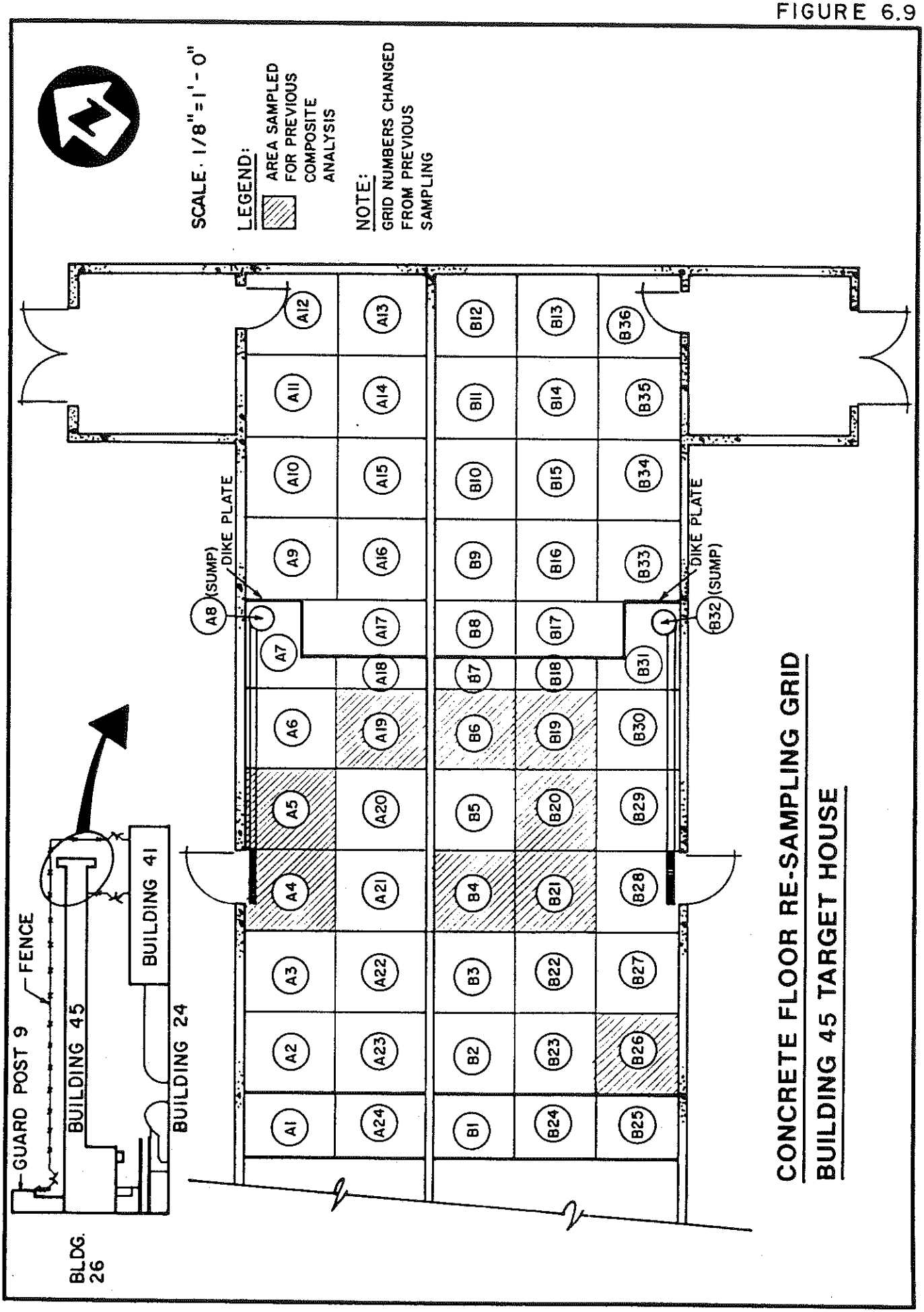

Runoff Stream Section
Elevation Datum: Bldg. 49 Floor = 100'
Banks
Stream Bed
assumed clay
Shale
Elevations, ft
100
99
98
97
96
95
94
93
92
91
90
89
88
0
20
40
60
80
100
120
Stream Coordinate, ft from culvert



SAMPLING GRID FOR DOCK 2-B CONCRETE SUB-FLOOR
FORMER TRW HAZARDOUS WASTE STORAGE AREA
BUILDING 26, BAYS AA-1, AA-2 and AA-3

FIGURE 6.8

FIGURE 6.9



ES ENGINEERING—SCIENCE

7. AIR EMISSIONS

Engineering controls and precautionary operational practices will be used during closure of the Hazardous Waste Managements Units at the TAPCO site to minimize air emissions of hazardous contaminants.

The soil to be excavated from the torpedo fuel discharge area at Building 49 formerly was swampy. Fugitive dust emissions from that area, which might contain PGDN and/or cyanides, will be controlled by keeping the soil moist. A risk assessment in the Building 49 Study Report (Attachment 2) established that volatilization of PGDN and/or cyanides would not result in harmful concentrations for human populations that might be exposed. However, air monitoring for cyanide emissions will be required during closure activities, and operations will be halted in the event that cyanide concentrations exceed 5 mg/cm^3.

Demolition of concrete flooring from Dock 2-B and/or the Building 45 Target House are contingent activities, to be undertaken only if efforts to remove hazardous waste residues are not successful. In that event, temporary barriers will be set up, and water will be sprayed on during air-hammering and/or saw cutting, to absorb any dust that might be generated.

8. PERSONNEL SAFETY AND FIRE PROTECTION

The Closure Contractor will be required to provide a site-specific Health and Safety Plan, in conformity with the applicable OSHA regulations.

It is anticipated that protective clothing and/or respiratory protection will be required for the following closure activities:

- Removal of soil and sediments from the Torpedo Fuel Discharge Area near Building 49 and loading into containers could release PGDN and cyanide particles. Equipment operators working in the cabs would require only Level C protection, i.e., air filters. Workers on foot would have to remain upwind from the soil being removed, and use Level B protection, if necessary, i.e., disposable impermeable clothing and supplied air respiration. See Figure 6.4 for layout of closure activities near Building 49.
- Cleaning the concrete below the existing wood block floor in Building 45 (after removal of the blocks) will require gloves and impermeable clothing.
- If required, air-hammering and/or saw cutting of the concrete at Dock 2-B could release miscellaneous particles. (These activities would not be required, if cleaning the concrete removes any hazardous residues.) In the absence of any identified toxic constituent present at detectable concentrations, Level C protection would be required, i.e., air filters. See Figure 6.2 for layout of closure activities at Dock 2-B.
- If required, air-hammering and/or saw cutting of the concrete flooring in Building 45 could relase toxic hexavalent chromium particles. (These activities would not be required, if cleaning the flooring removes the absorbed chromium.) Level B protection would be required, i.e., disposable impermeable clothing and supplied air respiration. See Figure 6.3 for layout of closure activities at Building 45.

- Air monitoring for cyanide emissions will be required during closure activities at the Building 49 site. Operation will be halted in the event that cyanide concentrations exceed 5 mg/m^3.

The danger of fire is not imminent. Of all the hazardous waste materials to be handled during closure, only the wood block flooring removed from Dock 2-B would be ignitable under normal conditions. However, in the event of fire at Dock 2-B, other chemicals stored there may be spread or may release toxic materials due to overheating. Containers of such chemicals should be cooled by spraying water over them.

In the event of any plant-wide emergency situation, particularly a fire in the contiguous buildings, closure activity at either Dock 2-B or Building 45 will be halted immediately upon notification by ARGO-TECH's Emergency Coordinator. Similarly, in the event of an emergency situation affecting Building 49, particularly a brush fire, closure activity there will be halted. In either instance, closure equipment will be secured, if possible, and all personnel will leave the area.

9. DECONTAMINATION EFFORTS

The 1,000 gallon underground separator tank formerly used to treat discharges of wastewater from torpedo testing operations, the vitreous clay auxiliary piping connecting this tank to Building 49 and to the discharge area, and the three underground holding tanks for torpedo testing wastewater will be unearthed and removed. These items will be taken to Building 48, the former laundry facility for the torpedo test complex, to be washed with a detergent solution (Wisk) and rinsed with city water. The detergent is routinely used for cleaning residues of torpedo fuel during torpedo test operations. This washing and rinsing will be repeated as necessary until the intensely reddish torpedo fuel color is no longer visible. The wash water and rinseate will be collected and disposed of off-site. See Figure 6.4 for layout of closure activities near Building 49.

Decontamination of concrete flooring under Dock 2B and at Building 45 will use three sequential rinses with pressurized water, and scrubbing or scraping, if possible residuals are detected. The rinseates will be retained for off-site disposal and analyzed for volatile solvents (Method 8240) and EP Toxicity Metals.

Decontamination of equipment used in the Closure activities is discussed in Section 14.

10. CRITERIA FOR SOIL CONTAMINATION

As indicated in the Schedule for Closure (Section 6), soil sampling will be carried out to ensure that any soil contaminated by hazardous waste generation and 90-day storage activities prior to closure will be removed for appropriate treatment and disposal. The procedures for soil sampling are discussed in Section 11.

It is vital to establish what constitutes a "clean" soil. The hazardous wastes managed at the TAPCO site are known to contain PGDN (torpedo fuel), cyanides and toxic heavy metals. PGDN and Cyanides are not naturally occurring, hence a detectable concentration would indicate contamination. The metals are naturally occurring elements in the area and are anticipated to be present, to some extent, in all soil samples. Detectable below EP-toxic concentrations of Barium, Chromium, Lead and Nickel were leached from soil samples taken near Building 49 (See Table 5.2).

The criterion for cyanide concentration will be 0.25 mg/kg, the detection limit, for soils at Building 45 or at Dock 2-B. However, for soils near Building 49, the criterion will be 10 mg/kg, which was established in a Risk Assessment as not constituting a threat to public health or the environment, specifically for the vicinity of Building 49 (See Attachment 2, the Building 49 Study Report, Appendix C and Appendix D).

The criterion for PGDN concentrations will be its detection limit, i.e., 25 mg/kg.

It is proposed that criteria for metals shall be established based on concentration levels measured on four (4) or more soil samples to be taken at various unaffected locations within the TAPCO site, as follows:

Parameter	Criterion
Cadmium (Cd)	$x_{Cd} + 2.35\ s_{Cd}$ (maximum 2.9 ug/kg)
Chromium (Cr)	$x_{Cr} + 2.35\ s_{Cr}$ (maximum 23 ug/kg)
Lead (Pb)	$x_{Pb} + 2.35\ s_{Pb}$ (maximum 39 ug/kg)
Nickel (Ni)	$x_{Ni} + 2.35\ s_{Ni}$

In the above tabulation, x and s, respectively, stand for the mean and standard deviation of the background values for the subscripted metal. This, in effect, establishes the standard at a concentration statistically greater than background level at about the 5% level of significance, using Student's t-test and assuming three (3) degrees of freedom. (With a larger data base, the level of significance would be lower than 5%.) In the event that the back-ground concentration of a metal exceeds its maximum value as noted above, that maximum value will apply as criterion. The maximum values noted here represent the upper limits of the range for Ohio farm soils.*

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* REFERENCE: Logan, T.J. and R.H. Miller, 1983, Background Levels of Heavy Metals in Ohio Farm Soils, Research Circular 275, Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH)

11. SAMPLING PLAN FOR SOIL AND ANALYTICAL METHODS

11.1 Building 49 Area

11.1.1 Analysis Parameters and Test Methods. The analysis parameters for the samples of soil and runoff stream sediments and the laboratory methods are as follows:

Parameter	Method No.
Cyanide (Total)	9010 (SW-846)
PGDN	Chromatographic (See Appendix 3)

These are the parameters used in the previous Building 49 Study (See Attachment 2). RCRA characterization of additional soil samples undertaken to develop this Closure Plan (See Section 5.3) did not reveal any other hazardous waste characteristics. Sediment samples shall be filtered before analysis. Appendix 3 contains details on the PGDN analysis method.

11.1.2 "Clean" Level for Soil. The Risk Assessment (See Appendix C and D of Attachment 2) presents the rationale for establishing what shall be taken to constitute a "clean" level for soil at Building 49. The target concentration levels and the detection limits are as follows:

Parameter	Criterion	Detection Limit
Cyanide (Total)	10 mg/kg	0.5 mg/kg
PGDN	Not Detected	25 mg/kg

11.1.3 Location of Samples. Figures 11.1 and 11.2 show the locations proposed for soil sampling in the Building 49 Area, to verify that the excavation of soils (for off-site disposal by incineration) has successfully removed residues of the indicator parameters above, to within their respective target concentration levels. As in the previous samplings of soil near Building 49, cells within a grid of numbered 5 ft x 5 ft squares were selected randomly. The Closure activity will sample approximately one cell in four, as follows:

- The 625 sq.ft. irregular polygon area for soil removal at the former torpedo test wastewater discharge area: 7 cells/29 (Figure 11.1).
- The 120 ft long runoff stream channel: 6 cells/24 (Figure 11.2).

The soil exposed after removal of the 1,000 gallon separator tank and an estimated 40 ft. of auxiliary piping should be sampled at four locations previously under the tank and at piping connections, if possible, and at sample points spaced about 5 ft.

If necessary (because of damage to the 20 mil plastic sheet), the 25 ft. x 25 ft. container staging area will be sampled using a 7 ft interval grid.

11.1.4 Sampling Methods and Equipment. A Soil Boring rig will be used to take the soil samples near Building 49. The samples will be collected in Shelby Tubes representing 1 ft intervals of depth below the surface. The tubes will be capped, marked with identifying numbers and delivered to a certified laboratory for chemical analysis.

11.2 Plan for Soil Sampling at Dock 2-B and Building 45, If Required

Concrete flooring will be demolished in Building 45 at the specific locations found to contain hazardous waste residues (See Section 6.12). It may also be necessary to demolish the concrete sub-flooring at Dock 2-B, at any specific locations found to contain hazardous waste residues. The surface soils immediately beneath the affected concrete will be inspected and, if necessary, sampled to ensure that no hazardous waste residues remain.

This contingent soil sampling will be limited to the specific parameters which were identified in the analysis of the concrete samples. These soil core samples, if any, will be taken by manually driving 2 inch pipes using a sledge hammer. The test methods for analyzing the parameters will be those provided in U.S. EPA Manual SW-846. Section 10, Criteria for Soil Contamination, presents the rationale for establishing what shall be taken to constitute a "clean" level for soil at the site.

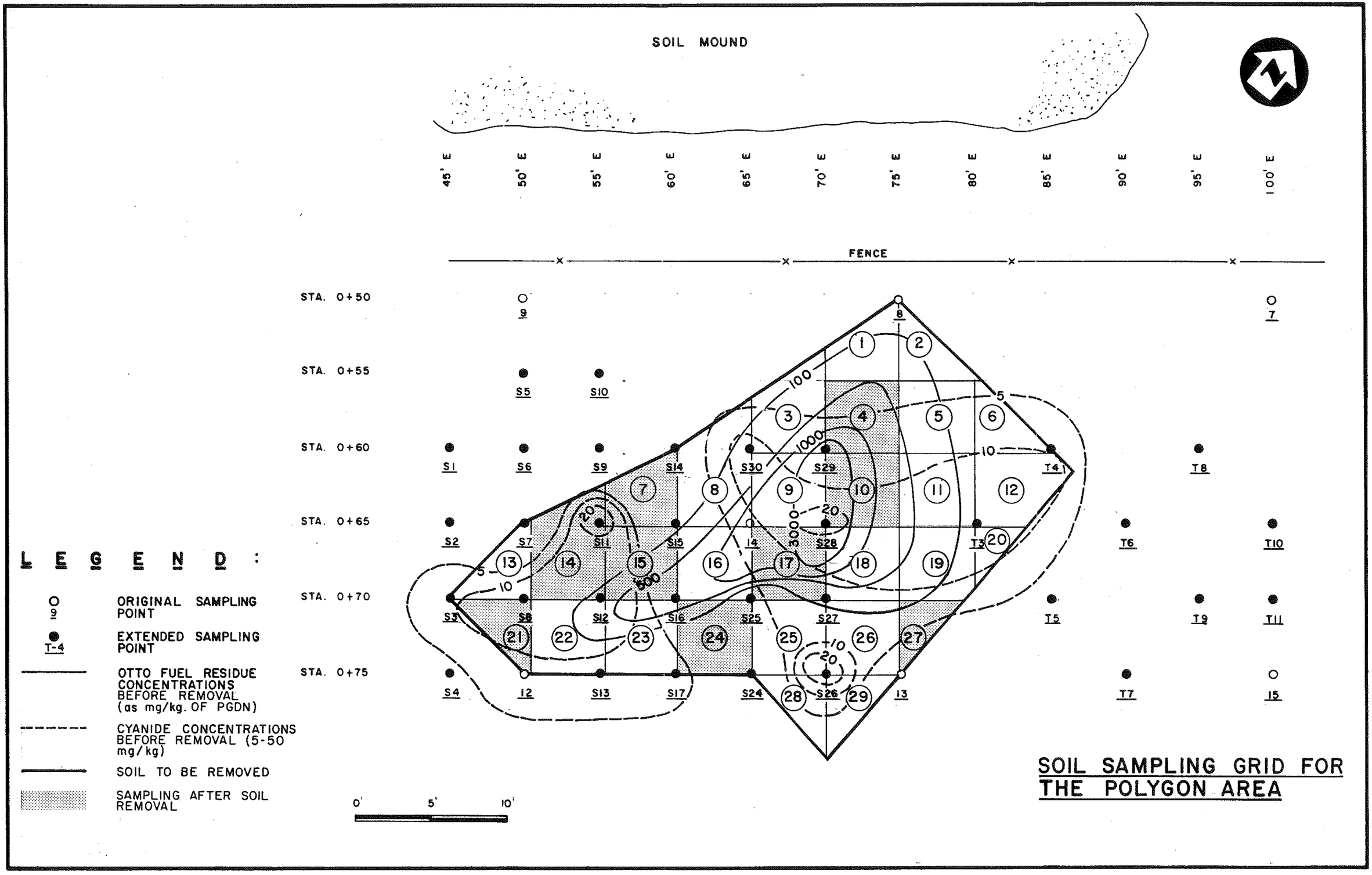
11.3 Background Samples

Additional soil sampling will be undertaken by TRW, not later than the beginning of closure activities, to provide a data base of four (4) or more soil samples taken at unaffected locations within the TAPCO site.

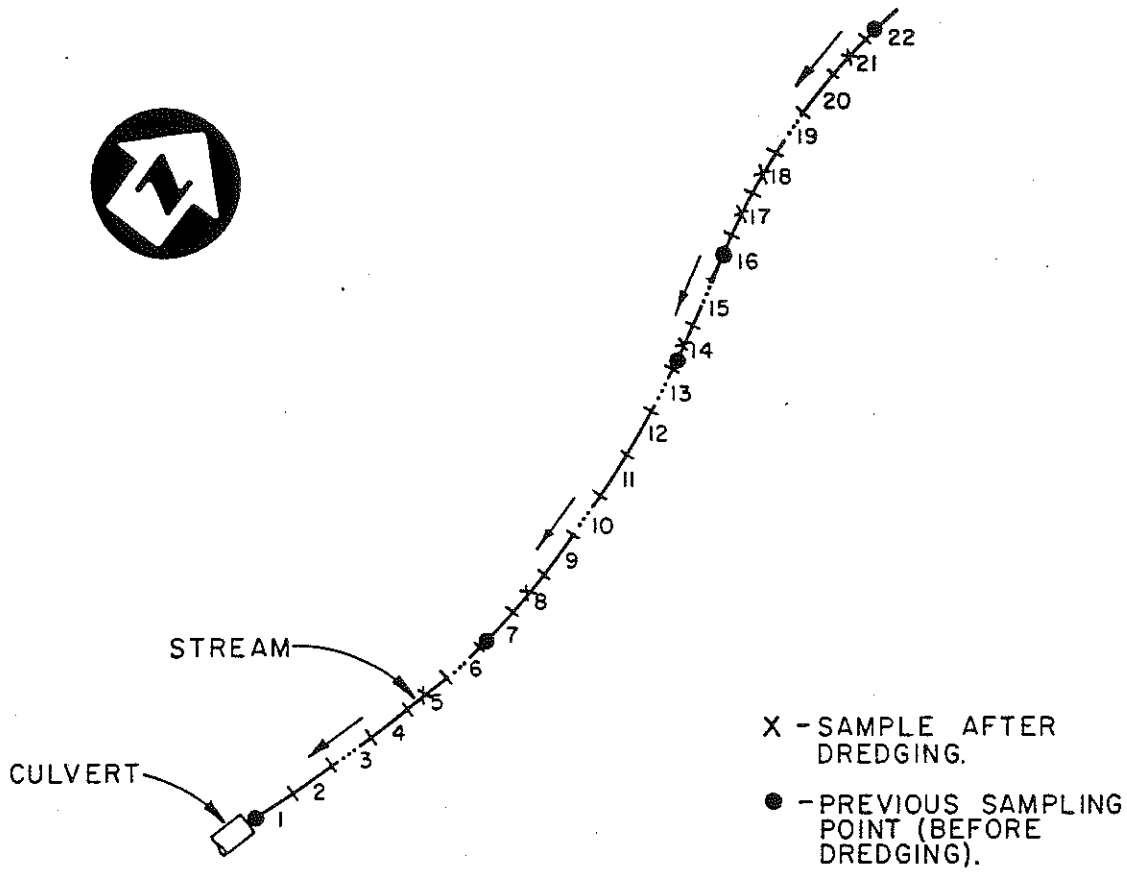
11.4 Quality Assurance/Quality Control Plan

The soil and sediment sampling plan will include 10% blind duplicates and field blanks, which will be submitted for laboratory analysis along with the regular samples. All sample numbers will be assigned using a sequential code, except for duplicates and blanks, which will be identified as such. Permanent numbered gummed labels and Chain-of-Custody Forms will be provided.

TRW's laboratory services subcontractor will be required to submit details of its analytical Quality Assurance program. This must include procedures for sample acceptance and logging in, quality control (QC) sampling of at least 10 percent (10%) of all logged samples (excepting field blanks and duplicates) for lab duplicate or spike tests. Spike tests shall include matrix spikes and, for GC/MS tests, surrogate spikes. Relative percent deviations for duplicates and spike recoveries shall be reported for all lab QC samples. In addition, laboratory documentation measures will be required to ensure the integrity and legal validity of all analytical results.



SOIL SAMPLING GRID FOR THE POLYGON AREA



PLAN
1" = 20'

SOIL SAMPLING GRID FOR RUNOFF STREAM
(NEAR BUILDING 49)

12. DESCRIPTION OF REMOVAL EFFORTS

The Closure of the Hazardous Waste Management Unit at Building 49 will excavate soil from the site of discharges of wastewater from torpedo test firings containing cyanides and torpedo fuel residues, for off-site disposal. The Closure of the former TRW Hazardous Waste Storage Area at Dock 2-B will remove wood flooring which was found to contain detectable concentrations of cyanides and priority pollutant organics. The closure of the Units at Building 45 will demolish concrete that contains residues of chromium. If necessary, concrete sub-flooring at Dock 2-B which may be found to contain hazardous waste residues will be demolished. The concrete rubble will be removed for off-site disposal.

The soil and the concrete rubble are solid materials. Laborers wil be at hand during all removal and transfer operations to recover any spilled material. The transfer routes will be covered with polyethylene sheet to ensure against loss of spilled material.

Additional details of the Closure Plan which are presented in this Section ensure proper disposal of all such material.

12.1 Removal of Soil and Sediments at Building 49

All soil excavated at the Building 49 area will be immediately loaded into containers, which will be transferred to a collection area at the north end of the pavement in the former Torpedo Testing compound. The Collection Area will be protected against contamination by a 20 mil plastic sheet. The containers will be hauled for off-site incineration and disposal, as soon as possible; hence, the maximum number of containers on-site will be about a single hauling load, at most, 20 tons. See Figure 6.4 for layout of facilities near Building 49.

All earthmoving equipment used in these operations will be decontaminated before being allowed to leave the compound area.

12.2 Removal of Oak Flooring at Dock 2-B

Wood flooring blocks will be removed from the former TRW Hazardous Waste Storage Area at Dock 2-B. These will be collected immediately in

fibre drum containers, which will be stored at the new or temporary ARGO-TECH Hazardous Waste Storage Area at the Dock, in a separate area, until all of the existing flooring in the area to be closed has been removed. Figure 6.2 shows the layout of facilities for closure activities at Dock 2-B.

12.3 Removal of Concrete and Soil at Building 45 and/or Dock 2-B, If Required

Rubble from demolition of the concrete at the former TRW Hazardous Waste Storage areas will be transferred to a roll-off container at the site. At Building 45, the container will be located outside the fence to the east of the former Target House. At Dock 2-B, the container will be located inside the building, at the edge of the dock, on street level. See Figures 6.2 and 6.3 for the layout of facilities for closure activities at these units.

The containers will be covered when not in use and will have dust control partitions. The containers will be hauled for off-site disposal at a landfill certified for heavy metals, as soon as possible. Hence, the maximum inventory of concrete rubble or soil on-site will be the roll-off container capacity, about 16 cu.yd.

In the event that hazardous waste residues are detected in the underlying soil after demolition of the concrete, all soil excavated from these areas will be collected, stored on-site and disposed of by off-site landfilling following the procedure outlined above for concrete rubble.

13. SPECIFIC CONSIDERATIONS

This section is reserved for details which are specific for Treatment or Disposal facilities. Although TRW's original application included possible treatment, the Hazardous Waste Management Units to be closed have only been storage facilities. Hence, no specific considerations are applicable.

14. DESCRIPTION OF EQUIPMENT CLEANING

All equipment used in the Closure activities will be either steam-cleaned or cleaned with a high pressure water spray before being allowed to leave the site. Temporary enclosures, approximately 25 ft x 50 ft, will be set up, using boards and polyethylene sheet. Condensate or spent spray water will be collected in a holding tank to trap any particles of soil or rubble dislodged from the equipment being cleaned. The holding tank will be cleaned, as necessary, and any solid residue removed from it will be transferred to containers for appropriate off-site disposal as hazardous waste.

The Decontamination Area for closure activities at both Building 45 and Dock 2-B will be in the Dock, near the edge, at building floor level (Figures 6.2 and 6.3). The location for the Decontamination Area for closure activities at Building 49 will be to the east of the building, near the southeast corner of the fence (Figure 6.4).

15. CERTIFICATION

TRW Incorporated will retain an independent registered Professional Engineer as an outside consultant, specifically to be present on-site at the former TAPCO site during all of the tasks comprising the Closure Plan and to verify that the activities were conducted in accordance with the Closure Plan which was accepted by the Ohio EPA and the U.S. Environmental Protection Agency.

The Engineer's report will be submitted to the Ohio EPA and the U.S. Environmental Protection Agency by TRW Incorporated.

16. STATUS OF THE FACILITY AFTER CLOSURE

The Closure of Hazardous Waste Management Units at Dock 2-B, Building 45 and Building 49 will be a complete closure. None of the units will be subject to requirements for Post-Closure inspection and maintenance or to requirements for ground water protection.

APPENDIX 1

RCRA INTERIM STATUS PERMIT FOR THE TAPCO FACILITY

Rec
5-[illegible]-82
AFK

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
111 West Jackson Blvd.
CHICAGO, ILLINOIS 60604

REPLY TO ATTENTION OF:

RCRA ACTIVITIES

MAY 14 1982

Andrew Resetar, Design Engieer
TRW Incorporated
23555 Euclid Avenue
Cleveland, Ohio 44117

RE: Interim Status Acknowledgement USEPA ID No. OHD 004 179 453
FACILITY NAME: TRW INC

Dear Mr. Resetar:

This is to acknowledge that the U.S. Environmental Protection Agency (USEPA) has completed processing your Part A Hazardous Waste Permit Application. It is the opinion of this office that the information submitted is complete and that you, as an owner or operator of a hazardous waste management facility, have met the requirements of Section 3005(e) of the Resource Conservation and Recovery Act (RCRA) for Interim Status. However, should USEPA obtain information which indicates that your application was incomplete or inaccurate, you may be requested to provide further documentation of your claim for Interim Status. Our opinion will be reevaluated on the basis of this information.

As an owner or operator of a hazardous waste management facility, you are required to comply with the interim status standards as prescribed in 40 CFR Parts 122 and 265, or with State rules and regulations in those States which have been authorized under Section 3006 of RCRA. In addition, you are reminded that operating under interim status does not relieve you from the need to comply with all applicable State and local requirements.

The printout enclosed with this letter identifies the limit(s) of the process design capacities your facility may use during the interim status period. This information was obtained from your Part A Permit application. If you wish to handle new wastes, to change processes, to increase the design capacity of existing processes, or to change ownership or operational control of the facility, you may do so only as provided in 40 CFR Sections 122.22 and 122.23.

As stated in the first paragraph of this letter, you have met the requirements of 40 CFR Part 122.23; your facility may operate under interim status until such time as a permit is issued or denied. This will be preceded by a request from this office or the State (if authorized) for Part B of your application. Please contact Arthur Kawatachi of my staff at (312) 886-7449, if you have any questions concerning this letter or the enclosure.

Sincerely yours,

Karl J. Klepitsch, Jr.

Karl J. Klepitsch, Jr., Chief
Waste Management Branch

Enclosure

cc: G. E. Schrader

TRW INC OHD 004 179 453

FACILITY OPERATOR

TRW INC

FACILITY OWNER

TRW INC

FACILITY LOCATION

23555 EUCLID AVE
CLEVELAND OH 44117

PROCESS CODE	DESIGN CAPACITY	UNIT OF MEASURE
S02	55800.00000	G
S01	27500.00000	G
T01	1210000.00000	U
T03	54.00000	E

---------- KEY ----------

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE
STORAGE:		
CONTAINER	S01	G or L
TANK	S02	G or L
WASTE PILE	S03	Y or C
SURFACE IMPOUNDMENT	S04	G or L
DISPOSAL:		
INJECTION WELL	D79	G,L,U, or V
LANDFILL	D80	A or F
LAND APPLICATION	D81	B or Q
OCEAN DISPOSAL	D82	U or V
SURFACE IMPOUNDMENT	D83	G or L
TREATMENT:		
TANK	T01	U or V
SURFACE IMPOUNDMENT	T02	U or V
INCINERATOR	T03	D,W,E, or H
OTHER	T04	U,V,J,R,N, or S

UNIT OF MEASURE	CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS/HOUR	W
GALLONS/HOUR	E
LITERS/HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q
POUNDS/HOUR	J
KILOGRAMS/HOUR	R
TONS PER DAY	N
METRIC TONS/DAY	S

FORM 1 GENERAL

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER

F OHD004179453

LABEL ITEMS

I. EPA I.D. NUMBER

II. FACILITY NAME

V. FACILITY MAILING ADDRESS

VI. FACILITY LOCATION

PLEASE PLACE LABEL IN THIS SPACE

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affi it in the designated space. Review the inform ation carefully; if any of it is incorrect, cro through it and enter the correct data in th appropriate fill-in area below. Also, if any the preprinted data is absent *(the area to th left of the label space lists the informatio that should appear)*, please provide it in th proper fill-in area(s) below. If the label complete and correct, you need not comple Items I, III, V, and VI *(except VI-B whic must be completed regardless)*. Complete items if no label has been provided. Refer the instructions for detailed item descri tions and for the legal authorizations und which this data is collected.

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of bold-faced terms.

SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED	SPECIFIC QUESTIONS	MARK 'X' YES	NO	FORM ATTACHED
A. Is this facility a publicly owned treatment works which results in a discharge to waters of the U.S.? (FORM 2A)		X		B. Does or will this facility *(either existing or proposed)* include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to waters of the U.S.? (FORM 2B)		X	
C. Is this a facility which currently results in discharges to waters of the U.S. other than those described in A or B above? (FORM 2C)	X			D. Is this a proposed facility *(other than those described in A or B above)* which will result in a discharge to waters of the U.S.? (FORM 2D)		X	
E. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)	X		X	F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)		X	
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)		X		H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)		X	
I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X		J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X	

III. NAME OF FACILITY

1 SKIP TRW INC

IV. FACILITY CONTACT

A. NAME & TITLE *(last, first, & title)*	B. PHONE *(area code & no.)*
2 RESETAR ANDREW DESIGN ENGINEER	216 692 5475

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX

3 23555 EUCLID AVENUE

B. CITY OR TOWN	C. STATE	D. ZIP CODE
4 CLEVELAND	OH	44117

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER

5 23555 EUCLID AVENUE

B. COUNTY NAME

CUYAGOGA

C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE *(if known)*
6 CLEVELAND	OH	44117	—

EPA Form 3510-1 (6-80)

CONTINUE ON REVER

VII. SIC CODES (4-digit, in order of priority)

A. FIRST	B. SECOND
3724 (specify) Aircraft Engine Components (Metal Finishing)	(specify)
C. THIRD	**D. FOURTH**
(specify)	(specify)

VIII. OPERATOR INFORMATION

A. NAME: TRW INC

B. Is the name listed in Item VIII-A also the owner? [X] YES [ ] NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)
F = FEDERAL; S = STATE; P = PRIVATE; M = PUBLIC (other than federal or state); O = OTHER (specify)
Answer: P (specify)

D. PHONE (area code & no.): A 216 692 5475

E. STREET OR P.O. BOX: 23555 EUCLID AVENUE

F. CITY OR TOWN: CLEVELAND

G. STATE: OH

H. ZIP CODE: 44117

IX. INDIAN LAND

Is the facility located on Indian lands? [ ] YES [X] NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water): N OH0000281	D. PSD (Air Emissions from Proposed Sources): P NA
B. UIC (Underground Injection of Fluids): U NA	E. OTHER (specify): NA (specify) NA
C. RCRA (Hazardous Wastes): R NA	E. OTHER (specify): NA (specify) NA

XI. MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in this map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Manufacture aircraft engine components.

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED
F. J. Rechin .P. & Gen. Mgr., TRW Aircraft Comp. Grp.		5/1/83

COMMENTS FOR OFFICIAL USE ONLY

FORM 3 RCRA

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

HAZARDOUS WASTE PERMIT APPLICATION

Consolidated Permits Program

(This information is required under Section 3005 of RCRA.)

I. EPA I.D. NUMBER: I O H D 0 0 4 1 7 9 4 5 3

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED (yr., mo., & day)	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below *(mark one box only)* to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA I.D. Number, or if this is a revised application, enter your facility's EPA I.D. Number in Item I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

C 8 — YR. | MO. | DAY — FOR EXISTING FACILITIES, PROVIDE THE DATE *(yr., mo., & day)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

☐ 2. NEW FACILITY *(Complete item below.)*

YR. | MO. | DAY — FOR NEW FACILITIES PROVIDE THE DATE *(yr., mo., & day)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

B. REVISED APPLICATION *(place an "X" below and complete Item I above)*

☒ 1. FACILITY HAS INTERIM STATUS

☐ 2. FACILITY HAS A RCRA PERMIT

III. PROCESSES – CODES AND DESIGN CAPACITIES

A. PROCESS CODE – Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the form *(Item III-C)*.

B. PROCESS DESIGN CAPACITY – For each code entered in column A enter the capacity of the process.

1. AMOUNT – Enter the amount.
2. UNIT OF MEASURE – For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER *(barrel, drum, etc.)*	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D79	GALLONS OR LITERS
LANDFILL	D80	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D81	ACRES OR HECTARES
OCEAN DISPOSAL	D82	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D83	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER *(Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Item III-C.)*	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING ITEM III *(shown in line numbers X-1 and X-2 below)*: A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons. The facility also has an incinerator that can burn up to 20 gallons per hour.

C — DUP — T/A: C — I

LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	B. 2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G	
X-2	T 0 3	20	E	
1	S 0 2	30,000	G	
2	S 0 2	1,000	G	
3	S 0 2	2,000	G	
4	S 0 1	4,400	G	
5	S 0 1	23,100	G	
6	S 0 2	30,000	G	
7	T 0 1	3	U	
8				
9				
10				

CONTINUE ON REVERSE

Continued from the front.

III. PROCESSES *(continued)*

C. SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESSES *(code "T04")*. FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

N/A

IV. DESCRIPTION OF HAZARDOUS WASTES

A. **EPA HAZARDOUS WASTE NUMBER** — Enter the four—digit number from 40 CFR, Subpart D for each listed hazardous waste you will handle. If you handle hazardous wastes which are not listed in 40 CFR, Subpart D, enter the four—digit number*(s)* from 40 CFR, Subpart C that describes the characteristics and/or the toxic contaminants of those hazardous wastes.

B. **ESTIMATED ANNUAL QUANTITY** — For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non—listed waste*(s)* that will be handled which possess that characteristic or contaminant.

C. **UNIT OF MEASURE** — For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE
POUNDS	P
TONS	T

METRIC UNIT OF MEASURE	CODE
KILOGRAMS	K
METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. **PROCESSES**

1. PROCESS CODES:
   For listed hazardous waste: For each listed hazardous waste entered in column A select the code*(s)* from the list of process codes contained in Item III to indicate how the waste will be stored, treated, and/or disposed of at the facility.
   For non—listed hazardous wastes: For each characteristic or toxic contaminant entered in column A, select the code*(s)* from the list of process codes contained in Item III to indicate all the processes that will be used to store, treat, and/or dispose of all the non—listed hazardous wastes that possess that characteristic or toxic contaminant.
   Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code*(s)*.

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: HAZARDOUS WASTES DESCRIBED BY MORE THAN ONE EPA HAZARDOUS WASTE NUMBER — Hazardous wastes that can be described by more than one EPA Hazardous Waste Number shall be described on the form as follows:

1. Select one of the EPA Hazardous Waste Numbers and enter it in column A. On the same line complete columns B,C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other EPA Hazardous Waste Number that can be used to describe the waste. In column D(2) on that line enter "included with above" and make no other entries on that line.
3. Repeat step 2 for each other EPA Hazardous Waste Number that can be used to describe the hazardous waste.

EXAMPLE FOR COMPLETING ITEM IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* — A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non—listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (if a code is not entered in D(1))
X-1	K 0 5 4	900	P	T 0 3 D 8 0	
	D 0 0 2	400	P	T 0 3 D 8 0	
	D 0 0 1	100	P	T 0 3 D 8 0	
X-4	D 0 0 2				*included with above*

CONTINUE ON PAGE 3

Continued from page 2

NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

Form Approved OMB No. 158 S80004

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W O H D 0 0 4 1 7 9 4 5 3	T/A C 1	W DUP	T/A C 2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

NO.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
1	D001	410	T	S02	
2	D002	500 *	T	S01	* See Attachment "A"
3	D003	670	P	S02 T01	
4	D008	5	T	S01	
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					
16					
17					
18					
19					
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21					
22					
23					
24					
25					
26					

EPA Form 3510-3 (6-80)

CONTINUE ON REVERS

Continued from page 2

NOTE. Photocopy this page before completing if you have more than 26 wastes to list.

Form Approved OMB No 158 S80004

EPA I.D. NUMBER (enter from page 1)	FOR OFFICIAL USE ONLY
W 1	W DUP 2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)				2. PROCESS DESCRIPTION (If a code is not entered in D(1))
1	F002	3200	P	S01				
2	F003	2500	P	S01				
3	F005	4700	P	S01				
4	F006	5900	T	S02				
5	F007	See F006	T	S02				
6	U151	10	P	S01				
7	U159	See F005	P	S01				
8	U160	1	P	S01				
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								

Continued from the front.

IV. DESCRIPTION OF HAZARDOUS WASTES *(continued)*

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM ITEM D(1) ON PAGE 3.

N/A

EPA I.D. NO. *(enter from page 1)*

F OHD004179453 6

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground—level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

II. FACILITY GEOGRAPHIC LOCATION

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*
41 34 040	081 31 018

VIII. FACILITY OWNER

[X] A. If the facility owner is also the facility operator as listed in Section VIII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VIII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*
E N/A	

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE
F	G		

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME *(print or type)*	B. SIGNATURE	C. DATE SIGNED
F. J. Rechin V.P. & Gen. Mgr., TRW Aircraft Comp. Grp.		5/9/83

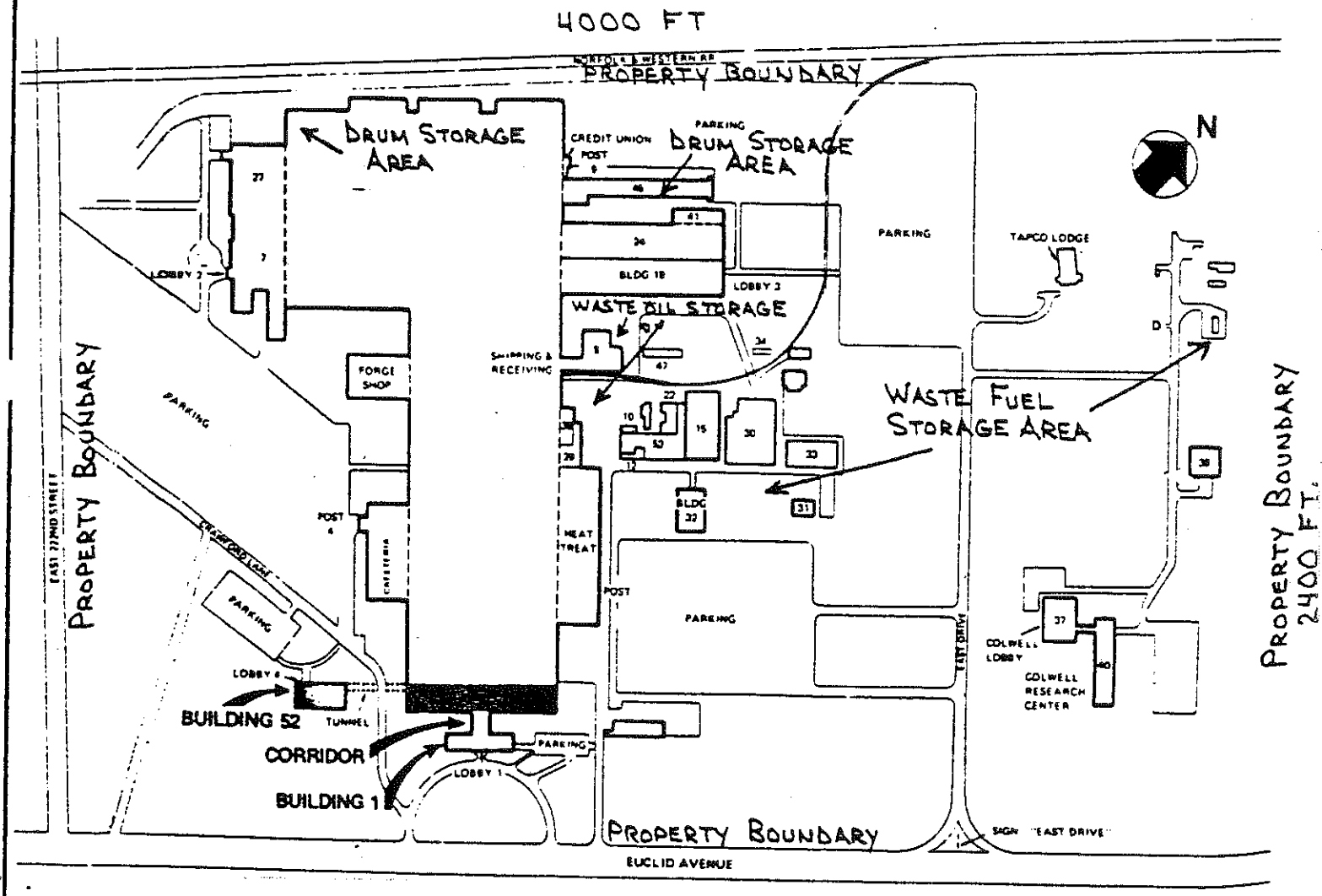
X. OPERATOR CERTIFICATION

rtify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached uments, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the mitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, cluding the possibility of fine and imprisonment.

A. NAME *(print or type)*	B. SIGNATURE	C. DATE SIGNED
F. J. Rechin V.P. & Gen. Mgr., TRW Aircraft Comp. Grp.		5/9/83

CONTINUE ON PAGE 5

TRW EUCLID PROPERTY



TRW
GENERAL OFFICES

November 14, 1980

ATTACHMENT "A"

Y. J. Kim
EPA Region V
RCRA Activities
P.O. Box 7861
Chicago, Illinois 60680

Please be advised that a solid corrosive material is generated from metal finishing operations at this plant. This statement is intended to notify you that an appropriate EPA Hazardous Waste Number is not included in Part 261. The estimated annual quantity of this waste is 250 tons.

TRW Aircraft Components Group
23555 Euclid Avenue
Cleveland, OH 44117

June 6, 1983

Mr. T. Crepeau
Division of Permits and Manifest Records
P. O. Box 1049
361 East Broad Street
Columbus, Ohio 43215

Dear Mr. Crepeau:

The original Resource Conservation and Recovery Act (RCRA) Part A permit application included information regarding a waste treatment system located at TRW's Euclid, Ohio facility (Items 1 through 10, inclusive, Page 1 of 5). This waste treatment system treats acid, alkali, chromium and cyanide wastes generated by electroplating and metal finishing operations. Due to revisions in RCRA and the fact that the waste treatment system's discharge is regulated by a National Pollutant Discharge Elimination System permit (OH0000281), said information has been removed from the Part A application.

The following revisions were also made to the application:

1) Removed information regarding a 1, 1, 1 - trichloroethane still recovery/recycling system (Section III C, Page 2 of 5).

2) Added D008 hazardous waste (Item 4, Page 3 A of 5).

3) Increased amount of "D002" solid corrosive material (Item 2, Page 3A of 5).

4) Added a hazardous waste storage area (Item 5, Page 1 of 5).

5) Added treatment rate for Otto fuel dewatering tank (Item 7, Page 1 of 5).

6) Removed treatment designation from Item 1, Page 3A of 5 since material is beneficially reused.

The amended application is hereby submitted for your records. Please advise me if you have any questions.

Respectfully,

Andrew L. Resetar

Andrew L. Resetar
Plant Engineering Department

Attachment
cc: RCRA Activities
USEPA
Region V

ALR/i

EPA

HAZARDOUS WASTE PERMIT APPLICATION

Consolidated Permits Program

(This information is required under Section 3005 of RCRA.)

I. EPA I.D. NUMBER: F O H D 0 0 4 1 7 9 4 5 3

OFFICIAL USE ONLY

DATE RECEIVED (yr., mo., & day)

COMMENTS

FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below *(mark one box only)* to indicate whether this is the first application you are submitting for your facility or a revised application. If this is your first application and you already know your facility's EPA I.D. Number, or if this is a revised application, enter your facility's I.D. Number in Item I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate data)*

[X] 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

FOR EXISTING FACILITIES, PROVIDE THE DATE (yr., mo., & day) OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*: YR. 69 MO. 01 DAY 01

[ ] 2. NEW FACILITY *(Complete item below.)*

FOR NEW FACILITIES, PROVIDE THE DATE (yr., mo., & day) OPERATION BEGAN OR IS EXPECTED TO BEGIN: YR. MO. DAY

B. REVISED APPLICATION *(place an "X" below and complete Item I above)*

[X] 1. FACILITY HAS INTERIM STATUS

[ ] 2. FACILITY HAS A RCRA PERMIT

III. PROCESSES — CODES AND DESIGN CAPACITIES

A. PROCESS CODE — Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the form *(Item III-C)*.

B. PROCESS DESIGN CAPACITY — For each code entered in column A enter the capacity of the process.
1. AMOUNT — Enter the amount.
2. UNIT OF MEASURE — For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER *(barrel, drum, etc.)*	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D79	GALLONS OR LITERS
LANDFILL	D80	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D81	ACRES OR HECTARES
OCEAN DISPOSAL	D82	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D83	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER *(Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Item III-C.)*	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	O

EXAMPLE FOR COMPLETING ITEM III *(shown in line numbers X-1 and X-2 below)*: A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons. The facility also has an incinerator that can burn up to 20 gallons per hour.

DUP T/A C I

A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY	LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT	2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY
S02	600	G		5				
T03	20	E		6				
02	1000	G		7				
01	4,400	G		8				
01	1,100	G		9				
				10				

CONTINUE ON REVERSE

APPENDIX 2

ENVIRONMENTAL SETTING OF THE TAPCO FACILITY

Introduction

The purpose of this section is to describe the regional conditions of geology which are likely to occur in the immediate vicinity of the TAPCO facility and how those conditions affect the groundwater geology. This report is based on public and private data sources which are readily available. It should be noted that available data is regional in nature and local conditions may differ from those reported in the literature. Data has been obtained from several government agencies and private sources. These data include: maps depicting geologic conditions in the Cuyahoga County area; a detailed soil survey of the mentioned county; and several water well boring logs in proximity to the study area. In addition to this, topographic maps and aerial photos have been secured to aid in the groundwater flow investigation.

Regional Subsurface Geology

Based on observations of the Map of Consolidated Material in Cuyahoga County, Ohio by the State of Ohio Department of Natural Resources (1952), the following generalized statement can be made. The site upon which the TAPCO facility is situated is underlain by a series of shale formations of very low permeability and of Mississippian and Devonian age which are in excess of 800 feet thick. These formations from oldest to youngest and therefore bottom to top are the Chagrin Shale, the Ohio Shale and the Bedford Shale.

The Chagrin Shale is a blue-gray to dark gray silty shale with scattered light blue-gray iron carbonate concretions and thin, hard, light gray calcareous sandstone layers. The Ohio Shale with the local member Cleveland Shale is a massive black bituminous shale containing pyrite concretions. The Ohio Shale unconformably lies on the Chagrin Shale, both of which are Devonian in age. The youngest of these formations and the closest to the surface is the Bedford Shale. This formation is a soft, blue-gray shale with thin calcareous sandstone lenses which thicken locally to form the basal Euclid sandstone member. This Euclid member is of special concern to this project do to its properties of high porosity and permeablility.

In certain areas these formations are unproductive of groundwater. However, domestic supplies of 3 to 4 gallons per minute may be developed. These wells would have to be much deeper than wells with similar yields in other aquifers.

The general structural attitude of the bedrock is flat with no major tectonic deformation activity.

Pleistocene Geology and Landforms

Pleistocene geology is geology of relatively recent times and events. It, therefore, has shaped and has a cause/effect relationship to our present day landform situation. There are three main features at or near the location of the TAPCO plant which are a result of Pleistocene geologic activity. These features play a prominent role in the definition of groundwater flow direction.

One feature is the generally flat broad plain which is a result of clay, silt and fine sands being deposited in a earlier stage of glacial lake inundation. Deposits are generally thin and underlain by glacial till except in buried valleys where thickness will be greater. This generally is a very poor source of groundwater. These deposits have been transforming for ten thousand years into today's soil types. This report will elaborate further on this matter.

Ancient beach ridges are another feature and are the result of wave dominated depositional action and consist of sand and gravel deposited at the ancient lake shoreline. These beaches are generally not more than 20 feet thick. Water supplies are usually small. Because of their porous nature these ridges are of important concern especially if they are associated with contamination by hazardous materials. They are a separate geologic entity which would necessitate independent study and surveillance. Locations of these beach ridges according to referenced maps are shown in Figure 2.

The most visually prominent feature is the Lake Cliffs. As one stands on the TAPCO Property looking in a Southeasterly direction, a definite and abrupt increase in topographic relief can be observed. This is the Lake Cliffs which were formed by a glacial lake cutting into a previously deposited shale or clay unit, forming the truncated feature. The importance of this feature is that it provides a probable hydraulic upgradient location from which to base groundwater background studies.

Soils

The soils portion of this report is based upon a soil survey of Cuyahoga County, Ohio, done by the Soil Conservation Services, et.al. (1977). There are basically three distinct mappable soil units present on the TAPCO premises. The nomenclature for the three units to be discussed is Ub-urban land, Uc-urban land-Allis complex, and HsC-Hornell-Urban land complex, rolling.

The majority of the soil on the property is considered to be Ub. Urban land is areas where more than 80 percent of the surface is covered by asphalt, concrete, buildings or other manmade surfaces. These areas are usually in excess of 10 acres and are nearly level to gently sloping. Examination and identification of soils or soil like materials in this unit are difficult at best, and impractical for the scope of the report from which this information is being drawn. Onsite investigation is needed to determine specific local conditions in this category.

A relatively small area in the Northeast portion of the property being scrutinized is designated as Uc-Urban land-Allis complex. This unit is comprised of urban land and a moderately deep, nearly level and gently sloping, poorly drained Allis soil. Typically, the Allis soil has a surface layer of dark grayish brown, friable silt loam which is about six inches deep. The subsoil is approximately twenty-seven inches in depth and is a grayish brown, mottled, very firm silty clay. The substratum is dark gray rippable, partially weathered shale bedrock. Most of this area is artificially drained. Undrained areas of Allis soil have a perched seasonal high water table near the surface in Fall, Winter, Spring and, of course, during extended wet periods. Permeablility is slow or very slow, and runoff is slow. Other characteristics of this unit are: a low available water capacity, a moderate shrink-swell potential, and an extremely acid to strongly acidic subsoil.

The third major soil unit at the TAPCO property is HsC-Hornell-Urban land complex, rolling. This unit consists of a rolling Hornell soil that is moderately deep and somewhat poorly drained. This mappable entity runs parallel to Euclid Avenue on the Southeast boundary of the TAPCO plant. Typically the Hornell soil has a surface layer of dark grayish brown, friable silt loam about six inches thick. The subsoil is about twenty inches thick. It is a yellowish brown and grayish brown, mottled, firm, silty clay loam and silty clay. The substratum goes to an

average depth of thirty-four inches and is a grayish brown, firm, shaly silty clay. Areas of the Hornell soil that are not drained have a perched seasonal high water table at a depth of twelve to thirty inches in winter, spring, and during extended wet periods. Permeability is very slow. Run off is very rapid. The Hornell soil has a low available water capacity. The subsoil is strongly acidic to very strongly acidic.

Only with onsite investigation can any totally accurate site-specific comments be made about the soil conditions, aerial extents and confining boundaries.

Aerial Photos, Topography and Groundwater Flow

Aerial photos dated April, 1978, were used to determine the topographic relief gradient of the TAPCO property. The actual photos were obtained from Graphco, Base Resource Division, a map supply company in Cleveland. The photos used had topographic information superimposed onto them by photogrammetric methods. This allows for a greater degree of accuracy to be employed while viewing. The USGS topographic map does not have this degree of detail.

Generally, the highest elevations are along a line parallel and adjacent to Euclid Avenue, on the Southwest boundary of the property. The lower elevations are along the Northwest boundary. A topographic cross section was constructed from the aerial photos and is given in Figure 3. Figure 4 shows the location of the cross section. The highest elevation on the property in this line of cross section is approximately 686 feet. The lowest elevation is 647 feet. This is an elevation difference of 39 feet. Most of the topography is very flat. On the cross section near building no. 37, the surface is very flat as the line of cross section is followed to the northwest.

It should be noted that a check for additional vintages of air photos was made with the USGS. Other vintages do exist; however, none are significantly different from the 1978 photos used for this report.

Overall groundwater flow is expected to be southeast to northwest as a result of the topographic relief gradient dip direction. The rate at which the groundwater flows is yet to be determined, however, it is expected to be very slow, based on the Cuyahoga County soils report.

APPENDIX 3

LABORATORY ANALYSIS METHOD FOR PROPYLENE GLYCOL DINITRATE

1938-1988
50 YEARS
WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing, mobile labs
4101 Shuffel Drive N.W. / North Canton, Ohio 44720

RECEIVED
SEP 19 1988
CLEVELAND ES

September 16, 1988

Engineering Science LTD.
19101 Villaview Rd.
Suite 301
Cleveland, Ohio 44119

Attention: Richard Prober

Dear Richard,

In response to your question concerning the method used to analyze the Otto fuel component propylene glycol dinitrate, I am submitting the following summary:

Propylene Glycol Dinitrate Analytical Summary

Extraction was performed using a soxhlet extractor for 18 hours with methylene chloride as the solvent. This extraction is similar to Method 3540 without the addition of any surrogate standards. Extracts were concentrated to 10 ml. for analysis.

The analysis was performed using a gas chromatograph equipped with a flame ionization detector. The column was a 30 meter DB-1 megabore, 0.53 mm with nitrogen carrier gas. A temperature was programmed from 60° to 120°C.

External standards were used to quantify results. The sample extract was initially analyzed and quantified against a single point calibration. If the initial analysis was outside a 50-200% limit of the prepared standard, the sample extract was diluted or concentrated to meet this criteria. A standard was rerun every 3-5 runs to assure consistent response. The standard was derived from a sample of Otto fuel supplied by TRW and was assumed to be 76% propylene glycol dinitrate (PGDN) as described in its specifications. Because of the nature of the standard no further standardization was performed.

CORPORATE AND LABORATORY: North Canton, Ohio (216) 497-9396
LABORATORY: Cleveland, Ohio (216) 642-9151
LABORATORY: Bartow, Florida (813) 533-2150
SOUTHEAST REGIONAL OFFICE: Lexington, South Carolina (803) 957-6590
24-HOUR ALERT LINE (216) 497-9338

1938-1988
50 YEARS
WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing, mobile labs
4101 Shuffel Drive N.W. / North Canton, Ohio 44720

Samples were periodically spiked with the "standard" PGDN to determine extraction efficiency and analytical accuracy. The quantitation limit was set at 20% of a standard giving a half scale response. Blanks were also analyzed and were determined to be clean if no quantifiable PGDN was present.

This should suffice as a summary of the method. If you have any questions feel free to cam me.

Sincerely,

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph.D.
Vice President
Corporate Technical Director

MWS:pjh

CORPORATE AND LABORATORY: North Canton, Ohio (216) 497-9396
LABORATORY: Cleveland, Ohio (216) 642-9151
LABORATORY: Bartow, Florida (813) 533-2150
SOUTHEAST REGIONAL OFFICE: Lexington, South Carolina (803) 957-6590
24-HOUR ALERT LINE (216) 497-9338

TRW Inc.

Executive Offices
1900 Richmond Road
Cleveland, OH 44124

November 30, 1987

RECEIVED
DEC 03 1987
SWD - AIS
U.S. EPA, REGION V

Ms. Lisa Pierard
USEPA Region V
P. O. Box A3587
Chicago, IL 60690

Dear Ms. Pierard:

TRW Inc. is hereby submitting a closure plan for its former 23555 Euclid Avenue, Cleveland, Ohio facility. Please be advised that TRW Inc. previously withdrew application #02-18-0653 on December 21, 1984, via a certified letter to Mr. Edwin Y. Lim of the Ohio Hazardous Waste Facility Board.

TRW Inc. believes that that withdrawal, plus the operation of the facility as a 90 day generator, effectively removed TRW from the regulatory system which requires a closure plan.

However, the Northeastern District Office of the Ohio EPA has requested TRW Inc. to submit the attached plan for review and approval by both the Ohio and the U.S. EPA. In order to terminate as expeditiously as possible TRW Inc.'s responsibility for a facility which was sold in the fall of 1986, TRW Inc. is complying with that request.

I trust that the attached information is satisfactory. Please call me at (216) 291-7839 if you have any questions.

Sincerely,

Andrew L. Resetar

Andrew L. Resetar
Environmental Project Manager

cc: M. A. Brennan, Baker & Hostetler (w/o attachment)
K. Coder, Ohio EPA, Twinsburg (w/o attachment)
D. Trickey (w/o attachment)

ALR/th
18091
Attachments (2 copies)

WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing,
consulting, mobile labs

HEADQUARTERS AND
LABORATORY
1600 Fourth Street, S.E.
P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

SOUTHEASTERN
REGIONAL OFFICE
744 Sunset Boulevard
West Columbia, SC 29169
(803) 794-6251

REGIONAL
LABORATORY
Route 3 - Box 235
Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

) 454-5809

ATTACHMENT 1
LABORATORY REPORTS

RECEIVED
SEP 2 6 1988
U. S. EPA, REGION V
SWB — PMS

ANALYTICAL REPORT

TRW-CLEVELAND SITE

Presented to :

RICHARD PROBER

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

11/ 6/86

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23563
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-1

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23564
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-2

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23565
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-3, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23565
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-3, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	14 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23566
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-3, 1'-3'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23566
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-3, 1'-3'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.66 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23567
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-4, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing,
consulting, mobile labs

HEADQUARTERS AND
LABORATORY
1600 Fourth Street, S.E.
P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

SOUTHEASTERN
REGIONAL OFFICE
744 Sunset Boulevard
West Columbia, SC 29169
(803) 794-6251

REGIONAL
LABORATORY
Route 3 – Box 235
Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

ANALYTICAL REPORT

TRW SITE

PROJECT 66207.00

Presented to :

RICHARD PROBER

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

10/15/86

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23567
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-4, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	9.1 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23568
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-4, 1'-3'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23568
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-4, 1'-3'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23569
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-5, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23569
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-5, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	4.7 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23570
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-5, 1'-3'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23570
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-5, 1'-3'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.54 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23571
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-7, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23571
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-7, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.2 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23572
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : T-7, 1'-3'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23572
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : T-7, 1'-3'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.93 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23573
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : S-9, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23573
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : S-9, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.5 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23574
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : S-28, REST OF CORE

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23574
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : S-28, REST OF CORE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.5 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23575
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86
EXTRACTION DATE : 10/27/86
ANALYSIS DATE : 11/ 3/86

SAMPLE ID : S-29, REST OF CORE

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	80	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5275-23575
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/22/86

SAMPLE ID : S-29, REST OF CORE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

486-9005

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO.	PROJECT NAME/LOCATION
	TRW - Cleveland

SAMPLER(S): (Signature) Ray Banary Ray Banary

SHIP TO:
ENGINEERING-SCIENCE, INC.
1687 Tullie Circle
Suite 105
Atlanta, GA. 30329
(404) 325-5923

DATE	TIME	SAMPLE DESCRIPTION	NO. OF CONTAINERS	ANALYSES REQUIRED: PDGN ANAL.	CYANIDE						REMARKS
10/16	2:00	CULVERT SEDIMENT T-1 East	1 plast.	X	X						
"		" T-2 West	1 plast.	X	X						
"		SOIL CORING 0+65 @ 80E T-3	1	X	X						
"		0+60 @ 85E T-4	1	X	X						
		0+70 @ 85E T-5	1	X	X						
		0+65 @ 90E T-6	1	X	X						
		0+75 @ 90E T-7	1	X	X						
		0+60 @ 95E T-8	1	X	X						
		0+70 @ 95E T-9	1	X	X						
		0+65 @ 100E T-10	1	X	X						
		0+70 @ 100E T-11	1	X	X						

Relinquished by: (Signature)	Date/Time	Received by: (Signature)	Relinquished by: (Signature)	Date/Time	Received by: (Signature)
	10/16 4:15		Steven A Einselen	10/17 8:12	Roger A. Custer

Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)	Date/Time	Remarks

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22136
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S2, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	4.3 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22137
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S3, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	4.3 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22138
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S4, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.4 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22139
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S7, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22139
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S7, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.4 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22140
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S8, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22140
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S8, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.3 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22141
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S11, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22141
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S11, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	26 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22142
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S12, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22142
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S12, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.2 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22143
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S13, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22143
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S13, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.5 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22144
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S14, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22144
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S14, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.74 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22147
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S17, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22147
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S17, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	6.0 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22146
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S16, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22146
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S16, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.58 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22153
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S24, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22153
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S24, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.1 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22151
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S22, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.4 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22152
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S23, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.81 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22148
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S18, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22148
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S18, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.0 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22149
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S20, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22150
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S21, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	2.1 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22145
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S15, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22145
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S15, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.61 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22154
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S25, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22154
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S25, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.52 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22155
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S26, 0-1'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22155
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S26, 0-1'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	40 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22156
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S27, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

RECEIVING DATE : 10/ 2/86

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22156
SAMPLE MATRIX : SOLID

SAMPLE ID : CORE S27, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.67 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22157
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S28, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22157
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S28, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.4 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22158
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S29, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22158
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S29, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.77 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ORGANIC COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22159
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86
EXTRACTION DATE : 10/ 2/86
ANALYSIS DATE : 10/10/86

SAMPLE ID : CORE S30, 1-2'

	RESULT (mg/kg)	DETECTION LIMIT
Propylene glycol dinitrate	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4937-22159
SAMPLE MATRIX : SOLID

RECEIVING DATE : 10/ 2/86

SAMPLE ID : CORE S30, 1-2'

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.73 mg/kg	0.50 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #3
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 5' ½"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #4
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3' 9 7/8"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #5
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4' 1"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #6
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 5' 3"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #7
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4' 8¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #8
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3' 11½"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #9
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'10"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #10
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	1.2 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'9¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #15
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'5¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #16
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.31 mg/kg	0.52 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 5'

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #13
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.85 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'11"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #14
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	5.7 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	1,600 mg/kg	<25 mg/kg

Length of core 4'11"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #19
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'10½"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #20
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	1.4 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'11 7/8"

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 624 VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36671
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/16/87
ANALYSIS DATE : 6/17/87

SAMPLE ID : ES-49-2 6/2/87

	RESULT (mg/kg)	DETECTION LIMIT
Benzene	ND	1
Bromodichloromethane	ND	1
Bromoform	ND	1
Bromomethane	ND	1
Carbon tetrachloride	ND	1
Chlorobenzene	ND	1
Chloroethane	ND	1
2-Chloroethylvinyl ether	ND	1
Chloroform	ND	1
Chloromethane	ND	1
Dibromochloromethane	ND	1
1,2-Dichlorobenzene	ND	1
1,3-Dichlorobenzene	ND	1
1,4-Dichlorobenzene	ND	1
1,1-Dichloroethane	ND	1
1,2-Dichloroethane	ND	1
1,1-Dichloroethene	ND	1
trans-1,2-Dichloroethene	ND	1
1,2-Dichloropropane	ND	1
cis-1,3-Dichloropropene	ND	1
trans-1,3-Dichloropropene	ND	1
Ethylbenzene	ND	1
Methylene chloride	ND	1
1,1,2,2-Tetrachloroethane	ND	1
Tetrachloroethene	ND	1
Toluene	ND	1
1,1,1-Trichloroethane	ND	1
1,1,2-Trichloroethane	ND	1
Trichloroethene	ND	1
Trichlorofluoromethane	ND	1
Vinyl chloride	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8080 PCB ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36671
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/11/87
ANALYSIS DATE : 6/16/87

SAMPLE ID : ES-49-2 6/2/87

	RESULT (mg/kg)	DETECTION LIMIT
PCB-1016	ND	1
PCB-1221	ND	1
PCB-1232	ND	1
PCB-1242	ND	1
PCB-1248	ND	1
PCB-1254	ND	1
PCB-1260	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #17
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.71 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'5"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #18
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'4"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #21
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.33 mg/kg	0.28 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'11½"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #22
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'3"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #39
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.38 mg/kg	3.9 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4' 10¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #38
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4' 6 3/4"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #37
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.72 mg/kg	0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 7' 8½"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #36
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'6 3/4"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #11
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.82 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'6 "

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #12
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	7.4 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'7¼"

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36667
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-8 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36668
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-9 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36661
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-1 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	1.5	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36662
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-3 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	2.4	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36669
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-10 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD. **RECEIVING DATE** : 6/ 5/87
LABORATORY ID : 1139-36670
SAMPLE MATRIX : SOIL

SAMPLE ID : ES-49-MC (COMPOSITE SAMPLE OF ES-49-M1 THRU M4) 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36663
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-4 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	1.5	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36664
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-5 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	0.5	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

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ANALYTICAL REPORT

TAPCO/BLDG. 49

PROJECT #CL065

Presented to :

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

July 10, 1987

CORPORATE AND LABORATORY: Canton, Ohio (216) 454-5809
LABORATORY: Cleveland, Ohio (216) 642-9151
LABORATORY: Bartow, Florida (813) 533-2150
SOUTHEAST REGIONAL OFFICE: Lexington, South Carolina (803) 957-6590
24 HOUR ALERT LINE: (216) 454-8304

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36665
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-6 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	0.5	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36666
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-7 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36671
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-2 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	2.2	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36672
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-B1 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36673
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-B2 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	1.9	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36674
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-B3 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	1	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36675
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-B4 6/2/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 624 VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36676
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/16/87
ANALYSIS DATE : 6/17/87

SAMPLE ID : ES-49-BC (COMPOSITE OF ES-49-B1 THRU B4) 6/2/87

	RESULT (mg/kg)	DETECTION LIMIT
Benzene	ND	1
Bromodichloromethane	ND	1
Bromoform	ND	1
Bromomethane	ND	1
Carbon tetrachloride	ND	1
Chlorobenzene	ND	1
Chloroethane	ND	1
2-Chloroethylvinyl ether	ND	1
Chloroform	ND	1
Chloromethane	ND	1
Dibromochloromethane	ND	1
1,2-Dichlorobenzene	ND	1
1,3-Dichlorobenzene	ND	1
1,4-Dichlorobenzene	ND	1
1,1-Dichloroethane	ND	1
1,2-Dichloroethane	ND	1
1,1-Dichloroethene	ND	1
trans-1,2-Dichloroethene	ND	1
1,2-Dichloropropane	ND	1
cis-1,3-Dichloropropene	ND	1
trans-1,3-Dichloropropene	ND	1
Ethylbenzene	ND	1
Methylene chloride	ND	1
1,1,2,2-Tetrachloroethane	ND	1
Tetrachloroethene	ND	1
Toluene	ND	1
1,1,1-Trichloroethane	ND	1
1,1,2-Trichloroethane	ND	1
Trichloroethene	ND	1
Trichlorofluoromethane	ND	1
Vinyl chloride	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36676
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/11/87
ANALYSIS DATE : 6/18/87

SAMPLE ID : ES-49-BC (COMPOSITE OF ES-49-B1 THRU B4) 6/2/87

	RESULT (mg/kg)	DETECTION LIMIT
Acenaphthene	ND	10
Acenaphthylene	ND	10
Anthracene	ND	10
Benzidine	ND	50
Benzo(a)anthracene	ND	10
Benzo(b)fluoranthene	ND	10
Benzo(k)fluoranthene	ND	10
Benzo(ghi)perylene	ND	10
Benzo(a)pyrene	ND	10
Bis(2-chloroethoxy)methane	ND	10
Bis(2-chloroethyl)ether	ND	10
Bis(2-chloroisopropyl)ether	ND	10
Bis(2-ethylhexyl)phthalate	ND	10
4-Bromophenyl phenyl ether	ND	10
Butyl benzyl phthalate	ND	10
2-Chloronaphthalene	ND	10
4-Chlorophenyl phenyl ether	ND	10
Chrysene	ND	10
Dibenzo(a,h)anthracene	ND	10
Di-n-butyl phthalate	ND	10
1,2-Dichlorobenzene	ND	10
1,3-Dichlorobenzene	ND	10
1,4-Dichlorobenzene	ND	10
3,3'-Dichlorobenzidine	ND	10
Diethyl phthalate	ND	10
Dimethyl phthalate	ND	10
2,4-Dinitrotoluene	ND	10
2,6-Dinitrotoluene	ND	10
Di-n-octyl phthalate	ND	10
Fluoranthene	ND	10
Fluorene	ND	10
Hexachlorobenzene	ND	10
Hexachlorobutadiene	ND	10
Hexachlorocyclopentadiene	ND	10
Hexachloroethane	ND	10
Indeno(1,2,3-CD)pyrene	ND	10
Isophorone	ND	10
Naphthalene	ND	10
Nitrobenzene	ND	10
N-Nitrosodimethylamine	ND	10
N-Nitrosodiphenylamine	ND	10
N-Nitrosodi-n-propylamine	ND	10
Phenanthrene	ND	10
Pyrene	ND	10
1,2,4,Trichlorobenzene	ND	10

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 ACID ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36676
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/11/87
ANALYSIS DATE : 6/15/87

SAMPLE ID : ES-49-BC (COMPOSITE OF ES-49-B1 THRU B4) 6/2/87

	RESULT (mg/kg)	DETECTION LIMIT
4-Chloro-3-methylphenol	ND	10
2-Chlorophenol	ND	10
2,4-Dichlorophenol	ND	10
2,4-Dimethylphenol	ND	10
2,4-Dinitrophenol	ND	50
2-Methyl-4,6-dinitrophenol	ND	50
2-Nitrophenol	ND	10
4-Nitrophenol	ND	50
Pentachlorophenol	ND	50
Phenol	ND	10
2,4,6-Trichlorophenol	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC PESTICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36676
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/22/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : ES-49-BC (COMPOSITE OF ES-49-B1 THRU B4) 6/2/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
Lindane	ND	0.05
Chlordane	ND	0.5
Endrin	ND	0.1
Heptachlor	ND	0.05
Heptachlor Epoxide	ND	0.05
Toxaphene	ND	1
Methoxychlor	ND	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC HERBICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36676
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/19/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : ES-49-BC (COMPOSITE OF ES-49-B1 THRU B4) 6/2/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
2,4-D	ND	1
Silvex	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8080 PCB ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/24/87
ANALYSIS DATE : 6/25/87

SAMPLE ID : ES-49-DC 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
PCB-1016	ND	1
PCB-1221	ND	1
PCB-1232	ND	1
PCB-1242	ND	1
PCB-1248	ND	1
PCB-1254	ND	1
PCB-1260	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD. RECEIVING DATE : 6/ 5/87
LABORATORY ID : 1139-36676
SAMPLE MATRIX : SOIL

SAMPLE ID : ES-49-BC (COMPOSITE OF ES-49-B1 THRU B4) 6/2/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Silver	ND	0.01
Arsenic	ND	0.005
Barium	2.1	0.1
Cadmium	ND	0.01
Chromium	0.04	0.02
Mercury	ND	0.005
Nickel	0.49	0.04
Lead	0.54	0.05
Selenium	ND	0.005

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

GAS CHROMATOGRAPH ANALYSIS REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36677
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
ANALYSIS DATE : 6/23/87
EXTRACTION DATE : 6/21/87

SAMPLE ID : ES-49-13 6/3/87

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
PGDN	ND	25

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36677
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-13 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	11	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

GAS CHROMATOGRAPH ANALYSIS REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36678
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
ANALYSIS DATE : 6/23/87
EXTRACTION DATE : 6/21/87

SAMPLE ID : ES-49-14 6/3/87

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
PGDN	1,300	100

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36678
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-14 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	16	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

GAS CHROMATOGRAPH ANALYSIS REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36679
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
ANALYSIS DATE : 6/23/87
EXTRACTION DATE : 6/21/87

SAMPLE ID : ES-49-15 6/3/87

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
PGDN	330	100

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36679
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-15 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	23	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 624 VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/16/87
ANALYSIS DATE : 6/17/87

SAMPLE ID : ES-49-DC 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
Benzene	ND	1
Bromodichloromethane	ND	1
Bromoform	ND	1
Bromomethane	ND	1
Carbon tetrachloride	ND	1
Chlorobenzene	ND	1
Chloroethane	ND	1
2-Chloroethylvinyl ether	ND	1
Chloroform	ND	1
Chloromethane	ND	1
Dibromochloromethane	ND	1
1,2-Dichlorobenzene	ND	1
1,3-Dichlorobenzene	ND	1
1,4-Dichlorobenzene	ND	1
1,1-Dichloroethane	ND	1
1,2-Dichloroethane	ND	1
1,1-Dichloroethene	ND	1
trans-1,2-Dichloroethene	ND	1
1,2-Dichloropropane	ND	1
cis-1,3-Dichloropropene	ND	1
trans-1,3-Dichloropropene	ND	1
Ethylbenzene	ND	1
Methylene chloride	ND	1
1,1,2,2-Tetrachloroethane	ND	1
Tetrachloroethene	ND	1
Toluene	ND	1
1,1,1-Trichloroethane	ND	1
1,1,2-Trichloroethane	ND	1
Trichloroethene	ND	1
Trichlorofluoromethane	ND	1
Vinyl chloride	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

OTHER COMPOUNDS PRESENT

COMPANY : ENGINEERING SCIENCE LTD.
SAMPLE ID : ES-49-DC 6/3/87
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL
RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/16/87
ANALYSIS DATE : 6/17/87

Non-listed Quantified Compounds

None

MS/DS Identified Non-regulated Compounds With Their Estimated Concentrations

2-propyl-furan	1 mg/kg
Unknown hydrocarbon	2 mg/kg
Unknown cyclic hydrocarbon	3 mg/kg
Unknown cyclic hydrocarbon	5 mg/kg
Unknown hydrocarbon	1 mg/kg

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/11/87
ANALYSIS DATE : 6/18/87

SAMPLE ID : ES-49-DC 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
Acenaphthene	ND	10
Acenaphthylene	ND	10
Anthracene	ND	10
Benzidine	ND	50
Benzo(a)anthracene	ND	10
Benzo(b)fluoranthene	ND	10
Benzo(k)fluoranthene	ND	10
Benzo(ghi)perylene	ND	10
Benzo(a)pyrene	ND	10
Bis(2-chloroethoxy)methane	ND	10
Bis(2-chloroethyl)ether	ND	10
Bis(2-chloroisopropyl)ether	ND	10
Bis(2-ethylhexyl)phthalate	ND	10
4-Bromophenyl phenyl ether	ND	10
Butyl benzyl phthalate	ND	10
2-Chloronaphthalene	ND	10
4-Chlorophenyl phenyl ether	ND	10
Chrysene	ND	10
Dibenzo(a,h)anthracene	ND	10
Di-n-butyl phthalate	ND	10
1,2-Dichlorobenzene	ND	10
1,3-Dichlorobenzene	ND	10
1,4-Dichlorobenzene	ND	10
3,3'-Dichlorobenzidine	ND	10
Diethyl phthalate	ND	10
Dimethyl phthalate	ND	10
2,4-Dinitrotoluene	ND	10
2,6-Dinitrotoluene	ND	10
Di-n-octyl phthalate	ND	10
Fluoranthene	ND	10
Fluorene	ND	10
Hexachlorobenzene	ND	10
Hexachlorobutadiene	ND	10
Hexachlorocyclopentadiene	ND	10
Hexachloroethane	ND	10
Indeno(1,2,3-CD)pyrene	ND	10
Isophorone	ND	10
Naphthalene	ND	10
Nitrobenzene	ND	10
N-Nitrosodimethylamine	ND	10
N-Nitrosodiphenylamine	ND	10
N-Nitrosodi-n-propylamine	ND	10
Phenanthrene	ND	10
Pyrene	ND	10
1,2,4,Trichlorobenzene	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 ACID ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/11/87
ANALYSIS DATE : 6/18/87

SAMPLE ID : ES-49-DC 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
4-Chloro-3-methylphenol	ND	10
2-Chlorophenol	ND	10
2,4-Dichlorophenol	ND	10
2,4-Dimethylphenol	ND	10
2,4-Dinitrophenol	ND	50
2-Methyl-4,6-dinitrophenol	ND	50
2-Nitrophenol	ND	10
4-Nitrophenol	ND	50
Pentachlorophenol	ND	50
Phenol	ND	10
2,4,6-Trichlorophenol	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC PESTICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/22/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : ES-49-DC 6/3/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
Lindane	ND	0.1
Chlordane	ND	1
Endrin	ND	0.1
Heptachlor	ND	0.1
Heptachlor Epoxide	ND	0.3
Toxaphene	ND	3
Methoxychlor	ND	0.5

MATRIX INTERFERENCE

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC HERBICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/19/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : ES-49-DC 6/3/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
2,4-D	ND	3
Silvex	ND	3

MATRIX INTERFERENCE

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8080 PCB ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/13/87
ANALYSIS DATE : 6/16/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
PCB-1016	ND	1
PCB-1221	ND	1
PCB-1232	ND	1
PCB-1242	ND	1
PCB-1248	ND	1
PCB-1254	ND	1
PCB-1260	ND	1

MATRIX INTERFERENCE

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD. **RECEIVING DATE** : 6/ 5/87
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

SAMPLE ID : ES-49-DC 6/3/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Silver	ND	0.01
Arsenic	ND	0.005
Barium	1.2	0.1
Cadmium	ND	0.01
Chromium	0.05	0.02
Mercury	ND	0.005
Nickel	ND	0.04
Lead	0.16	0.05
Selenium	ND	0.005

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36680
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-DC 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Ash Content	72	%	0.5
BTU	ND	BTU/Lb.	1000
Corrosivity	N/A		
Flash Point	>180	Deg. F	
Sulfide	ND	mg/kg	50
Total Solids	73	%	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36681
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-11 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36682
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-12 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 624 VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/16/87
ANALYSIS DATE : 6/17/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
Benzene	ND	1
Bromodichloromethane	ND	1
Bromoform	ND	1
Bromomethane	ND	1
Carbon tetrachloride	ND	1
Chlorobenzene	ND	1
Chloroethane	ND	1
2-Chloroethylvinyl ether	ND	1
Chloroform	ND	1
Chloromethane	ND	1
Dibromochloromethane	ND	1
1,2-Dichlorobenzene	ND	1
1,3-Dichlorobenzene	ND	1
1,4-Dichlorobenzene	ND	1
1,1-Dichloroethane	ND	1
1,2-Dichloroethane	ND	1
1,1-Dichloroethene	ND	1
trans-1,2-Dichloroethene	ND	1
1,2-Dichloropropane	ND	1
cis-1,3-Dichloropropene	ND	1
trans-1,3-Dichloropropene	ND	1
Ethylbenzene	ND	1
Methylene chloride	ND	1
1,1,2,2-Tetrachloroethane	ND	1
Tetrachloroethene	ND	1
Toluene	ND	1
1,1,1-Trichloroethane	ND	1
1,1,2-Trichloroethane	ND	1
Trichloroethene	ND	1
Trichlorofluoromethane	ND	1
Vinyl chloride	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/11/87
ANALYSIS DATE : 6/18/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
Acenaphthene	ND	10
Acenaphthylene	ND	10
Anthracene	ND	10
Benzidine	ND	50
Benzo(a)anthracene	ND	10
Benzo(b)fluoranthene	ND	10
Benzo(k)fluoranthene	ND	10
Benzo(ghi)perylene	ND	10
Benzo(a)pyrene	ND	10
Bis(2-chloroethoxy)methane	ND	10
Bis(2-chloroethyl)ether	ND	10
Bis(2-chloroisopropyl)ether	ND	10
Bis(2-ethylhexyl)phthalate	ND	10
4-Bromophenyl phenyl ether	ND	10
Butyl benzyl phthalate	ND	10
2-Chloronaphthalene	ND	10
4-Chlorophenyl phenyl ether	ND	10
Chrysene	ND	10
Dibenzo(a,h)anthracene	ND	10
Di-n-butyl phthalate	ND	10
1,2-Dichlorobenzene	ND	10
1,3-Dichlorobenzene	ND	10
1,4-Dichlorobenzene	ND	10
3,3'-Dichlorobenzidine	ND	10
Diethyl phthalate	ND	10
Dimethyl phthalate	ND	10
2,4-Dinitrotoluene	ND	10
2,6-Dinitrotoluene	ND	10
Di-n-octyl phthalate	ND	10
Fluoranthene	ND	10
Fluorene	ND	10
Hexachlorobenzene	ND	10
Hexachlorobutadiene	ND	10
Hexachlorocyclopentadiene	ND	10
Hexachloroethane	ND	10
Indeno(1,2,3-CD)pyrene	ND	10
Isophorone	ND	10
Naphthalene	ND	10
Nitrobenzene	ND	10
N-Nitrosodimethylamine	ND	10
N-Nitrosodiphenylamine	ND	10
N-Nitrosodi-n-propylamine	ND	10
Phenanthrene	ND	10
Pyrene	ND	10
1,2,4,Trichlorobenzene	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 ACID ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

ANALYSIS DATE : 6/18/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

	RESULT (mg/kg)	DETECTION LIMIT
4-Chloro-3-methylphenol	ND	10
2-Chlorophenol	ND	10
2,4-Dichlorophenol	ND	10
2,4-Dimethylphenol	ND	10
2,4-Dinitrophenol	ND	50
2-Methyl-4,6-dinitrophenol	ND	50
2-Nitrophenol	ND	10
4-Nitrophenol	ND	50
Pentachlorophenol	ND	50
Phenol	ND	10
2,4,6-Trichlorophenol	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC PESTICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/22/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
Lindane	ND	0.1
Chlordane	ND	0.5
Endrin	ND	0.1
Heptachlor	ND	0.05
Heptachlor Epoxide	ND	0.05
Toxaphene	ND	1
Methoxychlor	ND	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC HERBICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87
EXTRACTION DATE : 6/19/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
2,4-D	ND	1
Silvex	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD. **RECEIVING DATE** : 6/ 5/87
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Silver	ND	0.01
Arsenic	ND	0.005
Barium	0.8	0.1
Cadmium	ND	0.01
Chromium	0.36	0.02
Mercury	ND	0.005
Nickel	ND	0.04
Lead	0.08	0.05
Selenium	ND	0.005

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 1139-36683
SAMPLE MATRIX : SOIL

RECEIVING DATE : 6/ 5/87

SAMPLE ID : ES-49-SC (COMPOSITE OF ES-49-11 THRU 12) 6/3/87

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Corrosivity	N/A		
Flash Point	>180	Deg. F	
Sulfide	140	mg/kg	50
Total Solids	70	%	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

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ANALYTICAL REPORT

Presented to:

Dr. Richard Prober

of

Engineering Science

WADSWORTH/ALERT LABORATORIES, INC.

Robert E. George

Robert E. George
Technical Director & General Manager

July 7, 1987

CORPORATE AND LABORATORY: Canton, Ohio (216) 454-5809
LABORATORY: Cleveland, Ohio (216) 642-9151
LABORATORY: Bartow, Florida (813) 533-2150
SOUTHEAST REGIONAL OFFICE: Lexington, South Carolina (803) 957-6590
24-HOUR ALERT LINE: (216) 454-8304

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87

SAMPLE ID : 45-COMP

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	ND	mg/kg	0.10
Flash Point	NA		
Sulfide	ND	mg/kg	10
pH	11.0	S.U.	

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8240 VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/ 9/87
ANALYSIS DATE : 6/10/87

SAMPLE ID : 45-COMP

	RESULT (mg/kg)	DETECTION LIMIT
Benzene	ND	1
Bromodichloromethane	ND	1
Bromoform	ND	1
Bromomethane	ND	1
Carbon tetrachloride	ND	1
Chlorobenzene	ND	1
Chloroethane	ND	1
2-Chloroethylvinyl ether	ND	1
Chloroform	ND	1
Chloromethane	ND	1
Dibromochloromethane	ND	1
1,2-Dichlorobenzene	ND	1
1,3-Dichlorobenzene	ND	1
1,4-Dichlorobenzene	ND	1
1,1-Dichloroethane	ND	1
1,2-Dichloroethane	ND	1
1,1-Dichloroethene	ND	1
trans-1,2-Dichloroethene	ND	1
1,2-Dichloropropane	ND	1
cis-1,3-Dichloropropene	ND	1
trans-1,3-Dichloropropene	ND	1
Ethylbenzene	ND	1
Methylene chloride	ND	1
1,1,2,2-Tetrachloroethane	ND	1
Tetrachloroethene	ND	1
Toluene	ND	1
1,1,1-Trichloroethane	ND	1
1,1,2-Trichloroethane	ND	1
Trichloroethene	ND	1
Trichlorofluoromethane	ND	1
Vinyl chloride	ND	1

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/17/87
ANALYSIS DATE : 7/ 2/87

SAMPLE ID : 45-COMP

	RESULT (mg/kg)	DETECTION LIMIT
Acenaphthene	ND	2
Acenaphthylene	ND	2
Anthracene	ND	2
Benzidine	ND	10
Benzo(a)anthracene	ND	2
Benzo(b)fluoranthene	ND	2
Benzo(k)fluoranthene	ND	2
Benzo(ghi)perylene	ND	2
Benzo(a)pyrene	ND	2
Bis(2-chloroethoxy)methane	ND	2
Bis(2-chloroethyl)ether	ND	2
Bis(2-chloroisopropyl)ether	ND	2
Bis(2-ethylhexyl)phthalate	ND	2
4-Bromophenyl phenyl ether	ND	2
Butyl benzyl phthalate	ND	2
2-Chloronaphthalene	ND	2
4-Chlorophenyl phenyl ether	ND	2
Chrysene	ND	2
Dibenzo(a,h)anthracene	ND	2
Dibenzofuran	ND	2
Di-n-butyl phthalate	ND	2
1,2-Dichlorobenzene	ND	2
1,3-Dichlorobenzene	ND	2
1,4-Dichlorobenzene	ND	2
3,3'-Dichlorobenzidine	ND	10
Diethyl phthalate	ND	2
Dimethyl phthalate	ND	2
2,4-Dinitrotoluene	ND	2
2,6-Dinitrotoluene	ND	2
Di-n-octyl phthalate	ND	2
Fluoranthene	ND	2
Fluorene	ND	2
Hexachlorobenzene	ND	2
Hexachlorobutadiene	ND	2
Hexachlorocyclopentadiene	ND	2
Hexachloroethane	ND	2
Indeno(1,2,3-CD)pyrene	ND	2

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491

SAMPLE ID : 45-COMP

	RESULT (mg/kg)	DETECTION LIMIT
Isophorone	ND	2
2-Methylnaphthalene	ND	2
Naphthalene	ND	2
Nitrobenzene	ND	2
N-Nitrosodimethylamine	ND	2
N-Nitrosodiphenylamine	ND	2
N-Nitrosodi-n-propylamine	ND	2
Phenanthrene	ND	2
Pyrene	ND	2
1,2,4,Trichlorobenzene	ND	2

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 ACID ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/17/87
ANALYSIS DATE : 7/ 2/87

SAMPLE ID : 45-COMP

	RESULT (mg/kg)	DETECTION LIMIT
4-Chloro-3-methylphenol	ND	2
2-Chlorophenol	ND	2
2,4-Dichlorophenol	ND	2
2,4-Dimethylphenol	ND	2
2,4-Dinitrophenol	ND	10
2-Methyl-4,6-dinitrophenol	ND	10
2-Nitrophenol	ND	2
4-Nitrophenol	ND	10
Pentachlorophenol	ND	10
Phenol	ND	2
2,4,6-Trichlorophenol	ND	2

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8080 PCB ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/ 8/87
ANALYSIS DATE : 6/ 8/87

SAMPLE ID : 45-COMP

	RESULT (mg/kg)	DETECTION LIMIT
PCB-1016	ND	10
PCB-1221	ND	10
PCB-1232	ND	10
PCB-1242	ND	10
PCB-1248	ND	10
PCB-1254	ND	10
PCB-1260	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

LAND DISPOASL CHARACTERISTIC PESTICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/12/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : 45-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
Lindane	ND	0.1
Endrin	ND	0.1
Toxaphene	ND	3
Methoxychlor	ND	0.5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

LAND DISPOSAL CHARACTERISTIC HERBICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/12/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : 45-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
2,4-D	ND	3
Silvex	ND	3

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87

SAMPLE ID : 45-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Arsenic	ND	0.005
Barium	0.3	0.1
Cadmium	ND	0.01
Chromium	13	0.02
Lead	ND	0.05
Mercury	ND	0.005
Selenium	ND	0.005
Silver	ND	0.01

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19491
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87

SAMPLE ID : 45-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Nickel	ND	0.04

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87

SAMPLE ID : 2B-COMP

PARAMETER	RESULT	UNITS	DETECTION LIMIT
Cyanide	1.04	mg/kg	0.10
Flash Point	NA		
Sulfide	ND	mg/kg	10
pH	7.4	S.U.	

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8240 VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/ 9/87
ANALYSIS DATE : 6/10/87

SAMPLE ID : 2B-COMP

	RESULT (mg/kg)	DETECTION LIMIT
Benzene	ND	30
Bromodichloromethane	ND	30
Bromoform	ND	30
Bromomethane	ND	30
Carbon tetrachloride	ND	30
Chlorobenzene	ND	30
Chloroethane	ND	30
2-Chloroethylvinyl ether	ND	30
Chloroform	ND	30
Chloromethane	ND	30
Dibromochloromethane	ND	30
1,2-Dichlorobenzene	ND	30
1,3-Dichlorobenzene	ND	30
1,4-Dichlorobenzene	ND	30
1,1-Dichloroethane	ND	30
1,2-Dichloroethane	ND	30
1,1-Dichloroethene	ND	30
trans-1,2-Dichloroethene	ND	30
1,2-Dichloropropane	ND	30
cis-1,3-Dichloropropene	ND	30
trans-1,3-Dichloropropene	ND	30
Ethylbenzene	ND	30
Methylene chloride	ND	30
1,1,2,2-Tetrachloroethane	ND	30
Tetrachloroethene	ND	30
Toluene	ND	30
1,1,1-Trichloroethane	ND	30
1,1,2-Trichloroethane	ND	30
Trichloroethene	ND	30
Trichlorofluoromethane	ND	30
Vinyl chloride	ND	30

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

OTHER COMPOUNDS PRESENT

COMPANY : Engineering-Science, Inc.
SAMPLE ID : 2B-COMP
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID
RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/ 9/87
ANALYSIS DATE : 6/10/87

MS/DS Identified Non-regulated Compounds With Their Estimated Concentrations

Dimethyl octatriene	3500	mg/kg
Methylene dimethyl bicycloheptane	900	mg/kg

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/17/87
ANALYSIS DATE : 7/ 2/87

SAMPLE ID : 2B-COMP

	RESULT (mg/kg)	DETECTION LIMIT
Acenaphthene	130	50
Acenaphthylene	ND	50
Anthracene	350	50
Benzidine	ND	250
Benzo(a)anthracene	370	50
Benzo(b)fluoranthene	670	50
Benzo(k)fluoranthene	ND	50
Benzo(ghi)perylene	120	50
Benzo(a)pyrene	160	50
Bis(2-chloroethoxy)methane	ND	50
Bis(2-chloroethyl)ether	ND	50
Bis(2-chloroisopropyl)ether	ND	50
Bis(2-ethylhexyl)phthalate	ND	50
4-Bromophenyl phenyl ether	ND	50
Butyl benzyl phthalate	ND	50
2-Chloronaphthalene	ND	50
4-Chlorophenyl phenyl ether	ND	50
Chrysene	520	50
Dibenzo(a,h)anthracene	ND	50
Dibenzofuran	320	50
Di-n-butyl phthalate	ND	50
1,2-Dichlorobenzene	ND	50
1,3-Dichlorobenzene	ND	50
1,4-Dichlorobenzene	ND	50
3,3'-Dichlorobenzidine	ND	250
Diethyl phthalate	ND	50
Dimethyl phthalate	ND	50
2,4-Dinitrotoluene	ND	50
2,6-Dinitrotoluene	ND	50
Di-n-octyl phthalate	ND	50
Fluoranthene	960	50
Fluorene	140	50
Hexachlorobenzene	ND	50
Hexachlorobutadiene	ND	50
Hexachlorocyclopentadiene	ND	50
Hexachloroethane	ND	50
Indeno(1,2,3-CD)pyrene	200	50

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 SEMI-VOLATILE ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492

SAMPLE ID : 2B-COMP

	RESULT (mg/kg)	DETECTION LIMIT
Isophorone	ND	50
2-Methylnaphthalene	280	50
Naphthalene	410	50
Nitrobenzene	ND	50
N-Nitrosodimethylamine	ND	50
N-Nitrosodiphenylamine	ND	50
N-Nitrosodi-n-propylamine	ND	50
Phenanthrene	2200	50
Pyrene	1000	50
1,2,4,Trichlorobenzene	ND	50

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

OTHER COMPOUNDS PRESENT

COMPANY : Engineering-Science, Inc.
SAMPLE ID : 2B-COMP
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID
RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/17/87
ANALYSIS DATE : 7/ 2/87

MS/DS Identified Non-regulated Compounds With Their Estimated Concentrations

Bicyclo trimethyl hepane	530	mg/kg
Methyl naphthalene	140	mg/kg
Methyl phenanthrene	110	mg/kg
Fluorenone	230	mg/kg
Carbazole	180	mg/kg
Octaphenanthrene carboxylic acid	170	mg/kg
Unknown (4 peaks)	1300	mg/kg

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8270 ACID ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/17/87
ANALYSIS DATE : 7/ 2/87

SAMPLE ID : 2B-COMP

	RESULT (mg/kg)	DETECTION LIMIT
4-Chloro-3-methylphenol	ND	50
2-Chlorophenol	ND	50
2,4-Dichlorophenol	ND	50
2,4-Dimethylphenol	ND	50
2,4-Dinitrophenol	ND	250
2-Methyl-4,6-dinitrophenol	ND	250
2-Nitrophenol	ND	50
4-Nitrophenol	ND	250
Pentachlorophenol	ND	250
Phenol	ND	50
2,4,6-Trichlorophenol	ND	50

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

METHOD 8080 PCB ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/ 8/87
ANALYSIS DATE : 6/ 8/87

SAMPLE ID : 2B-COMP

	RESULT (mg/kg)	DETECTION LIMIT
PCB-1016	ND	10
PCB-1221	ND	10
PCB-1232	ND	10
PCB-1242	ND	10
PCB-1248	ND	10
PCB-1254	ND	10
PCB-1260	ND	10

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

LAND DISPOASL CHARACTERISTIC PESTICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/12/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : 2B-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
Lindane	ND	3
Endrin	ND	5
Toxaphene	ND	25
Methoxychlor	ND	5

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

LAND DISPOSAL CHARACTERISTIC HERBICIDE COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc.
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

RECEIVING DATE : 5/29/87
EXTRACTION DATE : 6/12/87
ANALYSIS DATE : 6/23/87

SAMPLE ID : 2B-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

	RESULT (ug/L)	DETECTION LIMIT
2,4-D	ND	14
Silvex	ND	14

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc. **RECEIVING DATE** : 5/29/87
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

SAMPLE ID : 2B-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Silver	ND	0.01
Arsenic	0.007	0.005
Barium	0.4	0.1
Cadmium	0.09	0.01
Chromium	0.50	0.02
Mercury	ND	0.005
Lead	1.0	0.05
Selenium	ND	0.005

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

TOXICITY CHARACTERISTIC METAL COMPOUNDS ANALYTICAL REPORT

COMPANY : Engineering-Science, Inc. **RECEIVING DATE :** 5/29/87
LABORATORY ID : 2372-19492
SAMPLE MATRIX : SOLID

SAMPLE ID : 2B-COMP

Analysis performed in accordance with USEPA Toxic Characteristic Leachate Procedure.

ELEMENT	RESULT (mg/L)	DETECTION LIMIT
Nickel	0.16	0.04

ND - NONE DETECTED

WADSWORTH/ALERT LABS
P. O. BOX 208
CANTON, OH 44701
(216) 454-8304

CHAIN-OF—CUSTODY RECORD

№ 1725

PROJECT LOCATION	NAME OF CLIENT	PROJECT TELEPHONE NO	PROJECT NUMBER
TAPCO SITE	[illegible]		[illegible]

ITEM NUMBER	SAMPLE NUMBER	NUMBER & SIZE OF CONTAINERS	DESCRIPTION	TRANSFER NUMBER & CHECK 1	2	3	4	5	6	7
1	[illegible]	15 JARS	[illegible]							
	45-1A 1W									
	45-8A 2F									
	45-5A 2W									
	45-15A 3F									
	45-15A 3W									
	45-7A-4									
	45-1B 1F									
	45-11B-1W									
	45-8B-2F									
	45-14B 3F									
	45-14B 3W									
	45-12B 4F									
	45-5B-5									
	45-4B 6F									
2	[illegible]	BAGS ~~JARS~~	[illegible]							
	[illegible]									
	[illegible]									
	[illegible]									
	[illegible]									
	[illegible]									
	[illegible]									
	[illegible]									

Person Responsible for sample	Affiliation	Date	Time

Purpose of analysis (use back of front sheet if necessary)

[illegible]

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY	DATE	TIME
1	1 & 2	[illegible]	[illegible]	5-29-87	15:00
2					
3					
4					
5					

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consulting, mobile labs

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LABORATORY
1600 Fourth Street, S.E.
P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

SOUTHEASTERN
REGIONAL OFFICE
744 Sunset Boulevard
West Columbia, SC 29169
(803) 794-6251

REGIONAL
LABORATORY
Route 3 – Box 235
Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

ANALYTICAL RESULTS

ENGINEERING SCIENCE, LTD
CLEVELAND, OHIO

Presented to:

Richard Prober

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph.D.
Vice President & Director General Laboratory Program

May 13, 1986

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #1
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4' 9¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #2
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4' 4½"

AL...VU...H/...ER... LAL...
...). BOX 208
...NTON, OH 44701
...5) 454-8304

CHAIN-OF—CUSTODY RECORD

№ 785

PROJECT LOCATION	NAME OF CLIENT	PROJECT TELEPHONE NO	PROJECT NUMBER
TRW - Cleveland, OHIO	Engineering - Science	2164869005	CL021

ITEM NUMBER	SAMPLE NUMBER	NUMBER & SIZE OF CONTAINERS	DESCRIPTION	TRANSFER NUMBER & CHECK 1	2	3	4	5	6	7
	W-1	1 liter	- Ground Water Samples - (Analyze For Cyanide)							
	W-2									
	W-3									
	W-4									
	W-5									

...son Responsible for sample	Affiliation	Date	Time
...Palombo	E-S	10-9	5:00

...rpose of analysis (use back of front sheet if necessary)

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY	DATE	TIME
1	1	Steven A Einselen	Thomas C. Kelly Jr.		
2					
3					
4					
5					

ADSWORTH/ALERT LABS
O. BOX 208
ANTON, OH 44701
16) 454-8304

CHAIN-OF—CUSTODY RECORD

№ 785

PROJECT LOCATION	NAME OF CLIENT	PROJECT TELEPHONE NO	PROJECT NUMBER
TRW - Cleveland, OHIO	Engineering - Science	2164869005	CL021

ITEM NUMBER	SAMPLE NUMBER	NUMBER & SIZE OF CONTAINERS	DESCRIPTION	TRANSFER NUMBER & CHECK 1	2	3	4	5	6	7
	W-1	1 liter	- Ground Water Samples - (Analyze For Cyanide)							
	W-2									
	W-3									
	W-4									
	W-5									

erson Responsible for sample	Affiliation	Date	Time
K. Palombo	E-S	10-9	5:00

urpose of analysis (use back of front sheet if necessary)

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY	DATE	TIME
1	1	Steven A Eniselen	Thomas C. Kelly Jr.		
2					
3					
4					
5					

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #35
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.41 mg/kg	0.29 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #34
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.26 mg/kg	2.8 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'11 3/4"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #33
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'11 3/4"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #32
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'6"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #31
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	1.0 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'6"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #30
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'7¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #29
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	0.34 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'6½"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #28
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'8¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #27
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'8¼"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #26
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	2.1 mg/kg	0.47 mg/kg
Propyleneglycoldinitrate	89 mg/kg	<25 mg/kg

Length of core 4'

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #25
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	2.3 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'11"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #24
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 3'8 3/4"

WADSWORTH/ALERT
LABORATORIES, INC.

Company: Engineering-Science, Ltd.
Sample Identification: #23
Laboratory Identification: 2124-13240
Sample Matrix: Soil

Parameters	Top	Bottom
Total Cyanide	<0.25 mg/kg	<0.25 mg/kg
Propyleneglycoldinitrate	<25 mg/kg	<25 mg/kg

Length of core 4'1"

WADSWORTH/ALERT
LABORATORIES, INC.

Sampling, testing,
consulting, mobile labs

HEADQUARTERS AND
LABORATORY
1600 Fourth Street, S.E.
P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

SOUTHEASTERN
REGIONAL OFFICE
744 Sunset Boulevard
West Columbia, SC 29169
(803) 794-6251

REGIONAL
LABORATORY
Route 3 - Box 235
Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

ANALYTICAL REPORT

PROJECT NO. CL021

TRW-CLEVELAND BUILDING 49

Presented to :

KEVIN PALUMBO

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

10/ 6/86

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21133
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : W-1

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21134
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : W-2

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21135
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : W-3

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21136
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : W-4

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21137
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : W-5

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21138
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : SW-1

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4692-21139
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/17/86

SAMPLE ID : SW-2

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	0.24 mg/L	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT LABS
P. O. BOX 208
CANTON, OH 44701
(216) 454-8304

CHAIN-OF—CUSTODY RECORD

№ 807

PROJECT LOCATION	NAME OF CLIENT	PROJECT TELEPHONE NO	PROJECT NUMBER
TRW-Cleveland Building 49	Engineering Science	216 486-9005	CL021

ITEM NUMBER	SAMPLE NUMBER	NUMBER & SIZE OF CONTAINERS	DESCRIPTION	TRANSFER NUMBER & CHECK 1	2	3	4	5	6	7
1	W-1	1 l. Amber	WATER Samples TO BE ANALYZED FOR CN							
1	W-2	"								
1	W-3	"								
1	W-4	"								
1	W-5									
1	SW-1	1 l amber	water Samples to be analyzed For CN							
1	SW-2	1 l amber								

Person Responsible for sample	Affiliation	Date	Time
K. Palombo	ES	9/17	7:50 AM.

Purpose of analysis (use back of front sheet if necessary)

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY	DATE	TIME
1	1	Steven A. Eusebio	Brad Custer	9/17/86	4:35
2					
3					
4					
5					

WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing,
consulting, mobile labs

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P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

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744 Sunset Boulevard
West Columbia, SC 29169
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REGIONAL
LABORATORY
Route 3 - Box 235
Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

OCT 01 1986
CLEVELAND ES

ANALYTICAL REPORT

TRW SITE

Presented to :

RICHARD PROBER

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

9/30/86

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20633
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W1 (1-3.5') COMPLETE TUBE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20634
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W1 (3.5-4.5') COMPLETE TUBE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20641
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-4 (1-3.5') COMPLETE TUBE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20642
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-4 (3.5-5') COMPLETE TUBE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20635
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/24/86

SAMPLE ID : W2 (1-3') TOP 9"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20635
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W2 (1-3') TOP 9"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	2.0 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20636
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W2 (1-3') BOTTOM 9"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20636
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W2 (1-3') BOTTOM 9"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20637
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W2 (3-5') TOP 14"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20637
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W2 (3-5') TOP 14"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20638
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W2 (3-5') BOTTOM 14"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20638
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W2 (3-5') BOTTOM 14"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20639
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W-3 (3-5') TOP 9"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20639
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-3 (3-5') TOP 9"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	2.0 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20640
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W-3 (3-5') BOTTOM 9"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20640
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-3 (3-5') BOTTOM 9"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20643
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W-5 (1-3') COMPLETE TUBE

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20643
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-5 (1-3') COMPLETE TUBE

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.2 mg/kg	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20644
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W-5 (3-5') TOP 13"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20644
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-5 (3-5') TOP 13"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

VOLATILE COMPOUNDS ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20645
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86
EXTRACTION DATE : 9/24/86
ANALYSIS DATE : 9/25/86

SAMPLE ID : W-5 (3-5') BOTTOM 13"

PARAMETER	RESULT (mg/kg)	DETECTION LIMIT
Propylene Glycol Dinitrate	ND	125 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4571-20645
SAMPLE MATRIX : SOIL

RECEIVING DATE : 9/10/86

SAMPLE ID : W-5 (3-5') BOTTOM 13"

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.5 mg/kg

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

Sampling, testing,
consulting, mobile labs

HEADQUARTERS AND
LABORATORY
1600 Fourth Street, S.E.
P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

SOUTHEASTERN
REGIONAL OFFICE
744 Sunset Boulevard
West Columbia, SC 29169
(803) 794-6251

REGIONAL
LABORATORY
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Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

ANALYTICAL REPORT

TRW Cleveland
Bldg. 49 Site

Presented to:

Richard Prober

Engineering Science

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph.D.
Vice President & Director General Laboratory Program

September 5, 1986

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S3 0+70 X45E
Laboratory Identification: 4064-18996
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	9.5	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S4 0+75 X45E
Laboratory Identification: 4064-18997
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	0.95	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S8 0+70 X50E
Laboratory Identification: 4064-19001
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	13	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S12 0+70 X55E
Laboratory Identification: 4064-19005
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	15	mg/kg	0.50
Propylene Glycol Dinitrate *	480	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S13 0+75 X55E
Laboratory Identification: 4064-19006
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	6.3	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S14 0+60X60E
Laboratory Identification: 4064-19007
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	1.5	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S15 0+60X60E
Laboratory Identification: 4064-19008
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	0.90	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S16 0+70 X60E
Laboratory Identification: 4064-18990
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	2.0	mg/kg	0.50
Propylene Glycol Dinitrate *	800	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S18 Swale
Laboratory Identification: 4064-18992
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	18	mg/kg	0.50
Propylene Glycol Dinitrate *	240	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S20 Swale Bank
Laboratory Identification: 4064-18993
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	6.1	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S21 SWALE
Laboratory Identification: 4064-19009
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	14	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S22 SWALE BANK
Laboratory Identification: 4064-19010
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	4.7	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S23 SWALE BANK
Laboratory Identification: 4064-19011
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	1.1	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S25 0+70 X65E
Laboratory Identification: 4064-19013
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	3.8	mg/kg	0.50
Propylene Glycol Dinitrate *	ND	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S27 0+70 X70E
Laboratory Identification: 4064-19015
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	7.2	mg/kg	0.50
Propylene Glycol Dinitrate *	150	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S28 0+65 X70E
Laboratory Identification: 4064-19016
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	54	mg/kg	0.50
Propylene Glycol Dinitrate *	3,600	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S29 0+60 X70E
Laboratory Identification: 4064-19017
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	5.5	mg/kg	0.50
Propylene Glycol Dinitrate *	4,900	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: S30 0+60 X65E
Laboratory Identification: 4064-19018
Sample Matrix: Soil Cor
Site: TRW Cleveland, Bldg 49

Parameter	Concentration	Units	Detectable Limit
Cyanide	11	mg/kg	0.50
Propylene Glycol Dinitrate *	150	mg/kg	25

*
Extraction Date: 8/22/86
Analysis Date: 8/29/86

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OCT 30 1986
CLEVELAND ES

ANALYTICAL REPORT

PROJECT NO. CL021

TRW-CLEVELAND, OHIO

Presented to :

KEVIN PALOMBO

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

10/27/86

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5081-22662
SAMPLE MATRIX : WATER

RECEIVING DATE : 10/11/86

SAMPLE ID : W-1, TRW BLDG.49 (10/9/86)

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5081-22663
SAMPLE MATRIX : WATER

RECEIVING DATE : 10/11/86

SAMPLE ID : W-2, TRW BLDG.49 (10/9/86)

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5081-22664
SAMPLE MATRIX : WATER

RECEIVING DATE : 10/11/86

SAMPLE ID : W-3, TRW BLDG.49 (10/9/86)

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5081-22665
SAMPLE MATRIX : WATER

RECEIVING DATE : 10/11/86

SAMPLE ID : W-4, TRW BLDG.49 (10/9/86)

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 5081-22666
SAMPLE MATRIX : WATER

RECEIVING DATE : 10/11/86

SAMPLE ID : W-5, TRW BLDG.49 (10/9/86)

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

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ANALYTICAL REPORT

PROJECT NO. 66021

TRW-CLEVELAND BUILDING 49

Presented to :

KEVIN PALUMBO

ENGINEERING SCIENCE LTD.

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

10/ 6/86

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4814-21603
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/24/86

SAMPLE ID : (ACH-1) INFLOW TO SWAMP,TRW

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	ND	0.005 mg/L

ND - NONE DETECTED

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CHAIN-OF—CUSTODY RECORD

№ 1647

PROJECT LOCATION	NAME OF CLIENT	PROJECT TELEPHONE NO	PROJECT NUMBER
TRW, Build. 49, Cleveland	Engineering Science	216/486 9005	66021

ITEM NUMBER	SAMPLE NUMBER	NUMBER & SIZE OF CONTAINERS	DESCRIPTION	TRANSFER NUMBER & CHECK 1	2	3	4	5	6	7
1	ACH-1	1 liter AMBER	surface water samples of inflow and outflow from swamp near Build 49. To be analyzed for CN							
1	OFH-2	1 liter AMBER								

Person Responsible for sample	Affiliation	Date	Time
Kevin Palombo	ES	9/24	2:00

Purpose of analysis (use back of front sheet if necessary)

TRANSFER NUMBER	ITEM NUMBER	TRANSFERS RELINQUISHED BY	ACCEPTED BY	DATE	TIME
1	1	Steven A Eunselen	Alesia Dayford	9/24	5PM
2					
3					
4					
5					

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

COMPANY : ENGINEERING SCIENCE LTD.
LABORATORY ID : 4814-21604
SAMPLE MATRIX : WATER

RECEIVING DATE : 9/24/86

SAMPLE ID : (OFH-2) OUT FLOW FROM SWAMP,TRW

PARAMETER	RESULT	DETECTION LIMIT
Cyanide	1.3 mg/L	0.005 mg/L

ND - NONE DETECTED

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ANALYTICAL REPORT

SEP
CLEVELAND ES

TRW Cleveland
Bldg. 49 Site

Presented to:

Richard Prober

Engineering Science

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph.D.
Vice President & Director General Laboratory Program

September 4, 1986

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Waste Pile
Laboratory Identification: 4185-19312
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	1,100	mg/kg	125

WADSWORTH/ALERT
LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Storm Sewer #1
Laboratory Identification: 4185-19314
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	ND	mg/kg	125

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: CB #1
Laboratory Identification: 4185-19313
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	ND	mg/kg	125

ND = None Detected

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SOIL SAMPLE ANALYSES

PROPYLENE GLYCOL DINITRATE/CYANIDE

PRESENTED TO:

TRW

ANDY RESETAR

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director General Laboratory Program

December 23, 1985

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

WADSWORTH/ALERT
LABORATORIES, INC.

INTRODUCTION

This report includes the analytical results for samples submitted by Engineering Science for TRW, Cleveland. Each sample was analyzed for propylene glycol dinitrate, according to the GC method developed for Otto Fuel analysis, and for total cyanide using USEPA Method 9010.

The analyses revealed low levels of cyanide in several of the samples. Only three samples (B 103 A,B,C) contained any detectable amount of the propylene glycol dinitrate. The highest set of cyanide concentrations correspond to these three samples.

WADSWORTH/ALERT LABORATORIES, INC.

Company: TRW
Laboratory ID: 92557
Sample Matrix: Soils

Sample Identification					Total Cyanide	Propylene Glycol Dinitrate
B-101	10/28/85	2:40P	NE Corner Hand Auger/Core sample sediment		6.3 mg/kg	<300 mg/kg
B-102-A	10/28/85	3:00P	SW Portion of Swamp	0-1'	11.0	<300
B-102-B	10/28/85			1-2'	1.2	<300
B-102-C	10/28/85			2-3'	1.9	<300
B-103-A	10/28/85	3:30	@ discharge point into the swamp	0-1'	5.3	850
B-103-B	10/28/85			1-2'	11.0	720
B-103-C	10/28/85			2-3'	2.8	1300
B-104-A	10/28/85	4:00	@ eastern edge of swamp	0-1'	<0.25	<300
B-104-B	10/28/85			1-2'	<0.25	<300
B-104-C	10/28/85			2-3'	<0.25	<300

WADSWORTH/ALERT LABORATORIES, INC.

Company: TRW
Laboratory ID: 92557
Sample Matrix: Soils

Sample Identification					Total Cyanide	Propylene Glycol Dinitrate
B-105-A	10/28/85	4:30	@ southern edge of swamp	0-1'	<0.25 mg/kg	<300 mg/kg
B-105-B	10/28/85			1-2'	<0.25	<300
B-105-C	10/28/85			2-3'	<0.25	<300
B-106-A	10/28/85	4:45	@ central portion of swamp (between 103 & 105)	0-1'	0.87	<300
B-106-B	10/28/85			1-2'	<0.25	<300
B-106-C	10/28/85			2-3'	<0.25	<300
B-107	10/28/85	5:05	@ surface location 3' north of 101	Surface 2.0' from fence @ NE corner of test site	3.9	<300

WADSWORTH/ALERT LABORATORIES, INC.

6 / SAMPLING - Chain of Custody

CHAIN OF CUSTODY RECORD

PROJ. NO.: 80861.61

PROJECT NAME: TRW - Euclid Plant

SAMPLERS: (Signature) Dennis A. Palombo

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	REMARKS
B-101	10/29/85	2:40p		✓	NORTHEAST CORNER	1	HAND AUGER/CORE SAMPLE SEDIMENT
B-102	"	3:00		✓	SW portion of swamp	1	A-0.0 to 1.0' Depth (yellow-green)
	"			✓	"	1	B- 1.0' to 2.0' Depth
	"			✓	"	1	C- 2.0' to 3.0' Depth
B-103	"	3:30		✓	AT Discharge point into	1	A- 0.0' to 1.0' Depth (yellow-green)
	"			✓	the swamp	1	B- 1.0 to 2.0' Depth
	"			✓	"	1	C- 2.0 to 3.0' Depth
B-104	"	4:00		✓	AT EASTERN EDGE	1	A- 0.0' to 1.0' Depth
	"			✓	of swamp	1	B- 1.0 to 2.0' Depth
	"			✓	"	1	C- 2.0' to 3.0' Depth
B-105	"	4:30		✓	AT SOUTHERN EDGE	1	A- 0.0 to 1.0' Depth
	"			✓	of swamp	1	B- 1.0' to 2.0' Depth
	"			✓	"	1	C- 2.0' to 3.0' Depth

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Dennis A. Palombo	10/29/85 11:00AM	Richard Probes	Richard Probes	10/29/85 1:45	[illegible]
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature) D. Pohl	Date / Time 10/29 5:30PM	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

WADSWORTH/ALERT LABORATORIES, INC.

SAMPLING - Chain of Custody

CHAIN OF CUSTODY RECORD

PROJ. NO.: 8081.61

PROJECT NAME: TRW-EUCLID PLANT

SAMPLERS: (Signature) Dennis R Palombo

STA. NO.	DATE	TIME	COMP.	GRAB	STATION LOCATION	NO. OF CONTAINERS	REMARKS
B-106	10/28/85	4:45		✓	AT central portion of	1	A - 0.0' to 1.0' depth
				✓	swamp (between 103	1	B - 1.0' to 2.0' depth
				✓	and 105)	1	C - 2.0' to 3.0' depth
B-107	10/28/85	5:05		✓	AT surface located	1	Surface sample, 2.0' from fence
					3' north of 101		AT NE corner of TEST SITE

Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received by: (Signature)	Relinquished by: (Signature)	Date / Time	Received by: (Signature)
Relinquished by: (Signature)	Date / Time	Received for Laboratory by: (Signature) D. Pokl	Date / Time 10/29 5:30PM	Remarks	

Distribution: Original Accompanies Shipment; Copy to Coordinator Field Files

3 - 0605

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Storm Sewer #3
Laboratory Identification: 4185-19316
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	760	ug/L	60

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Storm Sewer #2
Laboratory Identification: 4185-19315
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	ND	ug/L	125

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Storm Sewer #6
Laboratory Identification: 4185-19318
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	ND	ug/L	80

ND = None Detected

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Storm Sewer #5
Laboratory Identification: 4185-19317
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	ND	mg/kg	125

ND = None Detected

ENGINEERING-SCIENCE

CHAIN OF CUSTODY RECORD

ES JOB NO. 66207

PROJECT NAME/LOCATION TRW-BLDG 49
23555 EUCLID AVE.
EUCLID, OHIO 44132

SAMPLER(S): (Signature) Mark W. [illegible] Ray Barnay

SHIP TO: WADSWORTH / ALERT
1600 FOURTH STREET, SE
P.O. BOX 208
CANTON, OHIO 44701

ANALYSES REQUIRED: PCDN by Acetone Extract and GC

DATE	TIME	SAMPLE DESCRIPTION	NO. OF CONTAINERS	PCDN by Acetone Extract and GC	REMARKS
8/15	P.M.	WASTE PILE (TWO BOTTLES)	2	✓	LEAVES AND DEBRIS (PLEASE COMPOSITE)
8/15	P.M.	CB #1	1	✓	PLEASE FILTER
8/15	P.M.	Storm Sewer #1	1	✓	" "
8/15	P.M.	Storm Sewer #2	1	✓	" "
8/15	P.M.	Storm Sewer #3	1	✓	" "
8/15	P.M.	Storm Sewer #5	1	✓	" "
8/15	P.M.	Storm Sewer #6	1	✓	" "
8/15	P.M.	Storm Sewer #7	1	✓	" "

Relinquished by: (Signature)	Date/Time	Received by: (Signature)
Mark W. [illegible]	8/15 4:30 P.M.	Carol Hanlon 8/18/86
Relinquished by: (Signature)	Date/Time	Received for Laboratory by: (Signature)

Relinquished by: (Signature)	Date/Time	Received by: (Signature)
	Date/Time	Remarks

WADSWORTH/ALERT
LABORATORIES, INC.

ANALYTICAL REPORT

Company: Engineering Science
Sample Identification: Storm Sewer #7
Laboratory Identification: 4185-19319
Sample Matrix: Liquid
Site: TRW-Euclid, Bldg 49

Extraction Date: 8/22/86
Analysis Date: 8/29/86

Parameter	Concentration	Units	Detectable Limit
Propylene Glycol Dinitrate	ND	mg/kg	125

ND = None Detected

ES ENGINEERING-SCIENCE

19101 VILLAVIEW ROAD, SUITE 301 • CLEVELAND, OHIO 44119 • 216/486-9005

TELEX: 98-0713

8512CDC31:53

27 December, 1985

Wadsworth Alert Laboratories, Inc.
1600 Fourth Street
P.O. Box 208
Canton, Ohio 44707

Attention: Dr. Marvin W. Stephens
Vice President and Director

Dear Dr. Stephens:

This is with reference to the recent Soil Sample Analysis for TRW.

It is important to verify that no other organic materials related to the propylene glycol dinatrate were detected. Please review the chromatograms for any possible unidentified peaks which amounted to ten times background detector signal level at the same elution time.

Your assistance in this matter is appreciated.

Very truly yours,

Richard Prober

Richard Prober
Senior Engineer

RP/cq

cc: A.L. Resetar, TRW

WADSWORTH/ALERT
LABORATORIES, INC.
Sampling, testing,
consulting, mobile labs

1600 Fourth Street, S.E. / P.O. Box 208 / Canton, OH 44701 / (216) 454-5809

HEADQUARTERS AND
LABORATORY
1600 Fourth Street, S.E.
P.O. Box 208
Canton, OH 44701
(216) 454-5809

LABORATORY
2121 Fourth Street, S.E.
Canton, OH 44701
(216) 454-1703

SOUTHEASTERN
REGIONAL OFFICE
744 Sunset Boulevard
West Columbia, SC 29169
(803) 794-6251

REGIONAL
LABORATORY
Route 3 - Box 235
Bartow, FL 33830
(813) 533-2150
(Shipping address)
Avenue D North
Bartow Municipal Airport
Bartow, FL 33830

24-Hour ALERT line
(216) 454-8304
In Ohio Call:
800-544-5588

December 31, 1985

Engineering Science
19101 Villaview Road
Suite 301
Cleveland, Ohio 44119

Attn: Richard Prober

Dear Mr. Prober:

This is in reference to your request of evaluation of the chromatograms generated in the analysis of the soil samples from TRW for propylene glycol dinitrate.

All the chromatograms were reviewed. The only chromatogram that contained any significant peaks other than that reported was for sample B-101. This sample had some early eluting peaks, possibly due to a fuel oil type component.

I hope this information will clarify any questions you might have had.

Sincerely,

WADSWORTH/ALERT LABORATORIES, INC.

Marvin W. Stephens

Marvin W. Stephens, Ph. D.
Vice President & Director
General Laboratory Program

MWS/rlm

AMERICAN COUNCIL OF INDEPENDENT LABORATORIES, INC.

RECEIVED
SEP 26 1988
U. S. EPA, REGION V
SWB — PMS

BUILDING 49 STUDY

ASSESSMENT OF SOIL CONTAMINATION AND POTENTIAL CONTAMINANT MIGRATION

Prepared for TRW, INC.
Lyndhurst, Ohio

Modified

SEPTEMBER 1988

Submitted by

ENGINEERING-SCIENCE
19101 Villaview Road - Suite 301
Cleveland, Ohio 44119

889DDR/99:26

BUILDING 49 STUDY
ASSESSMENT OF SOIL CONTAMINATION AND POTENTIAL CONTAMINANT MIGRATION

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BUILDING 49 STUDY
ASSESSMENT OF SOIL CONTAMINATION AND POTENTIAL CONTAMINANT MIGRATION

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6	Generalized Water Level Elevation Map
7	Proposed Soil Removal and Remedial Actions

1. INTRODUCTION

TRW Inc., retained Engineering-Science (ES) to determine the extent of previously unsuspected discharges from the Building 49 Torpedo Test facilities. Soil sampling in support of this began in October 1985 and continued through several stages through October of 1986. TRW also authorized a coordinated assessment of potential effects of those discharges on surface water and ground water. This report summarizes the results of those studies and ES' recommendations for remedial action.

1.1 BACKGROUND AND SITE CONDITIONS

TRW Inc., conducted torpedo engine testing in Building 49, in the southeastern portion of its former TAPCO complex in Euclid, Ohio. Wastewater resulting from test firing activities has been discharged through a 1,000 gallon underground steel separator tank, which was designed to remove and collect liquid residues of the torpedo fuel. The overflow from this tank discharged through an underground pipeline onto the soil in an undeveloped area about 100 feet southeast from the building. Modifications of the facilities in Building 49 have been installed, and further discharges of the fuel residue have been eliminated. Torpedo testing activities are being transferred to new facilities elsewhere on the TAPCO complex.

The affected area is shown in relation to Building 49 in Figure 1 (See also appended Drawings 1 & 2). The now-discontinued discharges were released from an underground pipe in a flat undeveloped area to the southeast of Building 49, bounded on its north by the torpedo test area fence and by woods on its other sides. The former discharge area has typical swamp vegetation. Field activities have shown that the poor drainage is attributable to a layer of low permeability clay (10^{-6} to 10^{-8} cm/sec) which was found typically about 3 feet below the surface.

Run-on from the soil mound (explosion barrier for the torpedo testing) flows southeastward across the former discharge zone and drains southward through the runoff stream, as indicated on Drawing 2. Additional run-on from wooded areas to the north and east drains through the area immediately

to the southeast of the former discharge zone, and into the same runoff stream.

During the summer months, there was additional run-on due to daytime flows ofs 12-15 gpm city water through the Building 49 air conditioning unit, which discharged by pipeline in a wooded area to the northeast of the building. (Analysis of the air conditioner effluent showed no detectable concentrations of cyanides.)

The runoff stream flows southward through a wooded strip and emerges into a cleared area adjoining the roadway. A sorbent boom has been placed across the stream at the edge of the woods. From there, the stream discharges through a corrugated steel culvert (which is half filled with sediments), enters a drainage swale paralleling the roadway, then crosses under the roadway through a culvert, and discharges directly into a catch basin for the storm sewers. The 30-inch storm sewer serving the eastern part of the property proceeds westward about 300 ft to join other storm drains, and then along a northwesterly alignment to discharge into a culvert at the property line.

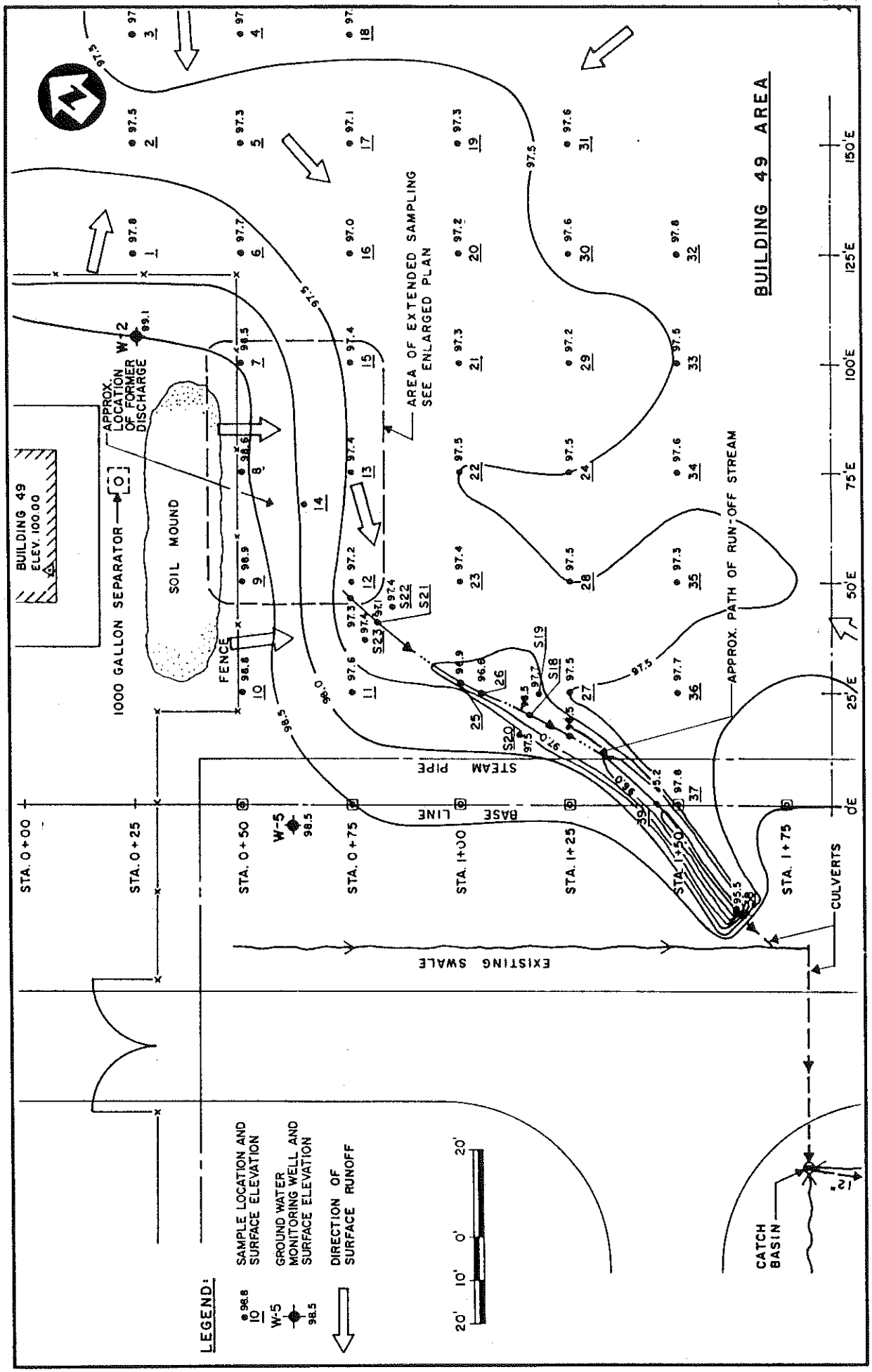
1.2 NATURE OF THE CHEMICALS DISCHARGED

The torpedo fuel, Otto Fuel II, is a liquid mixture consisting of about 76 percent propylene glycol dinitrate (PGDN), 22.5 percent di n-butyl sebacate and 1.5 percent 2-nitro diphenyl amine, which is stable at ambient pressures and temperatures. The fuel is heavier than water (specific gravity = 1.23) and is essentially immiscible with water. It is not volatile; the vapor pressure is 0.09 mm of mercury at 77°F.

Physical exposure by absorption through the skin or by ingestion is known to cause severe headaches, but definitive toxicity data are not available. Otto Fuel is considered hazardous, subject to liquid hazard classification Group 1 (combustible, but low fire hazard, with flash point 265°F) and compatibility Group G (not to be stored near other hazardous materials). [1] However, it is not flammable according to U.S. Department of Transportation or RCRA (Resource Conservation and Recovery Act) criteria since the flash point exceeds 140°F.

Wastewater discharges to the separator were intermittent, mainly in 200 to 300 gallon batches during and shortly after a torpedo test firing. Normally, the separator tank removed the liquid fuel residue effectively.

FIGURE 1


BUILDING 49 AREA
BUILDING 49
ELEV. 100.00
1000 GALLON SEPARATOR
APPROX. LOCATION OF FORMER DISCHARGE
W-2
SOIL MOUND
FENCE
AREA OF EXTENDED SAMPLING
SEE ENLARGED PLAN
APPROX. PATH OF RUN-OFF STREAM
STEAM PIPE
BASE LINE
W-5
STA. 0+00
STA. 0+25
STA. 0+50
STA. 0+75
STA. 1+00
STA. 1+25
STA. 1+50
STA. 1+75
CULVERTS
EXISTING SWALE
CATCH BASIN
LEGEND:
SAMPLE LOCATION AND SURFACE ELEVATION
GROUND WATER MONITORING WELL AND SURFACE ELEVATION
DIRECTION OF SURFACE RUNOFF
20' 10' 0' 20'
0E
25'E
50'E
75'E
100'E
125'E
150'E

2. METHODS OF CHEMICAL ANALYSIS

All samples in this study were transported to Wadsworth/Alert Laboratories, Canton, Ohio for analysis. Their reports are appended. Wadsworth has been designated by the U.S. Environmental Protection Agency (USEPA) as a Contract Laboratory Procedures facility for analysis of soil samples. Wadsworth has also been certified by the Ohio EPA for analysis of water and wastewater.

2.1 OTTO FUEL

The analysis for propylene glycol dinitrate (PGDN), the principal ingredient of Otto Fuel II, consisted of an acetone extraction followed by gas-liquid chromatography using a flame ionization detector. Otto Fuel II, nominally containing 76 percent PGDN, was used as a standard for calibration.

The detection limit for PGDN in a soil sample was 300 mg/kg for the initial sampling. This was improved to 25 mg/kg for the later soil samples and 125 mg/kg in a sample of suspect vegetation. The detection limit for PGDN in sediment samples varied from 60 to 80 ug/L (of unfiltered slurry), depending on sample size.

TRW authorized development of this analytical technique by Wadsworth, in conjunction with this study. The only other known analytical method is a wet-chemical technique [1], which has much higher detection limits.

2.2 CYANIDE

The cyanide analysis used the "total" cyanide technique (EPA Method 9010: acidification, volatilization and alkaline absorption), which is the standard for soil, sediment and solid waste samples. [2] The detection limit was 0.25 mg/kg of cyanide for soil samples and 0.005 mg/L for water samples. This method is quantitative for all forms of cyanide except the essentially non-toxic complexes of iron and cyanide.

2.3 SAMPLE PRESERVATION AND PREPARATION

Soil core samples were taken in carbon steel pipes, sealed at the site, and transported to the laboratory by Engineering-Science (ES). Chain-of-custody documentation was provided, although not formally required for the study.

Upon arrival at the laboratory, selected cores were cut to provide samples representing desired depth intervals. The soil core samples that were not analyzed initially were retained at the laboratory and stored in a cold room for possible later analysis, pending the results for other related samples.

3. DIRECTED SOIL SAMPLING PROGRAM

Soils in and near the former discharge area was sampled on four occasions between October 1985 and October 1986. The sample locations and analytical data are summarized in Table 1 and Figures 2 through 4 (Also see appended Drawings 3 through 5). The principal findings are as follows:

- An irregularly shaped area surrounding the former discharge pipe has Otto Fuel residue present at the surface (in the top 1 ft) at concentrations of 150 to 4,900 mg/kg of PGDN and Total Cyanide at concentrations of 5 to 50 mg/kg.

- PGDN was found at only one location below the top 1 ft., i.e., at the former discharge pipe outlet. Here, 80 mg/kg of PGDN was found in a composite sample from a 2 ft depth to the bottom of the core.

- At specific isolated locations in the runoff stream, 30 to 70 feet from the former discharge pipe, soil in the top 1 ft was found containing 89 to 240 mg/kg of PGDN and/or 5 to 20 mg/kg of Total Cyanide (See Figure 4 and appended Drawing 3).

- Cyanide was also found in the top 1 ft of soil at detectable, but low concentrations, typically 0.5 to 4 mg/kg, along a narrow belt of adjoining sampling stations, encircling Building 49 at distances of 75 to 300 ft. A clear zone, with cyanides below the detection limits, lies between Building 49 and this belt.

- Cyanide was detected below the top 1 ft of soil at or near the same sample locations (that had detectable cyanides in the top 1 ft), generally at lower concentrations than at the surface. However, three isolated sample locations along the belt of stations to the south and east of Building 49 had their highest cyanide concentrations (of 1.4 to 4 mg/kg) at the bottom.

It is believed that the Otto Fuel residue droplets settled rapidly after being released in the area near the former discharge pipe outlet and were absorbed by surface soil particles. Occasionally, isolated particles of soil were eroded, which mobilized small quantities of PGDN. However, cyanides in the torpedo test wastewater discharges, being soluble, spread over a larger area. Cyanides would be mobilized either by erosion or by leaching.

Cyanides in the belt to the south and east of Building 49 are attributed to deposition by downwash of exhaust gases vented during the torpedo testing.

A narrative of the soil sampling methods and the tentative findings at each stage follows.

3.1 OCTOBER 1985 SOIL SAMPLING

The initial sampling had as its objectives to confirm that discharges of torpedo fuel residue and cyanides had occurred, and to indicate whether either or both of these chemicals had spread away from the former discharge pipe. This sampling utilized hand augers and was limited to the top three feet. Some of the sample locations were ponded over at the time.

At the former discharge pipe, PGDN concentrations of 800 to 1,300 mg/kg were found, along with Total Cyanide at 3 to 1 mg/kg. Both chemicalsl were present in the samples representing the top 1 ft, the second 1 ft and the third 1 ft. This apparent vertical migration may have been due to movement of material from the surface into the lower samples, which could not have been prevented under the field conditions.

Cyanide was found at a location near the runoff stream, at concentrations of 11 mg/kg in the top 1 ft and at 1 to 2 mg/kg in the next 2 ft below that. Cyanide also was detected at 0.9 mg/kg in the top 1 ft at a location to the southeast of the former discharge pipe.

Samples also were collected at this time at two suspected spill locations at the northeast corner of the torpedo test complex. PGDN was not detected in either of these samples. However, cyanide was present at concentrations of 4 to 6 mg/kg.

3.2 MAY AND AUGUST 1986 SOIL SAMPLINGS

TRW authorized additional soil sampling and a survey of the area to define both the vertical and the lateral extent of soil contamination. In order to ensure personnel safety (See Appendix A, ES Health and Safety Report for this project), the sampling used a rig which could be operated some distance away from the former discharge area, on dry ground. The rig locations are noted on appended Drawing 1.

The sampling rig was a modified sheet piling driver, attached to a crane. Sample cores were obtained by driving a steam cleaned 10 foot length of 3-inch carbon steel pipe to refusal (typically 4 to 7 feet), withdrawing the pipe and sealing the ends. This effectively eliminated cross-contamination (between samples representing different depths). The core hole was refilled with powdered bentonite.

During the week of 31 March - 4 April 1986, 39 locations southeast of Building 49 were sampled, most of them within the ponded area, on the 25 ft center grid shown on Figure 1 and the appended drawings. Four of these samples (25, 26, 38 and 39) were from points in the runoff stream.

Concentrations of 1,600 mg/kg PGDN and 5.7 mg/kg CN were found at the surface near the former discharge pipe (Sample 14), confirming the previous results. However, neither chemical was detected in the bottom 1 ft of that sample core. PGDN was also found at a concentration of 89 mg/kg in the top 1 ft of sediments, at a pool in the runoff stream (Sample 26). Cyanide was detected at these points and at several other locations, either at the surface or at the bottom of the core.

During the 4-7 August 1986 period, 29 additional points (S-1 through S-29) were sampled, most of these being on a 5 ft center grid superimposed on the coarser grid in the vicinity of the former discharge pipe (See Figure 2 and the inset on appended Drawings 2 through 7). Two points in the runoff stream and four locations on the adjoining banks (S-18 through S-23) were included in this sampling. Selected cores were analyzed sequentially, starting with the top 1 ft section and in some cases continuing with the next lower 1 ft section and a composite of the remaining material below 2 ft.

PGDN and Cyanide were found in the top 1 ft at several sample locations near the former discharge pipe. PGDN concentrations there ranged from 150 to 3,900 mg/kg, and Cyanide ranged from 5 to 50 mg/kg. PGDN was

detected below the top 1 ft in only one of the sample cores (S-29), at the same location that had the highest surface PGDN concentration. Cyanide was detected below the top 1 ft at the locations near the former discharge pipe, at concentrations of about 1 mg/kg.

3.3 OCTOBER 1986 SOIL SAMPLING

Another nine soil core samples (T-3 through T-11) were collected on 16 October 1986, at locations on an extension of the 5 ft center grid eastward from the former discharge pipe (See Figure 2 and the inset on appended Drawings 2 through 7). These additional soil cores were collected by a modified Shelby Tube method, using 3 ft lengths of 2-inch black iron pipe threaded on one end. The pipe was driven into the ground with a sledge to a depth of 2-3 feet and manually withdrawn. The pipe ends were closed with plastic immediately after collection of the sample. The pipe was cleaned with detergent solution and pressurized water spray before sample collection.

Samples were analyzed from the four points closest to the August samples, abouts 20 ft to the east of the former discharge. PGDN was not detected in any of these cores. The cyanide concentrations were 5 to 15 mg/kg in the top 1 ft of soil, but less than 1 mg/kg for depths of 1 ft-2ft.

3.4 SEPTEMBER 1986 WELL INSTALLATION

Five wells were installed during the week of 5 to 8 September 1986, for the ground water monitoring activities discussed in Section 5. The wells were located 25 to 75 feet beyond the area of soil sampling of the former discharge area (See appended Drawing 1). During the well installation, the augers were cleaned between holes to eliminate cross-contamination. Undisturbed Shelby-tube samples of the unconsolidated sediments (W-1 through W-5) were obtained at shallow intervals. Generally, one tube was obtained for the 1 ft - 3 ft interval and another tube for the 3 ft - 5 ft interval.

All of the Shelby-tube samples were analyzed for Total Cyanide. It was found at the three northerly well locations, at concentrations of 1 to 2 mg/kg, at the 1 ft - 3 ft level. It was not detectd below that depth. Sediment samples from Wells W-2 and W-3 were also analyzed for PGDN, based

on the field observation that the silty clays just above bedrock appeared to be stained dark gray to black; the PGDN concentrations were below the detection limit of 25 mg/kg in both of those samples.

3.5 JUNE 1987 SOIL SAMPLING

Additional Shelby-tube soil sampling and laboratory analysis for cyanides was undertaken, to further define the extent of soils containing cyanides and to determine characteristics of the soil in the vicinity of Building 49, for purposes of treatment and disposal.

The soil samples at the former discharge pipe (C-13 through C-15) averaged 543 mg/kg PGDN and 17 mg/kg cyanides, similar in those noted in previous samplings. Priority pollutant organics and PCBs were not present at detectable concentrations.

Additional characteristics were determined for possible treatment of soil excavated from the former discharge area by incineration (to be followed by ultimate disposal of the resultant ash by landfilling). The observed high flash point (>180°F), low net heating value (<1,000 BTU/lb), high ash content (72 percent) and high solids content (73 percent) in discharge area samples were essentially the same as those of background soil samples taken further away from there.

The belt of detectable cyanides was found to continue on the north and west of Building 49, with concentrations of 0.5 to 2 mg/kg in the surface soils at distances up to 300 ft from the building (Sample Stations B-1 through B-4 and C-1 through C-12). However, the belt does not appear to extend into wooded land further to the east.

The soil mound south of Building 49 was also sampled and analyzed for cyanides. The concentration for a composite sample was below the detection limit of 0.25 mg/kg.

3.6 SPREADING OF PGDN AND CYANIDES FROM THE FORMER DISCHARGE AREA

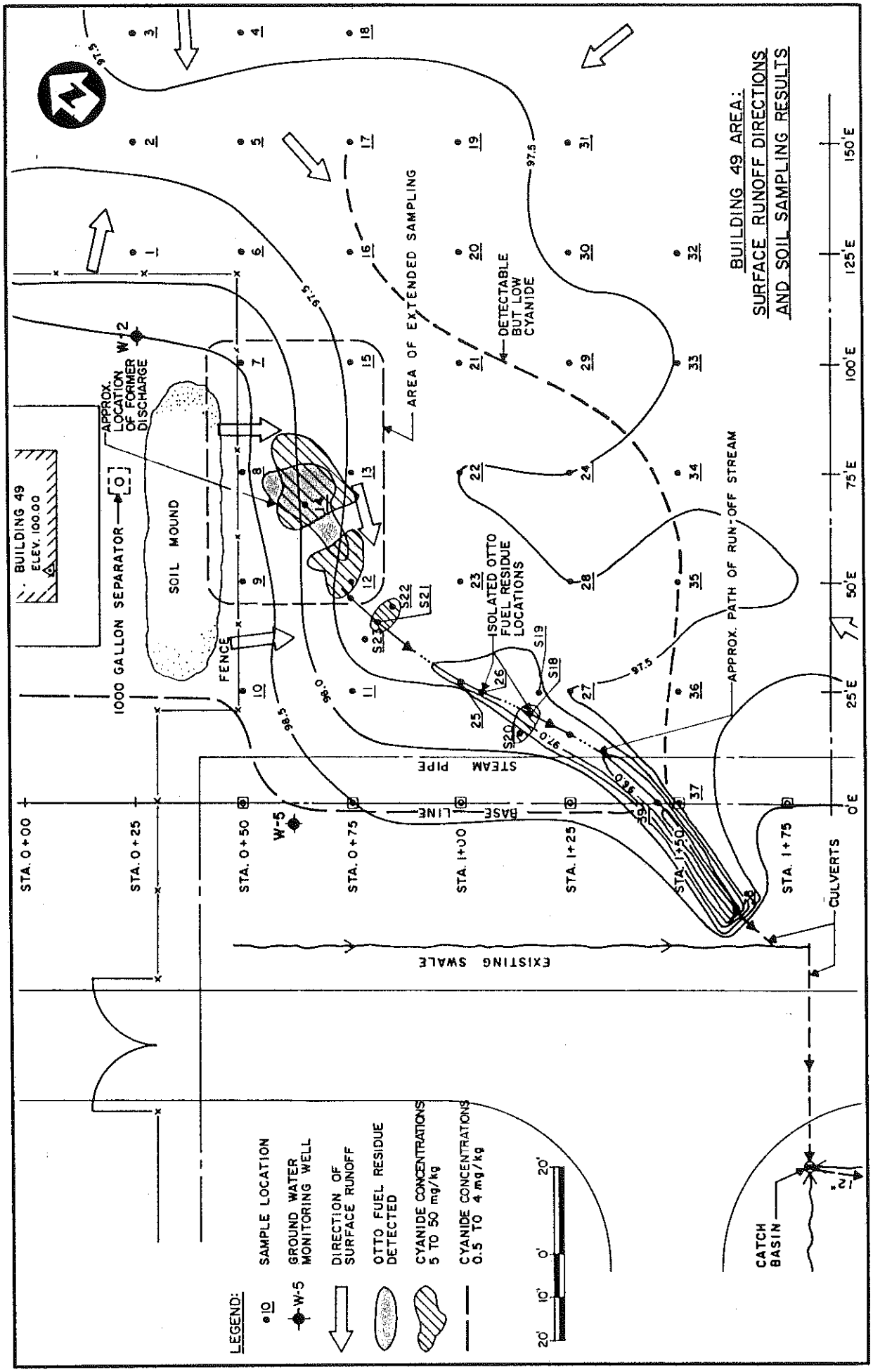
Figures 2 and 3 indicate the results of the soil sampling. The highest concentrations of Otto Fuel residue and cyanides are in an irregularly shaped area surrounding the former discharge pipe. Somewhat lower concentrations were found in the runoff stream, at specific isolated locations 30 to 70 feet away from there.

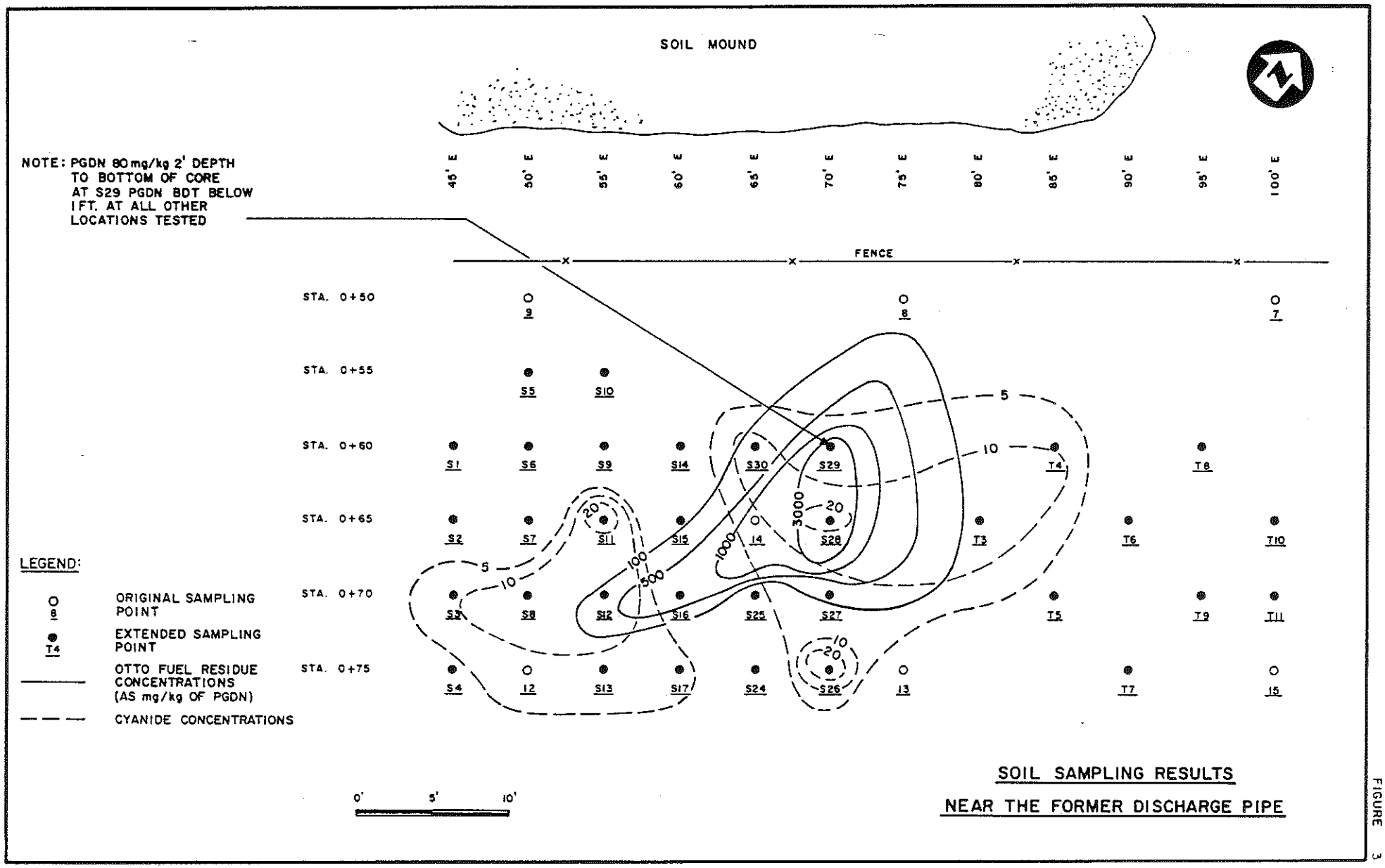
Detectable PGDN concentrations (solid lines in Figures 3) cover a portion of the area of highest concentrations, approximately on the path for drainage between the former discharge pipe and the runoff stream. It is believed that Otto Fuel residue droplets settled rapidly after discharge and were absorbed by surface soil particles. This essentially immobilized the water-immiscible fuel components, except for occasional isolated instances of erosion. Runoff from the soil mound to the northwest flowing directly over the discharge area could dislodge soil particles containing PGDN, carrying and depositing them into the runoff stream.

Detectable cyanide concentrations (dashed lines) near the former discharge pipe cover a larger area than PGDN. Soluble cyanides are spread over a larger area, having been mobilized either by erosion or by leaching. Cyanides also are subject to volatilization, chemical destruction and microbiological degradation, which may account for the bisection of the zones of high cyanide concentrations (5 to 50 mg/kg), at the former discharge area by a narrow belt of low cyanide concentrations.

Cyanide was also found at detectable, but low concentrations, typically about 1 mg/kg, along an encircling belt of adjoining sampling stations, 75 to 300 ft from Building 49. This is attributed to deposition of atmospheric cyanides by downwash of exhaust gas vented during the torpedo test firings. The cyanides at these locations would be subject to mobilization by leaching and to the degradation mechanisms noted above.

Subsurface cyanide concentrations generally decreased with depth below the surface and were found only at or adjoining locations with detectable surface cyanide concentrations. However, three isolated sample locations along the belt to the south and east of Building 49 had their highest cyanide concentrations (of 1.4 to 4 mg/kg) at the bottom of the soil core.


BUILDING 49 AREA:
SURFACE RUNOFF DIRECTIONS
AND SOIL SAMPLING RESULTS
BUILDING 49
ELEV. 100.00
1000 GALLON SEPARATOR
APPROX. LOCATION OF FORMER DISCHARGE
W-2
SOIL MOUND
FENCE
AREA OF EXTENDED SAMPLING
DETECTABLE BUT LOW CYANIDE
ISOLATED OTTO FUEL RESIDUE LOCATIONS
APPROX. PATH OF RUN-OFF STREAM
STEAM PIPE
BASE LINE
W-5
STA. 0+00
STA. 0+25
STA. 0+50
STA. 0+75
STA. 1+00
STA. 1+25
STA. 1+50
STA. 1+75
0'E
25'E
50'E
75'E
100'E
125'E
150'E
CULVERTS
EXISTING SWALE
CATCH BASIN
LEGEND:
SAMPLE LOCATION
GROUND WATER MONITORING WELL
DIRECTION OF SURFACE RUNOFF
OTTO FUEL RESIDUE DETECTED
CYANIDE CONCENTRATIONS 5 TO 50 mg/kg
CYANIDE CONCENTRATIONS 0.5 TO 4 mg/kg
20'
10'
0'
20'

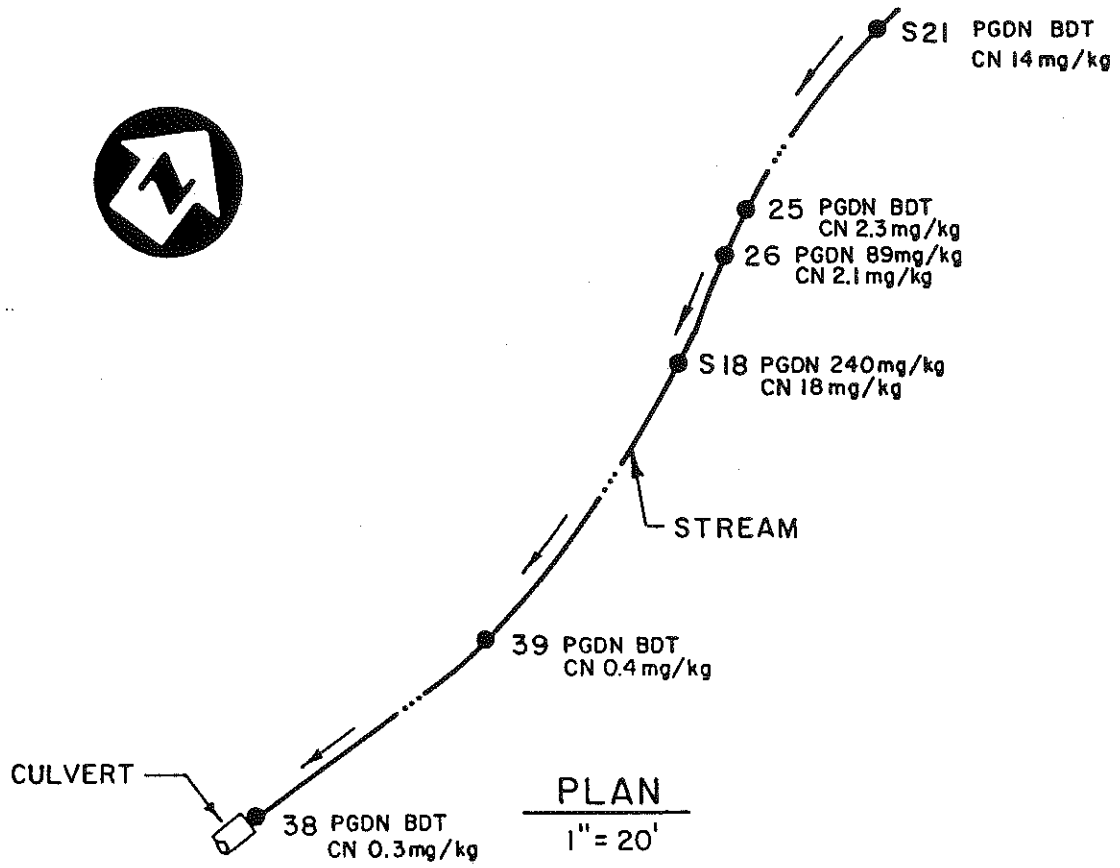


SOIL SAMPLING RESULTS
NEAR THE FORMER DISCHARGE PIPE

FIGURE 3

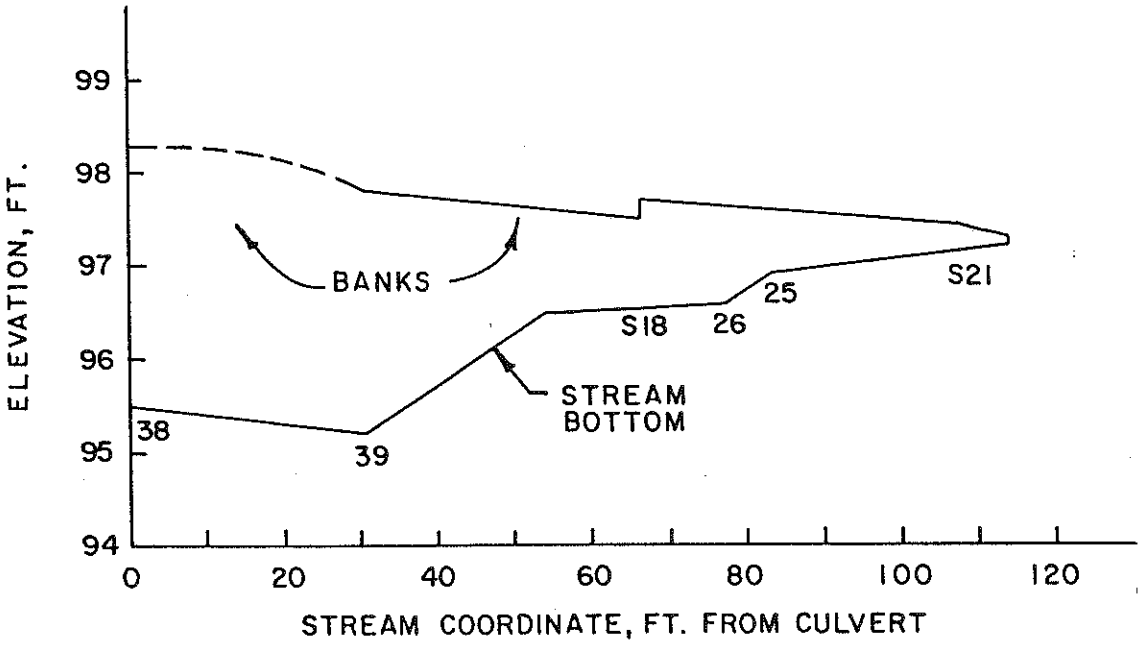
ES ENGINEERING-SCIENCE

FIGURE. 4



PLAN

1" = 20'



PROFILE

BUILDING 49 SOIL SAMPLING

RUNOFF STREAM PROFILE AND PLAN

Table 1

Summary of Building 49 Soil Sampling

Sample No.	Analytical Results (mg/kg) Top 1 ft CN	Top 1 ft PGDN	Bottom 1 ft CN	Bottom 1 ft PGDN	Locations(ft) Surface Elev.	Coordinates South	Coordinates East	Core Length (ft) as Driven	Core Length (ft) Compac -ted
1	BDT	BDT	BDT	BDT	97.8	25	125	5.7	4.8
2	BDT	BDT	BDT	BDT	97.5	25	150	5.3	4.4
3	BDT	BDT	BDT	BDT	97.6	25	175	4.9	5.0
4	BDT	BDT	BDT	BDT	97.7	50	175	4.5	3.8
5	BDT	BDT	BDT	BDT	97.3	50	150	4.7	4.1
6	BDT	BDT	BDT	BDT	97.7	50	125	5.3	5.2
7	BDT	BDT	BDT	BDT	98.5	50	100	6.3	4.7
8	BDT	BDT	BDT	BDT	98.6	50	75	5.9	4.0
9	BDT	BDT	BDT	BDT	98.9	50	50	6.4	4.8
10	1.2	BDT	BDT	BDT	98.8	50	25	5.7	3.8
11	0.8	BDT	BDT	BDT	97.6	75	25	4.9	4.5
12	7.4	BDT	BDT	BDT	97.2	75	50	5.3	4.6
13	0.9	BDT	BDT	BDT	97.4	75	75	4.9	3.9
14	5.7	1600	BDT	BDT	97.4	65	65	5.3	4.9
15	BDT	BDT	BDT	BDT	97.4	75	100	5.0	4.4
16	0.3	BDT	0.5	BDT	97.0	75	125	5.3	5.0
17	0.7	BDT	BDT	BDT	97.1	75	150	5.6	4.4
18	BDT	BDT	BDT	BDT	97.6	75	175	5.1	4.3
19	BDT	BDT	BDT	BDT	97.3	100	150	4.5	3.9
20	BDT	BDT	1.4	BDT	97.2	100	125	4.8	4.0
21	0.3	BDT	0.3	BDT	97.3	100	100	4.6	4.0
22	BDT	BDT	BDT	BDT	97.5	100	75	4.7	4.2
23	BDT	BDT	BDT	BDT	97.4	100	50	4.3	4.1
24	BDT	BDT	BDT	BDT	97.5	125	75	4.4	3.7
* 25	2.3	BDT	BDT	BDT	97.7	100	25	4.3	3.9
* 26	2.1	89	0.5	BDT	96.6	105	25	4.0	4.0
27	BDT	BDT	BDT	BDT	97.5	125	25	4.5	3.7
28	BDT	BDT	BDT	BDT	97.5	125	50	4.7	3.7
29	0.3	BDT	BDT	BDT	97.2	125	100	4.4	3.5
30	BDT	BDT	BDT	BDT	97.6	125	125	4.6	3.6
31	BDT	BDT	1.0	BDT	97.6	125	150	4.8	3.5
32	BDT	BDT	BDT	BDT	97.8	150	125	4.6	3.5
33	BDT	BDT	BDT	BDT	97.5	150	100	5.0	4.0
34	0.3	BDT	2.8	BDT	97.6	150	75	5.8	4.0
35	0.4	BDT	0.3	BDT	97.3	150	50	4.6	4.0
36	BDT	BDT	BDT	BDT	97.7	150	25	4.7	3.6
37	0.7	BDT	0.3	BDT	97.8	150	0	7.3	7.7
* 38	0.3	BDT	BDT	BDT	95.5	163	-25	4.8	4.6
* 39	0.4	BDT	3.9	BDT	95.2	145	0	5.6	4.8

* = stream sampling point -- = not analyzed
BDT = below detection limits: 0.25 mg/kg Total CN and 25 mg/kg PGDN
Datum for elevations 100.0 ft = floor level in Building 49

Table 1 (continued)

Summary of Building 49 Soil Sampling

Sample No.	Analytical Results (mg/kg) Top 1 ft CN	Top 1 ft PGDN	1 ft-2 ft CN	1 ft-2 ft PGDN	Below 2 ft CN	Below 2 ft PGDN	Locations (ft) Surface Elev.	Coordinates South	Coordinates East	Core Length (ft) as Driven	Core Length (ft) Compac-ted
S-1	--	--	--	--	--	--	97.6	60	45	6.0	4.8
S-2	4.3	--	--	--	--	--	97.4	65	45	5.8	5.3
S-3	9.5	BDT	4.3	--	--	--	97.2	70	45	5.2	4.8
S-4	0.95	BDT	1.4	--	--	--	97.2	75	45	5.3	4.8
S-5	--	--	--	--	--	--	98.1	55	50	6.2	4.3
S-6	--	--	--	--	--	--	97.6	60	50	5.6	4.8
S-7	1.4	BDT	--	--	--	--	97.3	65	50	5.5	4.8
S-8	13	BDT	1.5	BDT	--	--	97.2	70	50	5.8	4.8
S-9	1.5	BDT	--	--	--	--	97.5	60	55	6.2	5.0
S-10	--	--	--	--	--	--	98.1	55	55	7.7	7.7
S-11	26	BDT	--	--	--	--	97.3	65	55	5.7	4.7
S-12	15	480	1.2	BDT	--	--	97.3	70	55	5.0	4.4
S-13	6.3	BDT	1.5	BDT	--	--	97.3	75	55	5.2	4.8
S-14	1.5	BDT	0.74	BDT	--	--	97.6	60	60	5.7	4.0
S-15	0.9	BDT	0.61	BDT	--	--	97.3	65	60	5.6	5.0
S-16	2.0	800	0.58	BDT	--	--	97.3	70	60	5.6	4.6
S-17	6.0	BDT	--	--	--	--	97.4	75	60	5.1	4.1
* S-18	18	240	1.0	BDT	--	--	96.5	116	20	4.2	4.2
S-19	--	--	--	--	--	--	97.7	118	24	n/a	n/a
S-20	6.1	BDT	BDT	BDT	--	--	97.5	114	16	5.8	6.5
* S-21	14	BDT	2.1	--	--	--	97.1	81	42	4.9	4.0
S-22	4.7	BDT	1.4	--	--	--	97.4	84	45	5.2	4.9
S-23	1.1	BDT	0.81	--	--	--	97.4	78	38	4.4	4.1
S-24	1.1	BDT	--	--	--	--	97.1	75	65	5.0	4.4
S-25	3.8	BDT	0.52	BDT	--	--	97.3	70	65	5.2	4.2
S-26	40	BDT	--	--	--	--	97.4	75	70	5.2	4.8
S-27	7.2	150	--	BDT	--	--	97.3	70	70	5.7	5.2
S-28	54	3600	1.4	BDT	1.5	BDT	97.5	65	70	5.6	4.8
S-29	5.5	4900	0.77	BDT	BDT	80	97.7	60	70	6.2	5.9
S-30	11	150	0.73	BDT	--	--	97.6	60	65	6.0	5.4
T-3	14	BDT	0.66	BDT	--	--	97.5	65	80	>2.0	
T-4	9.1	BDT	BDT	BDT	--	--	97.6	60	85	>1.5	
T-5	4.7	BDT	0.54	BDT	--	--	97.3	70	85	>2.0	
T-6	--	BDT	--	BDT	--	--	97.5	65	90	>2.0	
T-7	1.2	BDT	0.93	BDT	--	--	97.5	75	90	>2.0	
T-8	--	BDT	--	BDT	--	--	97.7	60	95	>1.5	
T-9	--	BDT	--	BDT	--	--	97.2	70	95	>2.0	
T-10	--	BDT	--	BDT	--	--	97.6	65	100	>2.0	
T-11	--	BDT	--	BDT	--	--	97.6	70	100	>2.0	
W-1	--	--	BDT	--	BDT	--	97.7	198	123	4.5	
W-2	--	--	2.0	BDT	BDT	BDT	99.1	25	106	5.5	
W-3	--	--	--	--	2.0	BDT	98.9	-63	-5	6.0	
W-4	--	--	BDT	--	BDT	--	98.3	212	19	5.5	
W-5	--	--	1.2	BDT	BDT	BDT	98.5	63	-5	6.5	

* = stream sampling point -- = not analyzed n/a = core not recovered

BDT = below detection limits: 0.25 mg/kg Total CN and 25 mg/kg PGDN

Datum for elevations 100.0 ft = floor level in Building 49

Table 1 (cont'd)

Summary of Building 49 Soil Sampling

Sample No.	Analytical Results (mg/kg) Top 1 ft CN	Top 1 ft PGDN	1 ft- 2 ft CN	1 ft- 2 ft PGDN	Below 2 ft CN	Below 2 ft PGDN	Coordinates South	Coordinates East
B -1	BDT	--					-287	-139
B -2	1.9	--					-282	139
B -3	1.0	--					225	-10
B -4	BDT	--					229	181
C -1	1.5	--					-108	91
C -2	2.2	--					-245	100
C -3	2.4	--					-157	7
C -4	1.5	--					-132	-30
C -5	0.5	--					-18	-72
C -6	0.5	--					59	-105
C -7	BDT	--					-75	224
C -8	BDT	--					-126	200
C -9	BDT	--					0	237
C-10	BDT	--					-25	175
C-11	BDT	--					138	112
C-12	BDT	--					75	137
C-13	11	BDT					61	78
C-14	16	1300					70	56
C-15	23	330					66	66

-- = not analyzed Series B and C sampled only for top 1 ft.

BDT = below detection limits: 0.25 mg/kg Total CN and 25 mg/kg PGDN

4. SURFACE WATER STUDY

In August 1986, TRW authorized a study to assess potential migration of PGDN and Cyanide from the original affected area near Building 49 through surface water and ground water. This section deals with the assessment for surface water movement.

Table 2 summarizes the surface water monitoring and associated chemical analysis data. The principal findings with respect to surface water are as follows:

- Isolated and occasional soil particles containing Otto Fuel residue (mainly PGDN) have migrated out of the original affected area through the runoff stream and have entered the storm sewer system.
- The runoff stream also contains detectable, but low concentrations of Cyanide, typically not exceeding 1 mg/L.

Details follow on the studies that led to these findings.

4.1 SURFACE WATER RUNOFF MONITORING

The runoff stream flow exiting from the formerly swampy area south of Building 49 was monitored twice during September 1986, first during a low flow period after extended dry weather on 16 September, and a second time on 24 September, several hours after a moderate rain. The flow at the first culvert was measured with a portable weir on both occasions, and multiple grab samples were collected and field composited for Total Cyanide analysis. (The PGDN concentrations would have been below the detection limit of 25 mg/kg, since it is not miscible with water.)

The dry weather monitoring showed total flow of the runoff stream less than 3 gallons/day, but with a Total Cyanide concentration of 1.2 mg/L. After a moderate rainfall, the runoff stream flow was measured at about 1,760 gal/day, with a Total Cyanide concentration of 0.24 mg/L.

The Building 49 air conditioning discharge flow was also monitored on the same dates. At the entry to the pipeline that discharges the air conditioning effluent into the wooded area to the east of the building, the observed flows ranged from 13 to 15 gal/min (17,000 to 21,000 gal/day).

Grab samples from this stream did not contain Cyanides at detectable concentrations.

4.2 OTTO FUEL RESIDUE MIGRATION IN THE RUNOFF STREAM

The Surface Water Study provided additional evidence confirming that the occasional erosion of isolated soil particles containing Otto Fuel residue had carried them through the runoff stream.

TRW maintenance crews cleaned the runoff stream channel during the late fall of 1985. Leaves and debris removed from the stream in that operation were placed in the wooded area immediately to the west of Sample Location 11, between the former discharge area and the roadway (See Figure 1). A sample of this material was found to contain 1,100 mg/kg of PGDN. Such organic materials would be expected to absorb and retain PGDN effectively.

Sediment samples were collected on 15 August 1986, from the inverts of all accessible manholes in the storm sewer system downstream from the catch basin where the runoff stream enters. Manhole #3, some 300 ft westward from the catch basin which receives the runoff stream, was the only one of the sampling locations which had a sump bottom. Its sample contained 760 ug/L of PGDN, which is interpreted as the net result of 300 mg/L of soil particles containing 2,500 mg/kg PGDN. None of the other storm sewer sediment samples contained PGDN.

Additional sediment samples (T-1 and T-2) were collected on 16 October 1986 from the upstream and downstream ends of the first culvert for the runoff stream, just to the west of the point where the stream emerges from the wooded area. The culvert is about half filled with sediment. Neither of these sediment samples had a detectable concentration of PGDN.

PGDN had been detected in only two of the samples of sediments and organic debris from the runoff stream (See Section 3). It is believed that erosion gradually displaces particles containing PGDN further and further from the former discharge area. Cyanides would be present in the erosion-displaced particles, but at very low concentrations. Accordingly, the samples of sediments and organic debris from the culvert and the storm sewers were not tested for cyanides.

Table 2

Summary of Surface Water and Sediment Monitoring Data

Location	Date	Concentrations PGDN	Total CN	Flow
Surface Water Runoff Stream				
at Culvert	16 Sept	--	1.2 mg/L	3 gal/day
	24 Sept	--	0.3 mg/L	1760 gal/day
Air Cond	16 Sept	--	BDT	12 gal/min
Effluent	24 Sept	--	BDT	15 gal/min
Runoff Stream Debris		1100 mg/kg	--	
Runoff Stream Sediments (inside culvert)				
T-1 (upstream)	16 Oct	BDT	--	
T-2 (dnstream)	16 Oct	BDT	--	
Storm Sewers				
Catch Basin	15 Aug	BDT	--	
Manhole #1	15 Aug	BDT	--	
Manhole #2	15 Aug	BDT	--	
Manhole #3	15 Aug	760 ug/L	--	
Manhole #4	15 Aug	BDT	--	
Manhole #5	15 Aug	BDT	--	
Manhole #6	15 Aug	BDT	--	
Manhole #7	15 Aug	BDT	--	

Note: -- = not analyzed
BDT = below detection limits:
Total CN 0.005 mg/L in surface water stream
PGDN 25 mg/kg in runoff stream debris and sediments
PGDN 60-80 ug/L in storm sewer sediments

5. GROUND WATER STUDY

In August 1986, TRW authorized a study to assess potential migration of PGDN and Cyanide from the original affected area near Building 49 through surface water and ground water. This section deals with the assessment for ground water water.

The principal findings of the ground water study are as follows:

- The lateral ground water flow below and adjacent to the former discharge area is generally from north to south.
- Cyanide was not observed in any wells at detectable concentrations. Therefore, migration away from the Building 49 area via shallow ground water movement is not occurring.

Details follow on the methods for the ground water study and what led to these findings.

5.1 INSTALLATION OF GROUND WATER MONITORING WELLS

Five (5) shallow ground water monitoring wells were installed along the boundaries of the formerly swampy area south of Building 49. The wells were located 25 to 75 feet beyond the area of soil sampling of the former discharge area (see appended Drawing 6), with the major objective to determine whether cyanides are migrating out of this area via the ground water. (Otto Fuel residue was not of concern for ground water, owing to its immiscibility with water.) The monitoring wells were required to sample the shallow ground water for cyanides and to identify the approximate directions of lateral flow.

The wells were installed on 5 and 8 September 1986 by Lake Drilling Co., under the direction of Engineering-Science (ES). During the well installation, the drilling augers were cleaned between holes to eliminate cross-contamination, and undisturbed 24-inch length Shelby-tube samples of the unconsolidated sediments were obtained almost continuously down to the bedrock surface (The Shelby-tube samples were discussed in Section 3.4). The wells were completed to a depth 14 ft below the surface, and screens were installed in the bottom 10 ft. Stainless steel well casing and screen were used to ensure representative ground water samples and to ensure well

intergrity over extended time. After completion, the wells were developed by bailing and surging to remove fine-grained sediments. The well logs are included as Appendix B.

5.2 SAMPLING GROUND WATER

The ground water monitoring wells were sampled twice, first on 17 September and again on 9 October 1986. Each time, the wells were bailed of three to five volumes of water with a clean Teflon® bailer. In all cases, the wells recovered to static levels within a few hours. The samples were placed on ice immediately and delivered to the laboratory.

Cyanide was not detected in any of the five well samples on either sampling date. The detection limit was 0.005 mg/L, about one percent of the concentrations observed in the runoff stream.

5.3 GROUND WATER FLOW DIRECTION

The geology at the TAPCO complex in Euclid is typical of areas on the south shore of Lake Erie. Lacustrine silts and clays overlie weathered and fractured gray and brownish shales of Devonian age. At this location, the depth to bedrock varies from 3 to 5 ft.

Table 3 summarizes the observed water levels at the five ground water monitoring wells on two separate occasions during late September and early October 1986. On both of these observations, the water level was between 2.7 and 4.0 feet below grade, above the weathered bedrock interface. This thin weathered zone is the first saturated zone below the site.

Each time, the ground water flow was observed to be from North to South, the same direction as the surface runoff stream for the former discharge area (See appended Drawing 6). Shallow ground water flow would ordinarily be expected to follow a south-to-north gradient toward Lake Erie, following the regional surface topography. Where a surface runoff channel has cut into the topography, the ground water flow pattern may be slightly altered. In this area, the very shallow ground water may be induced to flow into this channel, thereby interrupting the overall south to north flow. Because shallow ground water is so close to the surface, it is likely that surface water and ground water are hydraulically connected.

Table 3

Monitoring Well Data

Well Number	W-1	W-2	W-3	W-4	W-5
date installed	05-Sep	05-Sep	08-Sep	08-Sep	08-Sep
Coordinates (ft)					
North	198	25	-63	212	63
East	123	106	-5	19	-5
Elevations (ft)					
Cover	99.3	100.5	100.4	99.7	99.9
Surface	97.7	99.1	98.9	98.3	98.5
Top of Clay	96.7	96.6-98.1	96.9	92.8-98.3	96.5-97.5
Top of Screen	93.7	95.1	94.9	94.3	94.5
Shale Interface	93.2	93.6	92.9	92.8	91.9
24-Sep-86 Well Level Monitoring (ft)					
Depth to Water *	5.1	5.2	4.1	5.6	5.5
Ground Water Level	94.2	95.3	96.3	94.1	94.4
09-Oct-86 Well Level Monitoring (ft)					
Depth to Water *	4.8	4.7	4.2	5.3	5.2
Ground Water Level	94.5	95.8	96.2	94.4	94.7
Cyanide Concentrations in Monitoring Samples (mg/L)					
17-Sep-86	BDT	BDT	BDT	BDT	BDT
09-Oct-86	BDT	BDT	BDT	BDT	BDT

Note: BDT = below detection limit (0.005 mg/L Total Cyanide)
Datum for elevations 100.0 ft = floor level in Building 49

* Depth indicated is in feet below the top of the cover

6. RECOMMENDATIONS FOR CLOSURE PLAN

An assessment of risks to human health was carried out for the residues of the chemical discharges from Building 49, using very conservative established procedures to identify any potential risk to public health. [3] The Risk Assessment is included in this report as Appendix C. The methodology provides a basis for ranking of the alternatives for remedial action for the former discharges of Otto Fuel residue and cyanides near Building 49, by systematic evaluation of the possible threats to public health. This involves an understanding of the nature of the chemicals, the potential pathways for exposure of human populations in the event of any future release from the site, the degrees to which such releases (if any) could violate applicable standards and criteria, and a measure of the potential threats to public health that might result from such releases.

The principal findings in this Risk Assessment are as follows:

- The no-action alternative is not recommended. Soil containing Otto Fuel residue and cyanides is a hazard to public health, posing an ongoing ingestion, inhalation and dermal contact danger. It would continue to be subject to mobilization by particle erosion, eventually discharging through the storm sewer system (into Lake Erie). Cyanides would continue to leach into the runoff stream in detectable, but low concentrations, posing a threat until chemical degradation, volatilization, bacterial action and/or plant uptake eventually mitigate the hazards due to cyanides.

- The minimum action required would be to remove soils containing detectable Otto Fuel residue and cyanide concentrations exceeding 10 mg/kg, at the former discharge pipe and in the runoff stream, with due precautions to avoid mobilization during removal.

- Ultimate disposal of the soil removed from the areas of highest concentrations should be by incineration.

- No further removal of soil from the area would be required. Although cyanides would be present, at concentrations less than 10 mg/kg, there would be no remaining significant threats to public health. The alternative of additional soil removal and disposal at an industrial landfill (not certified for hazardous materials containing cyanides) would not achieve significantly improved reduction of hazards.

Details of the Risk Assessment are found in Appendix C. These issues, and the implications for Closure of the Building 49 area, are addressed in the sections that follow:

6.1 CLOSURE OF THE SPILL AREA

Surface soil in the approximately 625 sq.ft polygon area noted on Figure 5 and the runoff stream channel will have to be excavated for off-site disposal. This will remove all areas with detectable PGDN concentrations and/or Total Cyanide exceeding 10 mg/kg. It is recommended that the removal should include the organic surface soils and the upper 1 ft. of clay. Assuming a total depth of 4 ft. removed from area near the former discharge pipe and 2 ft. x 2 ft. dredging of the 120 ft. long runoff stream, the soil removal would amount to about 100 cubic yards. The sediments in the first culvert and the sediments from all manholes in the storm sewer system will also have to be removed. The contaminated leaves and organic debris, previously removed from the runoff steam channel and dumped in the wooded area, should be collected and added to the soil and sediments.

A Gradall or a hydraulic clamshell would be required for the soil removal and stream dredging. Personnel protection would be necessary at Level B (disposable outer garments and respiration equipment). However, mechanical methods, i.e., working upwind or use of fans would minimize the need for supplied air (See Appendix C).

Site work will be required, to provide access to the removal area for earthmoving equipment. A 12 ft. wide temporary roadway using 9" to 12" coarse stone and construction filter fabric is recommended. This should follow a southward alignment on the east side of Building 49, through the existing fence, and westward to the removal area (See appended Drawing 7).

Additional site work should also be considered, to change the drainage to the runoff stream. A new drainage channel is proposed, which would follow a semi-circular arc from the low point in the ponding area, southwestward to join the existing runoff stream near the culvert (See appended Drawing 7). This would decrease leaching of cyanides into the runoff by preventing the ponding that now provides extended contact time. It will also reduce flow through the runoff stream, thereby reducing further migration by erosion of any contaminated sediment particles in the stream channel.

6.2 CONCENTRATION LIMITS FOR RESIDUES IN THE SOIL

The recommended action, to excavate soil near the former discharge pipe and to dredge the bed of the runoff stream, will remove all Otto Fuel residues detected in the soil sampling (See Figures 5 and 6). This conforms to the recommendation for off-site disposal of soil containing Otto Fuel from spills, in the U.S. Navy manual for Otto Fuel [1]. The Risk Assessment (Appendix C) identified toxic hazards to public health associated with the Otto Fuel Residues.

This action would also remove the soil with the highest cyanide concentrations, which occurred in essentially the same areas. After the removal, Cyanides will be present at concentrations not exceeding 10 mg/kg anywhere in the area. This is more stringent than the 20 mg/kg recommended preliminary cleanup target concentration for cyanides in soil [4]. The Risk Assessment indicates that the remaining soil, being free of PGDN and containing low concentrations of cyanides, should not be considered harmful. Natural soils under aerobic conditions are known to be tolerant of (and capable of assimilating) cyanides at concentrations exceeding 2 mg/kg [5].

Recent actions by State agencies with respect to cyanides in mineral processing residues have required removal to levels up to 10 mg/kg, based on rationale for the cyanide concentrations that would leach into surface water [6]. For example, the California Regional Water Quality Control Board, Colorado River Basin, Region 7 increased the limit on total cyanide found in abandoned leach piles from 1.0 mg/kg to 10 mg/kg, after a review of fish toxicity studies and the environmental chemistry of cyanides. Their rationale was that only the cyanide ion content has to be considered.

A cyanide level of 0.02 mg/L was acceptable in the receiving stream, and after multiplying by their customary factor of 100 to account for dilution, a level of 2.0 mg/L was obtained for the leachate. Then, the acceptable limit for a solid residue is 10 mg/kg based on leaching 1 part solid: 5 parts liquid [5].

The runoff stream from the former discharge area south of Building 49 was observed to contain from 0.24 to 1.2 mg/L of Total Cyanide. Leaching of cyanides into this stream is predicted to decrease by about 70 percent after the recommended removal of all soil and sediments containing detectable PGDN and Total Cyanides exceeding 10 mg/kg. Even discounting any further dilution, the predicted 0.07 to 0.36 mg/L (70 to 360 ug/L) concentrations in the runoff stream would be within the 700 ug/L preliminary cleanup target concentration for cyanides in water [4].

6.3 ULTIMATE DISPOSAL OF SOIL

The U.S. Navy manual for Otto Fuel [1] recommends off-site disposal for soil containing Otto Fuel from spills. Concentrated liquid residues of Otto Fuel are presently disposed of by incineration. (As supplied, Otto Fuel is considered by the Navy and by Navy contractors as subject to RCRA regulations as a reactive hazardous material.) Rotary-kiln incinerators would have to be used, since liquid hazardous waste incinerator installations generally can only handle limited quantities of drummed soil. The costs for disposal by incineration will be high, since there may be problems with ash disposal and/or material handling (size reduction, moisture content, etc.) depending on site-specific requirements of the installation to be used.

The manual does describe a method for chemical reduction of liquid Otto Fuel residues, using acetone solvent and sodium sulfide. [1] This does not appear to be feasible for on-site application, since it would require rigorous working area isolation facilities to ensure personnel safety and to prevent emission of toxic hydrogen sulfide fumes.

Depending on the quanity of soil involved, on-site chemical destruction of cyanide may be economically feasible in comparison to landfill disposal. The technology for alkaline hypochlorination of excavated soil using earth moving equipment was estimated by its developers (Haztech) to cost in the range of $50 to $150/cu.yd., for soil quantities of 250 to 500

cu.yd. This method has been used at two sites which had experienced spillage of concentrated cyanides, to treat soils containing 100 mg/kg or more of cyanides. It is claimed to be capable of reducing cyanides to concentrations below present detection limits, at somewhat higher costs. Preventing emission of toxic chlorine fumes during the soil treatment is a major drawback for this technology.

An optional alternative for site work could also be considered, to inter the remaining cyanides insitu, by regrading to provide an impermeable cap over the areas containing detectable cyanides and diverting all surface runoff and ground water that would otherwise contact the buried soil. However, this would involve a commitment to long-term monitoring of ground water quality.

6.4 CLOSURE OF BUILDING 49 AND THE ADJOINING AREA

The entire Torpedo Test area should undergo closure at the same time as the spill area. Additional activities that should be included in the Closure are discussed in the paragraphs that follow:

Leakage of torpedo test wastewater may have occurred from the underground tanks and piping. In order to locate such leakage sites, if any, the 1,000 gallon underground separator tank for wastewater discharges from Building 49 must be removed, and the former discharge piping should be unearthed along its entire length (estimated to be about 60 ft). Similarly, the new underground holding tanks for torpedo test wastewater, which were installed on the west side of Building 49, and the piping from the separator tank to the new holding tanks must also be removed.

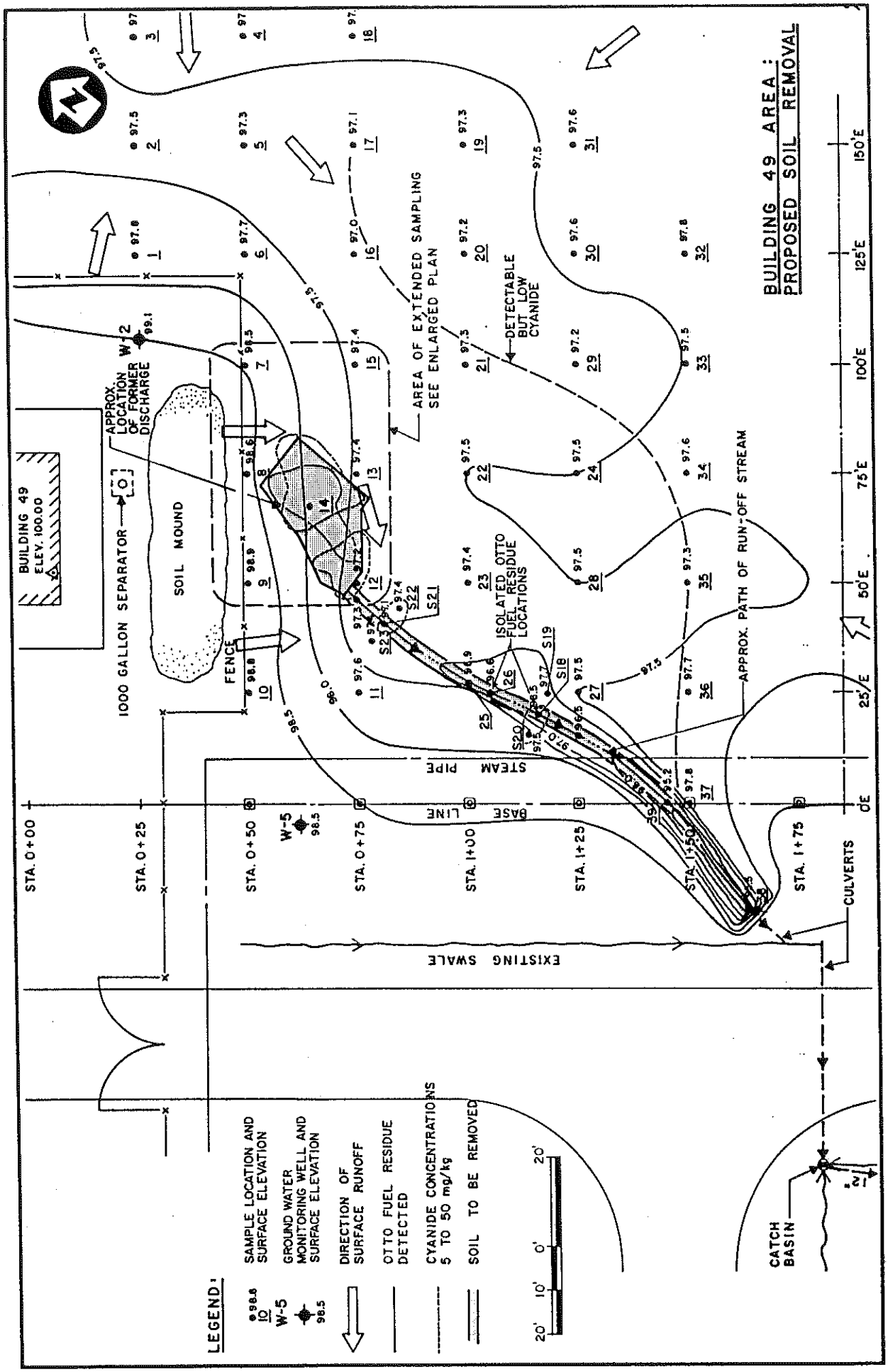
Soil sampling and analysis for PGDN should be carried out at the tank sites and along the piping, at the pipe joints and any other suspect locations. In addition, the soil at two areas of possible spillage of Otto Fuel or torpedo testing wastewater should also be sampled and analyzed for PGDN. Spills may have occurred at the Otto Fuel Storage area on the east side of Building 49 and/or on the concrete pad on the south side of the building.

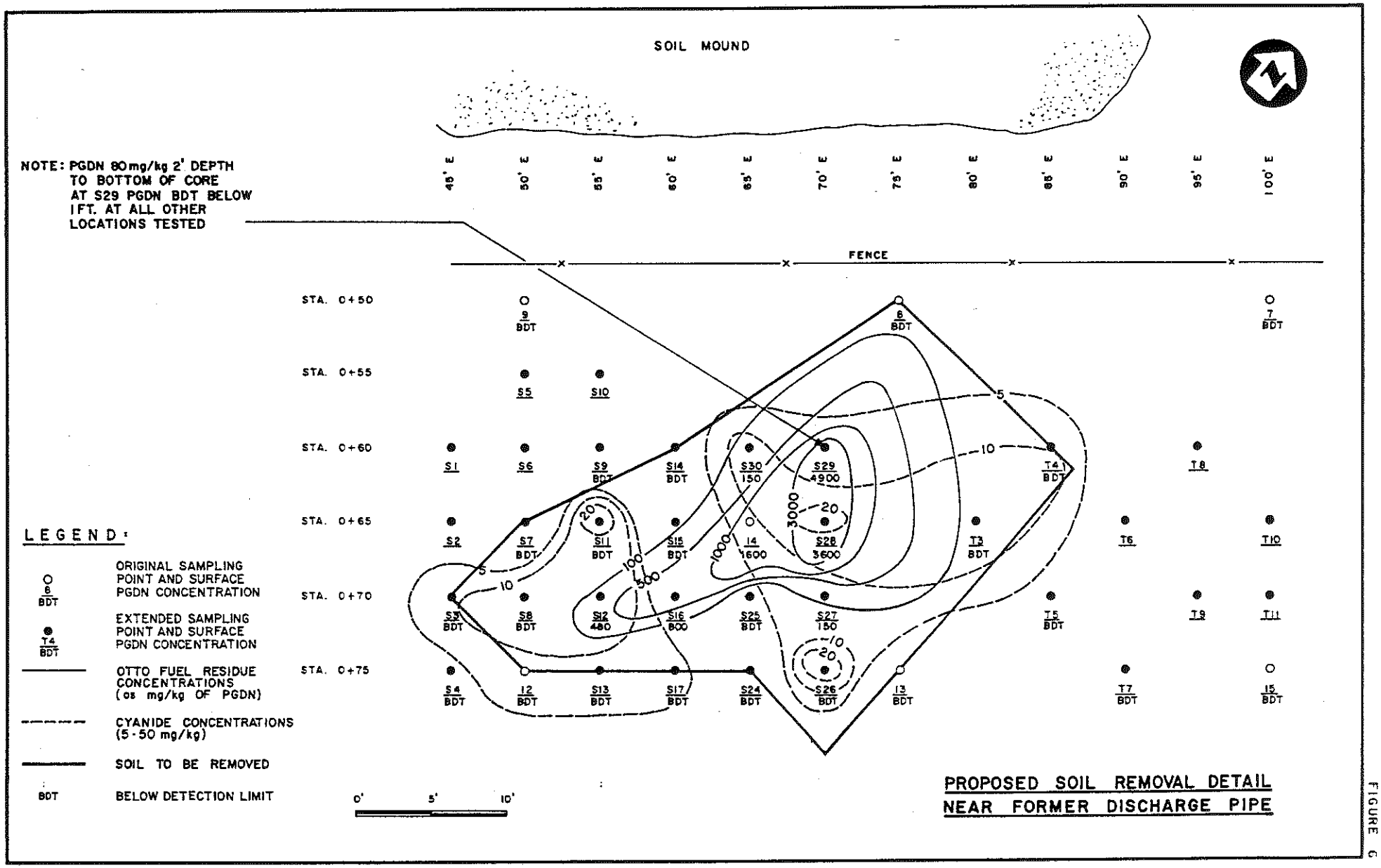
The tanks and pipe should be cleaned on site by rinsing with detergent solution (Wisk), and the spent rinses should be collected for disposal by incineration. Samples of the last spent rinses should be analyzed for PGDN to verify that no Otto Fuel residues remain. The tanks may then be

salvaged for reuse, if possible, or disposed of as non-hazardous solid waste.

In the event that Building 49 or any of the auxiliary buildings are to be demolished in the foreseeable future, it would be prudent to test at this time for asbestos insulation. Similarly, transformers in the torpedo testing compound should be checked for PCBs.

The soil mound between Building 49 and the former discharge area has been sampled and analyzed for cyanides. It was found to be free of cyanides, hence this soil can be used for backfilling after removal of soil containing residues of PGDN and cyanides.


BUILDING 49 AREA:
PROPOSED SOIL REMOVAL
BUILDING 49
ELEV. 100.00
1000 GALLON SEPARATOR
APPROX. LOCATION OF FORMER DISCHARGE
W-2
SOIL MOUND
FENCE
AREA OF EXTENDED SAMPLING
SEE ENLARGED PLAN
DETECTABLE BUT LOW CYANIDE
ISOLATED OTTO FUEL RESIDUE LOCATIONS
APPROX. PATH OF RUN-OFF STREAM
STEAM PIPE
BASE LINE
W-5
STA. 0+00
STA. 0+25
STA. 0+50
STA. 0+75
STA. 1+00
STA. 1+25
STA. 1+50
STA. 1+75
CULVERTS
EXISTING SWALE
CATCH BASIN
0'E
25'E
50'E
75'E
100'E
125'E
150'E
LEGEND:
SAMPLE LOCATION AND SURFACE ELEVATION
GROUND WATER MONITORING WELL AND SURFACE ELEVATION
DIRECTION OF SURFACE RUNOFF
OTTO FUEL RESIDUE DETECTED
CYANIDE CONCENTRATIONS 5 TO 50 mg/kg
SOIL TO BE REMOVED
20' 10' 0' 20'



PROPOSED SOIL REMOVAL DETAIL NEAR FORMER DISCHARGE PIPE

FIGURE 6

REFERENCES

1. Technical Manual: OTTO Fuel II Safety, Storage and Handling, 6th Revision, NAVSEA OP 3368 (U.S. Navy Sea Systems Command, 1 October, 1976).

2. Test Methods for Evaluating Solid Wastes: Physical and Chemical Methods, SW-846, Second Edition (Revised), U.S. Environmental Protection Agency, Office of Solid Wastes, 1984.

3. Superfund Public Health Evaluation Manual, OSWER Directive 9285.4-1, Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C., October 1986.

4. Surface Impoundment Clean Closure Guidance Manual, OSWER Directive 9476.00-8.C., Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C., October 1987.

5. Fuller, W.H., "Cyanides in the Environment, with Particular Attention to the Soil", keynote review paper presented at Conference on Cyanide and the Environment, Tucson, AZ., Dec. 1984, pp.19-45.

6. Engineering-Science, Inc. (ES), "Cyanide Chemistry" excerpt from report to U.S. Environmental Protection Agency, Water Management Division, State Programs Branch, Denver, CO., 1986. "Heap Leach Technology and Potential Effects in the Black Hills", pp. 283-340, (See Table B-11, "Western State Regulations or Guidelines for Neutralization of Spent Heap Leach Piles", pp. 326-327.)

NOTE: Reprints are provided of References [5] and [6], in Appendices D and E, respectively.

APPENDIX A

HEALTH AND SAFETY PLAN FOR BUILDING 49 STUDY

ES ENGINEERING-SCIENCE

57 EXECUTIVE PARK SOUTH, N.E., SUITE 590 • ATLANTA, GEORGIA 30329 • 404/325-0770

66207/864J50

April 7, 1986

Chris Raddel
Engineering-Science, Inc.
19101 Villaview Road
Suite 301
Cleveland, Ohio 44119

Dear Chris:

Please find enclosed the Safety Guidelines for the TRW site investigation. If you have any comments concerning any of the protocols feel free to contact me.

Sincerely,

ENGINEERING-SCIENCE

Edward Grunwald

Edward Grunwald
Corporate Health and Safety
Manager

EG/bb

Enclosure

Respiratory Protection

The personal levels of respiratory protection prescribed for the field work to be performed at TRW building 49 is level D with a contingency to use level C. This level is based upon the potential exposure to OTTO. OTTO is a monopropellant made up of 1,2-propylene glycol Dinitrate, Di-N-butyl Sebacate, and 2-Nitrodiphenylamine. OTTO has a very low vapor pressure, therefore, the inhalation of toxic gases, fumes, or vapors is unlikely to be encountered. The inhalation of toxic particulates (dusts, soils, etc.) can be a problem when soil conditions are dry. If the inhalation of airborn particulates is a problem, (as may be the case during drilling activities) field personnel should "water down" the area of concern. OTTO does not have an established Threshold Limit Value (TLV) or Permissible Exposure Limit (PEL). The major component of OTTO, 1,2-Propylene Glycol Dinitrate, has a TLV of 0.02 ppm. Because of the low TLV of 1,2-Propylene Glycol Dinitrate ambient air monitoring of organic vapors will be required at each sampling point and drilling location. This information will be used to aid the site manager in determining the level of protection for the various activities.

The following criteria should be used to select the appropriate respiratory protection:

Organic Vapor Concentration (in Breathing Zone)	Protection Level
0 PPM	Level D
0.02-5 PPM	Level C

Level C respiratory protection should not be used for protection with poor warning properties or in an atmosphere containing less than 19.5 percent oxygen (ANSI Z88.2-1980). Information is not available to determine if OTTO had good warning properties (i.e., low odor threshold

when compared to its TLV). For this reason the upper limit for level C respirator protection is set at 5 ppm, at this concentration cartridge breakthrough is unlikely to occur. Level C respiratory protection will consist of a full face air mask with organic vapor cartridges. Individuals who use air purifying respirators must wear a respirator which has successfully been fitted to their faces. An improperly fitted respirator delivers little respiratory protection. Additionally, a five minute escape air pack must be available when Level C operations commence.

Level B respiratory protection Self-Contained Breathing Apparatus (SCBA) will be worn when the following conditions occur:

- When organic vapor concentration (in the breathing zone) exceeds 5 PPM
- When evidence exists of immediate (less than five minutes) breakthrough time for the cartridge air-purifying respirator.
- Where there is reason to suspect that the cartridge sorbent has a high heat of reaction (hot to the touch) with one of the substances at the site.
- Where there is reason to suspect that a substance sorbed onto the surface of a cartridge is shock sensitive.

Dermal Protection

OTTO can be absorbed through the skin; OTTO is also an eye irritant. Personnel can avoid skin and eye contact by wearing the protective clothing specified below.

For level D Operations:

- Tyvek or Saranex suits (over coveralls)
- Neoprene boots
- Polyethylene gloves
- Goggles

For Level C Operations

- Full-face air purifying respirator equipped with organic vapor cartridges
- Neoprene outer gloves
- Polyethylene inner gloves
- Tyvek or Saranex suits (over coveralls)
- Steel-toed Neoprene boots

Health and Safety Training

Every potential respirator wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly.

Air Monitoring

Monitoring for organic vapors will be conducted using an HNu with an 11.7 ev lamp. Reading of organic vapor concentration above background will initiate Level C respiratory protection.

Health and Safety Equipment

Each field team shall have the following items readily available:

- Copy of site Health and Safety Plan including a list of emergency contacts
- First aid kit
- Eye wash bottle
- Duct tape
- Paper towels
- Plastic garbage bags
- HNu with 11.7 ev lamp
- Long-handle brushes
- Tyvek
- Gloves
- Full-face air purifying respirator
- Safety boots
- Decon solution
- Organic vapor cartridges

SITE SPECIFIC DECONTAMINATION PROCEDURES

Work at the TRW site will be of moderate duration and exposure to hazardous materials should be minimal if proper precautions are followed. Simple and expedient decontamination procedures, appropriate to the site and work conditions, will be followed.

Based upon the site information, it may be necessary to establish one or more zones of exclusion. Should this occur, a decontamination pad will be established at the entrance/exit point to each exclusion zone. Workers entering this area must be equipped in the level of protection previously established. The decontamination procedures must be followed by all personnel as they leave the zone of exclusion.

Level C decontamination at the TRW site will consist of the following:

Station 1: Segregated Equipment Drop

Deposit equipment used on the site (tools, sampling devices and containers, monitoring instruments, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment necessary is:

1. Containers of various sizes
2. Plastic liners
3. Plastic drop cloths

Station 2: Suit/Safety Boot and Outer-Glove Wash

Thoroughly wash tyvex or saranex suit, safety boots and outer-gloves. Scrub with long-handle, soft-bristle scrub brush and copious amount of decon solution (Wisk®/water solution). Repeat as many times as necessary (determined by visual inspection).

Equipment necessary is:

1. Container (30 gal)
2. Decon solution: Wisk®/water solution
3. Long-handle, soft-bristle scrub brushes

Station 3: Suit/Safety Boot and Outer-Glove Rinse

Rinse off decon solution (Wisk®/water solution) using copious amount of water. Repeat as many times as necessary.

Equipment necessary is:

1. Container (30 gal)
2. Spray unit
3. Water
4. Long-handle, soft-bristle scrub brushes

Station 4: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedures. Worker's canister is exchanged, new outer gloves and tyvec donned, and joints taped. Worker returns to duty.

Equipment necessary is:

1. Canister (or mask)
2. Tape
3. Boot covers
4. Gloves

Station 5: Outer Glove Removal

Remove outer gloves and deposit in individually marked plastic bags.

Equipment necessary is:

1. Container (30 gal)
2. Plastic liners
3. Bench or stool

Station 6: Tyvex or Saranex Suit Removal

With assistance of helper, remove tyvex or saranex suit. Deposit in container with plastic liner.

Equipment necessary is:

1. Container (30 gal)
2. Stool
3. Plastic liner

Station 7: Inner-Glove Wash

Wash inner-gloves with Wisk®/water solution that will not harm skin. Repeat as many times as necessary.

Equipment necessary is:

1. container
2. water
3. wash basin
4. brushes

Station 8: Inner-Glove Rinse

Rinse inner-gloves with water. Repeat as many times as necessary.

Equipment necessary is:

1. Water
2. Basin
3. Small table

Station 9: Safety Boot Removal

Remove safety boots and deposit in individually marked plastic bags.

Equipment necessary is:

1. Container
2. Plastic liners
3. Bench or stool

Station 10: Respirator Removal

Remove facepiece. Avoid touching face with gloves. Wash respirator in clean, sanitized solution (e.g., anticeptic mouthwash) and deposit facepiece in plastic bag. Store in clean area.

Equipment necessary is:

1. Plastic bags

Station 11: Inner-Glove Removal

Remove inner-gloves and deposit in container with plastic liner.

Equipment necessary is:

1. Container
2. Plastic liners

Station 12: Field Wash

Wash hands and face.

Equipment necessary is:

1. Water
2. Soap
3. Tables
4. Wash basins or buckets

Equipment Decontamination

The drill rigs and downhole equipment will be steam cleaned prior to drilling the first boring. Downhole equipment will be decontaminatied after the completion of each boring in the following manner:

- Downhole equipment (aguer bits, drill rods, etc.) will be steam clened to remove gross contamination;
- The equipment will then be washed in a detergent (Wisk®) solution and brushed.
- The equipment will then be rinsed with tap water, followed by acetone and distilled water.
- The downhole equipment will then be air dried in a clean section of the decontamination area.

Drill rigs will be steam cleaned upon the completion of the final boring. A drilling sequence heirarachy (from less likely to more likely contaminated boring locations) will be imposed to reduce the potential of cross contamination.

Hazard Evaluation

The compound of concern at the TRW site is OTTO. Although this chemical has a low vapor pressure air monitoring for organics should be conducted (particularly during drilling activities) to determine the need to upgrade the level of respiratory protection. Since OTTO is a propellant care should be taken to use non-sparking tools whenever possible. Smoking will be prohibited at the site. An explosimeter may

be a useful tool for monitoring combustible atmospheres when the chemical of concern is volatile but in the case of OTTO which is a non volatile, viscous substance the benefit gained by using an explosimeter is questionable.

The toxic effects from the inhalation of OTTO include: headaches, nasal congestion, and a drop in blood pressure. OTTO is also an eye irritant. The proper selection of protective clothing is important. Polyethylene and Neoprene clothing (gloves and boots) provide the greatest degree of protection. Butyl rubber and natural rubber tends to degrade quicker when exposed to the components of OTTO. Neoprene gloves and boots are recommened as a substitute for natural rubber garments.

APPENDIX B

WELL LOGS

DRILLING CONTRACTOR:
iller: LAKE DRILLING
spector: K.M. Palombo

ENGINEERING-SCIENCE DRILLING RECORD

PROJECT NAME TRW BUILDING 49 STUDY
PROJECT NO. CL021

BORING NO. W-1
Sheet 1 of 1
Location

GROUND WATER OBSERVATIONS

AT ___ FT. AFTER ___ HOURS

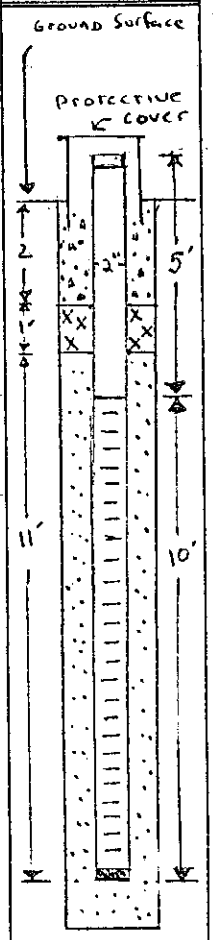
AT ___ FT. AFTER ___ HOURS

Weather Sunny 70°'s
Remarks
Screen Size .010
Stainless Steel

Surface Elev.
Date Start 9-5-86
Date Finish 9-5-86

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
	1-3.5	U					light Brown Silt
	3.5-4.5	U				1	grayish Brown clay
						4.5	Brownish gray weathered shale
						7.5	fractured gray SHALE
						12	Hard gray Shale.

WELL CONSTRUCTION DETAILS



coarse SAND
Bentonite
cement

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

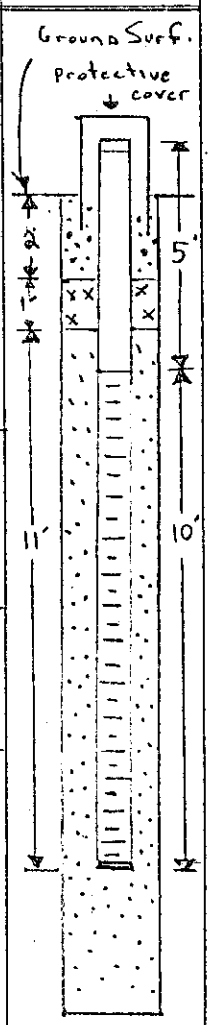
PAY QUANTITIES	
FOOTAGE IN EARTH	5
FOOTAGE IN ROCK	10
NO. OF SAMPLES	2
CORE BARREL	0

DRILLING CONTRACTOR:	ENGINEERING-SCIENCE DRILLING RECORD	BORING NO. W-2
Driller: LAKE DRILLING		Sheet 1 of 1
Inspector: K.M. Palombo		Location
	PROJECT NAME TRW Building 49 Study	
	PROJECT NO. CL021	

GROUND WATER OBSERVATIONS		
AT ___ FT. AFTER ___ HOURS	Weather Sunny 70's	Surface Elev.
	Remarks Screen Size .010	Date Start 9-5-86
	STAINLESS STEEL	Date Finish 9-5-86
AT ___ FT. AFTER ___ HOURS		

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
						1	Brown Sandy Topsoil
	1-3'	U				2.5	Light Brown Silty Clay
	3-5'	U				3.5	Dark gray to Black clay (Appears Stained)
						5.5	Brown weathered clay with shale fragments
						11	Weathered, fractured gray shale.
							Harder gray shale.

WELL CONSTRUCTION DETAILS



COARSE SA

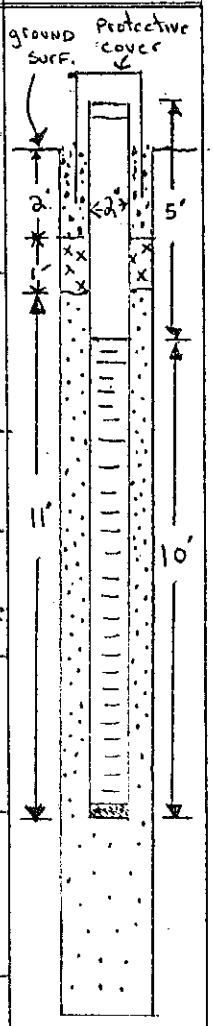
D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

PAY QUANTITIES	
FOOTAGE IN EARTH	5.5
FOOTAGE IN ROCK	11.5
NO. OF SAMPLES	2
CORE BARREL	0

DRILLING CONTRACTOR:	ENGINEERING-SCIENCE DRILLING RECORD	BORING NO. W-3
Driller: LAKE DRILLING		Sheet 1 of 1
Inspector: K.M. Palombo		Location
	PROJECT NAME TRW Building 49	
	PROJECT NO. CL021	

GROUND WATER OBSERVATIONS		
AT ___ FT. AFTER ___ HOURS	Weather Pt'ly Cloudy - Cool 60's	Surface Elev.
	Remarks Screen Size .010	Date Start 9-8-86
	Stainless Steel	Date Finish 9-8-86
AT ___ FT. AFTER ___ HOURS		

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)	WELL CONSTRUCTION DETAILS
							Top soil - Light Brown Silt w/minor Fine Sand	
						1		
							Gravel, old asphalt, wood (Fill)	
						2		
							Dark Gray clay (appears stained, hydrocarbon odor)	
	3.0-5.0'	U						
						3.5		
							Medium Brown Silty Clay	
						6.0		
							Brown Weathered Shale	
						6.5		
							Gray, weathered, (Broken) Shale	
						16		
							Gray Shale, harder, less weathered	
						18		
							Coarse Sand	
							Bentonite	
							Cement	



D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
= UNDISTURBED SS = SPLIT SPOON

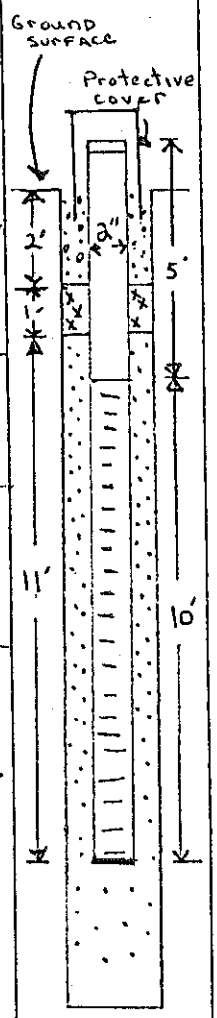
PAY QUANTITIES	
FOOTAGE IN EARTH	6.0
FOOTAGE IN ROCK	12.0
NO. OF SAMPLES	2
CORE BARREL	

DRILLING CONTRACTOR:	ENGINEERING-SCIENCE DRILLING RECORD	BORING NO. W-4
Driller: LAKE DRILLING		Sheet 1 of 1
Inspector: K.M. Palombo		Location
	PROJECT NAME TRW BUILDING 49 STUDY	
	PROJECT NO. CL021	

GROUND WATER OBSERVATIONS		
AT ___ FT. AFTER ___ HOURS	Weather PTLY CLOUDY, COOL 60'S	Surface Elev.
	Remarks SCREEN SIZE .010 STAINLESS STEEL	Date Start 9-8-86
AT ___ FT. AFTER ___ HOURS		Date Finish 9-8-86

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
							Brown Silty clay
						1	
	1-3.5	U					Reddish Brown Silty clay (MOIST)
						2.5	
	3.5-5	U					Brown Silty clay (Dry)
						5.5	
							Light Brown weathered shale
						7	
							gray shale – some fractures
						12	
							Brownish gray SHALE weathered, iron stains
						17	

WELL CONSTRUCTION DETAILS



COARSE SAND

BENTONITE

CEMENT

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

PAY QUANTITIES	
FOOTAGE IN EARTH	5.5
FOOTAGE IN ROCK	11.5
NO. OF SAMPLES	2
CORE BARREL	

Concentrations (detectable only in the top 1 ft of sample cores) - approximately 300 ft^2 area near the former discharge pipe site:

average of all detectable concentrations = 1900 mg/kg
maximum concentration observed = 4900 mg/kg

in the runoff stream sediments:

average of the two isolated samples with detectable concentrations = 160 mg/kg
maximum concentration observed = 240 mg/kg

Cyanides, which are present as a result of incomplete combustion of Otto Fuel in torpedo testing, are characterized as follows:

Mobility - Cyanides, being generally soluble in water, are capable of leaching either into surface runoff or into ground water flow. Cyanide concentrations of 0.24 to 1.2 mg/L were observed in the actual runoff stream flow.

Toxicity - Cyanides are notorious for toxicity to humans and animals, due to interference with oxygen metabolism.

Persistence - Cyanides do degrade in the environment. Under acidic conditions, cyanides are coverted to the volatile hydrocyanic acid (HCN) and released to the atmosphere. Other mechanisms of cyanide degradation, including ultraviolet light, bacterial action, and direct uptake by plants are known to occur [4].

Concentrations in the top 1 ft of sample cores) - (note that detectable, but generally much smaller concentrations are present further below the soil surface)

approximately 1,000 ft^2 area near the former discharge pipe:

average of all detectable concentrations = 10 mg/kg
maximum concentration observed = 54 mg/kg

DRILLING CONTRACTOR:
Driller: LAKE DRILLING
Inspector: K.M. Palombo

ENGINEERING-SCIENCE DRILLING RECORD

PROJECT NAME TRW BUILDING 49 STUDY
PROJECT NO. CL021

BORING NO. W-5
Sheet 1 of 1
Location 10' W. OF OVERHEAD STEAM LINES

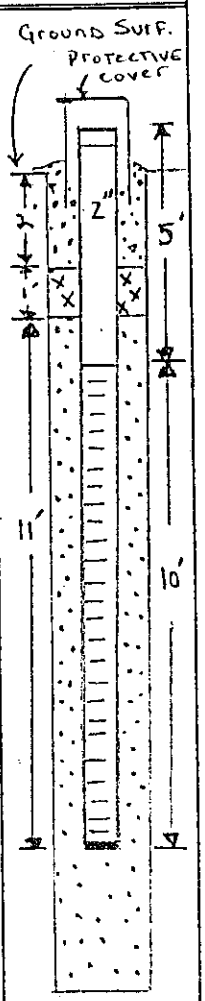
GROUND WATER OBSERVATIONS
AT ___ FT. AFTER ___ HOURS
AT ___ FT. AFTER ___ HOURS

Weather PTLY CLDY 60'S
Remarks Screen Size .010 STAINLESS STEEL SCREEN AND RISER

Surface Elev.
Date Start 9-8-86
Date Finish 9-8-86

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
	1-3'	U					Top Soil / Brown Silty Cly
						2	Dark gray clay - No odors
	3.5-5	U				3	Brownish-Gray Clay Moist at top Dry at bottom
						6	Brown Firm clay to weathered shale
						7	Gray Shale
						11	Brownish Gray Shale (weathered, fractured, iron stains)
						12	Gray Shale w/ Some Brown Streaks
						17	

WELL CONSTRUCTION DETAILS



Coarse sand
Bentonite
Cement

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

PAY QUANTITIES	
FOOTAGE IN EARTH	6
FOOTAGE IN ROCK	11
NO. OF SAMPLES	2
CORE BARREL	0

APPENDIX C

RISK ASSESSMENT

APPENDIX C
RISK ASSESSMENT

An assessment of risks to public health was carried out for the area near Building 49 affected by the discharges of Otto Fuel residue and cyanides. The assessment covered both existing conditions and alternatives for remedial action. The discussion that follows describes the Risk Assessment procedure in general terms and then applies that methodology to the case at hand.

1. BASELINE RISK ASSESSMENT PROCEDURE

The methodology for assessment of risks to public health is based on very conservative established procedures to identify and evaluate the possible threats [1]. This involves an understanding of the nature of the chemicals, the potential pathways for exposure of human populations in the event of any release from the site, the degrees to which such releases could violate applicable standards and criteria, and a measure of the potential threats to public health that might result from such releases. The risk assessment consists of five steps, as follows:

STEP 1: Selection of Indicator Chemicals chooses a tractable number of chemical species from among those present, for quantitative estimates. If necessary, the indicator species should be chosen on the basis of higher mobility, greater toxicity, more persistence in the environment and/or higher concentrations. A screening procedure is available for use with complicated mixtures.

STEP 2: Estimation of Exposure Point Concentrations consists of identifying possible pathways for exposure of human populations to indicator chemical releases from the site, identifying the potential exposure points, and estimating the chemical releases and their subsequent environmental fate and transport via air, ground water, surface water and soils. Separate accountings must be made for pathways leading to oral intake, to

direct dermal intake, or to intake by ingestion, since each intake mechanism has separate toxicological data base.

The exposure pathways are reviewed to identify which of them may be "complete" pathways for exposure of human populations. An exposure pathway is comprised of a source and mechanism of chemical release; an environmental transport medium; a human exposure point and a feasible exposure route to the exposure point. If any one portion of the exposure pathway is missing, then exposure by that route is not possible.

The projected exposure levels may then be compared to Applicable or Relevant and Appropriate Requirements (ARARs), which include allowance for the intake mechanisms and the toxicological limits. If possible, determinations should be made for both acute and chronic (long-term) exposure. In the event that ARAR values are available for all indicator chemicals, it is not necessary to proceed with the remaining steps of the Risk Assessment Procedure.

STEP 3: Estimation of Chemical Intake attempts to quantify the actual human exposure, in order to assess possible adverse health effects. The exposure is expressed in terms of intake, i.e., the amount of a substance taken into the body per day, per unit body weight. Each of the media should be considered separately, due to their differing assumptions and variable data quality.

The intakes for each indicator chemical are combined separately for the oral and inhalation routes. Toxicological data generally keep these routes separate. For long-term (chronic) exposure, the oral (or the inhalation) intake rates are combined by summation. However, for the short-term (subchronic) exposure, where peak intakes are of interest, the largest individual intake for the given route would be appropriate.

STEP 4: Toxicity Assessment presents critical toxicity values for the indicator chemicals, to be used in conjunction with the results of exposure assessment for characterization of risks. The USEPA has developed a tabulation of values which describe the degree of toxicity posed by various chemicals, as follows:

acceptable intake for subchronic exposure (AIS),
acceptable intake for chronic exposure (AIC),
carcinogenic potency factor (carcinogens only),

The AIC and AIS values were derived from quantitative information available from animal toxicity studies and limited human epidemiological data, and stated in units of mg/kg body weight/day. The values are intended to be protective of sensitive populations. The carcinogenic potency factors have units of lifetime cancer risk per (mg/kg body weight/day).

STEP 5: Risk Characterization makes the comparison between projected intakes and reference levels for non-carcinogens. When carcinogens are present, Step 5 compares the calculated risks to target risks. This is in addition to eariler comparison of exposure point concentrations vs. applicable or relevant and appropriate requirements (ARARs) or other standards and criteria.

To assess the overall potential for non-carcinogenic effects posed by multiple chemicals, EPA developed a Hazard Index approach which assumes that multiple sub-threshold exposures may result in an adverse effect, and that the magnitude of the adverse effect will be in proportion to the summation of the ratios of the individual sub-threshold exposures (intakes) to acceptable intake levels for each chemical, i.e.,

$$\text{Subchronic Hazard Index} = (IS_1/AIS_1 + IS_2/AIS_2 + \ldots)$$

$$\text{Chronic Hazard Index} = (IS_1/AIC_1 + IS_2/AIC_2 + \ldots)$$

The assumption of additivity is best applied to compounds that induce the same effect by the same mechanism. Applying the Hazard Index to a mixture of compounds that are not expected to induce the same type of effects could overestimate the risk.

The Hazard Indexes are determined individually for the oral and the ingestion routes (and separately for subchronic and chronic exposures). It is not appropriate to combine the two because toxicity data are route specific.

The formal risk assessment procedure concludes with a review of site-specific factors that may increase uncertainty. Sensitive populations, such as hospitals or institutions, could require a more conservative interpretation of hazards. Exposure uncertainties and non-quantifiable exposure routes, overall data adequacy, non-indicator chemicals and chemical or biological interactions should be reviewed.

2. BASELINE RISK ASSESSMENT - EXISTING CONDITIONS

STEP 1: Selection of Indicator Chemicals: For the area near Building 49 affected by the discharges of torpedos testing wastewater, only two chemicals are of concern: Propylene Glycol Dinitrate (PGDN) and Cyanides.

PGDN is the principal component of Otto Fuel II, a combustible chemical in its purified form, which is stable at ambient conditions (and not flammable according to U.S. Department of Transportation criteria). It is chemically similar to Nitroglycerin and to Ethylene Dinitrate (EDN), a byproduct of Nitroglycerin manufacturing.

Mobility - PGDN is essentially immiscible with water, but soluble in organic solvents, such as acetone or methanol. Once absorbed in the soil, it can be mobilized only by erosion of the host soil particles. It is not volatile, hence the principal pathways for exposure are by dermal contact or by ingestion.

Toxicity - PGDN is known to have toxic effects on humans; low level acute occupational exposure affecting the nervous system has been discussed in the U.S. Navy Manual [2]. Its toxicity can be estimated, based on established limits for Nitroglycerin or EDN [3].

Persistence - Otto Fuel II is a mixture of PGDN with non-toxic organic stabilizer compounds. It is considered to have a useful shelf life exceeding two years in storage at ambient conditions.

Concentrations (detectable only in the top 1 ft of sample cores) - approximately 300 ft^2 area near the former discharge pipe site:

average of all detectable concentrations = 1900 mg/kg
maximum concentration observed = 4900 mg/kg

in the runoff stream sediments:

average of the two isolated samples with detectable concentrations = 160 mg/kg
maximum concentration observed = 240 mg/kg

Cyanides, which are present as a result of incomplete combustion of Otto Fuel in torpedo testing, are characterized as follows:

Mobility - Cyanides, being generally soluble in water, are capable of leaching either into surface runoff or into ground water flow. Cyanide concentrations of 0.24 to 1.2 mg/L were observed in the actual runoff stream flow.

Toxicity - Cyanides are notorious for toxicity to humans and animals, due to interference with oxygen metabolism.

Persistence - Cyanides do degrade in the environment. Under acidic conditions, cyanides are coverted to the volatile hydrocyanic acid (HCN) and released to the atmosphere. Other mechanisms of cyanide degradation, including ultraviolet light, bacterial action, and direct uptake by plants are known to occur [4].

Concentrations in the top 1 ft of sample cores) - (note that detectable, but generally much smaller concentrations are present further below the soil surface)

approximately 1,000 ft^2 area near the former discharge pipe:

average of all detectable concentrations = 10 mg/kg
maximum concentration observed = 54 mg/kg

in the runoff stream sediments:

average of all detectable concentrations	=	6 mg/kg
maximum concentration observed	=	18 mg/kg

in a belt of detectable, but low cyanide concentrations encircling Building 49, at distances of 75 to 300 ft:

average of all detectable concentrations	=	1 mg/kg
maximum concentration observed	=	4 mg/kg

STEP 2: Estimation of Exposure Point Concentrations - Table C-1 summarizes a qualitative exposure pathway analysis for the (existing conditions) baseline case, which reviews the sources and the potential mechanisms for chemical releases. The sources in this case are soils and sediments containing the chemical residues from torpedo test wastewater discharges. The mechanisms for release from these sources include volatilization and fugitive dust emission into air, leaching and erosion into surface water, leaching into ground water, and dermal contact. The qualitative exposure pathway analysis then considers the human populations that may be affected.

In a reasonable worst case scenario, land use following Closure of the Building 49 discharge areas, could become residential. Adults and children residing near the site would be chronically exposed by chemical inhalation of volatilized air emissions. The children could be exposed further by episodic ingestion of surface water and/or soil, as well as by direct dermal contact with the soil. Given the short length (120 ft.) and small size of the runoff stream and its episodic flows following rainfall or snow melt, adult ingestion of surface water would not be reasonable. No significant adult or child exposure to PGDN and cyanides seems possible via ingestion of ground water. The shallow ground water aquifer is not suitable for water supply, and there are no known water well users in the vicinity.

Additional episodic exposures may occur for the same population of adults and children residing near the Building 49 discharge area site (as well as many others). These exposures would be via ingestion of small game fowl and/or fish contaminated with cyanides and/or PGDN from Building 49. In the former case, ducks or geese that browsed for food in the former

discharge area south of Building 49 would have been exposed to PGDN and/or cyanides by the same pathways that affect the human residents. In the latter case, the fish would have been contaminated in Lake Erie near-shore waters by exposure to sediments containing PGDN and cyanides. (Soluble cyanides transported with the runoff stream would have at least thousand-fold dilution with runoff from other areas served by the TAPCO site storm sewer system. The runoff stream drainage area is estimated to be about 0.1 acre, including the approximately 600 ft^2 affected area, out of about 200 acres total for the TAPCO property.)

Table C-2 summarizes the estimated exposure point concentrations and lists the Applicable or Relevant and Appropriate Requirements (ARARs). The only complete pathway having an ARAR value available for comparison is for ingestion of cyanides from surface water, where the water quality limit of 0.2 mg/L is assumed to apply. The exposure point concentrations of 0.24 to 1.2 mg/L, which were observed in the runoff stream, exceed this ARAR, indicating risk for the children who ingest that water. Soluble PGDN concentrations would be negligible, since it is water-immiscible. Concentrations of PGDN in the runoff stream in particulate form (droplets or soil particles) were also assumed to be negligible, due to the episodic nature of the erosion process. However, the same children would be exposed to direct dermal absorption of PGDN by contact with contaminated soil and sediments.

Table C-3 summarizes the calculations of exposure point concentrations for inhalation by volatilization and subsequent dispersion in air. The volatilization of cyanide and PGDN was estimated, based on mass transfer rate coefficients which were used in a risk assessment on mineral leaching residues [5]. The estimates are for a worst case scenario, based on the coefficients for volatilization from shallow (1 inch depth) quiescent surface waters, at conditions of ambient temperatures and neutral or acidic pH. Dispersion in air was then estimated for a downwind distance of 50 ft (15 m), using a documented model [6]. Exposures due to the belt of detectable, but low cyanide concentrations are seen to be small compared to those from the former discharge area.

The exposure point concentration for direct dermal contact with PGDN is the observed 80 to 4900 mg/kg range in surface soils near the former discharge pipe from Building 49. In the absence of an ARAR value for this

exposure pathway of PGDN, Table C-2 lists the occupational health standard for PGDN's close relatives, Nitroglycerin and EDN.

The exposure point concentrations for ingestion of contaminated game fowl or fish were estimated assuming that an animal ingested 1 gram of contaminated soil and the PGDN and cyanide in that soil are retained in 1 kg of edible tissue, i.e., a dilution of 1:1000 from soil concentrations.

In a situation such as this, where one or more of the indicator chemicals does not have an ARAR value available, it is necessary to continue with the remaining steps of the Risk Assessment Procedure. Since no values have been established for acceptable intakes (AIC or AIS) for PGDN ingestion and for dermal contact with cyanide or PGDN, the formal Estimation of Chemical Intakes, the Toxicity Assessments and the Risk Characterization steps are partially based on assumed toxicologically conservative values of acceptable intake and must be regarded as semi-quantitative.

STEP 3: Estimation of Chemical Intake is summarized in Table C-4 for PGDN and cyanides. The calculations for exposed adults and children are based on reasonable worst case scenario human exposure factors for inhalation, ingestion and dermal contact. The ingestion and dermal contact intakes, although episodic, could take place simultaneously and would be additive to the chronic inhalation intake. On a body weight basis, the intakes by children are more significant than those for adults.

STEPS 4 and 5: Toxicity Assessment and Risk Characterization are sumarized in Table C-5, which compares the calculated intakes with acceptable intakes. Cyanide ingestion by children is seen to have a Hazard Index value exceeding 100 percent, confirming the earlier judgement based on exposure point concentrations exceeding the ARAR. Ingestion of surface water is the most significant intake route for this. In the absence of documented Acceptable Intake values for PGDN, hazard index values were not calculated. The principal PGDN intake routes are seen to be ingestion of soil and dermal contact.

3. RISK ASSESSMENT FOR REMEDIAL ALTERNATIVES

3.1 Risk Assessment Procedure for Remedial Alternatives

Remedial Alternatives can be classified as either source control or management of migration. Source control remedial actions reduce the amount of mobile contaminant present in the soil, before it has migrated much

beyond the initial discharge area, e.g., by excavation or by immobilization. Management of migration alternatives would address contaminants that have migrated away from the source to reduce the exposure point concentrations, e.g., by treating ground water or runoff. Whichever type of alternative is considered, the objective is to reduce the risk level for exposure point populations to be within an acceptable target risk range.

For non-carcinogens, an ARAR provides a specific target exposure point concentration as a performance goal for each indicator chemical. If no ARAR value is available, the intakes in mg/kg body weight for exposure point populations should be reduced to acceptable levels (AIC or AIS). For carcinogenic indicator chemicals, remedies must reduce exposure point chemical concentrations to levels associated with a carcinogenic risk range of 10^{-4} to 10^{-8}.

In general, the concentration of chemical residues in soil required to achieve the desired exposure point concentration for a given alternative is not known in advance. Thus, evaluation of alternatives follows a tiered approach, as follows:

1) Reassess the indicator chemicals to determine whether any additions are necessary (usually required only for management of migration alternatives, in the event that an indicator chemical; used for the baseline study is not treatable).
2) Determine exposure pathways for each alternative, if different from the baseline study (usually required only for management of migration alternatives).
3) Develop preliminary target concentrations, based either on ARAR or potential carcinogenic indicator chemicals. (Carcinogens usually drive the final design.)
4) If no ARARs are available for the non-carcinogenic indicator chemicals, estimate the long-term concentrations to ensure that acceptable risk levels (chronic hazard index) are attained.
5) Estimate the target release rates, i.e., back calculate release rates which would result in target concentrations at the exposure points. Repeat Steps 1 through 4, if necessary.
6) Assess potential short-term health effects of remedial alternatives, including subchronic exposures, management practices during

remediation, and any potential effects that might result from failure.

3.2 Remedial Alternatives for the Former Building 49 Spill Area

The remedial actions considered for the Building 49 torpedo test wastewater discharge area were source control alternatives. Although PGDN and cyanides have migrated away from the former discharge area due to erosion, only isolated locations in the runoff stream have been affected. The situation does not require management of migration alternatives.

It is Engineering-Science's (ES) opinion that no alternative can be considered acceptable, if it leaves the chemical residues near Building 49 unchanged. The cyanide concentrations may eventually decrease to acceptable levels due to chemical degradation, volatilization, bacterial action, plant uptake or leaching. However, in the absence of some remedial action, the threats to future resident populations discussed in the preceding section would abate very slowly.

It is recommended to undertake a remedial action to remove soil from the area of highest chemical residue concentrations, for appropriate disposal off site and with due precautions to avoid mobilization of PGDN or cyanide during removal (See Figures 5 & 6 in the Building 49 Study Report text and Appended Drawing 7). This would result in excavation of soil from an irregular polygon area (about 625 ft^2) around the former discharge pipe and dredging of the entire length of the runoff stream (about 120 ft). All soils containing detectable PGDN and/or cyanides at concentrations exceeding 10 mg/kg would be removed. However, soil outside of these areas containing cyanide at concentrations below 10 mg/kg would remain undisturbed. This is more stringent than the preliminary target concentration value of 20 mg/kg for cyanides in soil established in the U.S. Environmental Protection Agency guidance for "Clean Closures" [7].

Alternatives which would not involve removal of soil and sediments for treatment and disposal (i.e., capping the polygon area and regrading to divert both surface runoff and ground water flow from that area) were considered qualitatively. However, any such remedial action would be required to include facilities for monitoring and control of any leachate and/or post-closure ground water quality monitoring for at least 30 years.

3.3 Quantitative Risk Assessment for the Recommended Alternative

A formalized risk assessment of the soil excavation for off-site treatment and disposal alternative follows. This risk assessment evaluates the hazards that may result from allowing low concentrations of cyanide, below 10 mg/kg, to remain in the soil on site, based on the rationale that the cyanide concentrations which would leach into surface water or ground water would not pose a risk for public health. A similar rationale was followed in recent actions by State agencies and the USEPA with respect to cyanides in mineral processing residues [5].

STEP 1: Review of Indicator Chemicals is cursory at this stage, since PGDN will have been removed to below detectable concentrations. Only Cyanides will be of concern.

Concentrations:

near the former discharge pipe site, cyanides will have been removed to below 10 mg/kg, with the resultant distribution in an approximately 400 ft^2 area as follows:

average of all detectable concentrations = 2 mg/kg
maximum concentration remaining = 5 mg/kg

in the runoff stream, the entire channel will have been dredged, which will remove all cyanides previously there;

however, the belt of soil encircling Building 49 containing detectable, but low cyanide concentrations, will remain as before:

average of all detectable concentrations = 1 mg/kg
maximum concentration observed = 4 mg/kg

STEP 2: Estimation of Exposure Point Concentrations is concerned only with Cyanides, and only for the same resident human populations as in the Baseline Assessment. The exposure pathways previously identified for cyanides would remain, but with decreased exposure point concentrations. The exposure point concentration estimates in Table C-6 are based on reductions of the affected area size and its cyanide concentrations. The recommended remedial action will reduce the soil area containing cyanides

to about 40 percent of its original size, and the average of detectable cyanide concentrations would be about 20 percent of the present value. Thus, the amount of cyanides remaining in the former discharge would be about 8 percent of the present quantity. Air emissions and leaching should be reduced by 92 percent.

The target concentration for cyanide at the exposure points are the ARARs value listed in Table C-6, which are based on Preliminary Target Values for Clean Closures [7]. It is seen that the estimated exposure point concentrations of cyanide do not exceed these values, hence, the recommended remedial action would be adequate.

STEPS 3 THROUGH 5: Estimation of Chemical Intakes, Toxicity Assessment and Risk Characterization are summarized in Tables C-7 and C-8. The intake estimates are based on 92 percent reductions of the exposure point concentrations for cyanides from the former discharge area and unabated exposure point concentrations due to the encircling belt of detectable, but low concentrations of cyanides. The resultant hazard index reductions for cyanide ingestion by children to well below 100 percent confirms the projected efficacy of the proposal remedial action.

TABLE C-1

QUALITATIVE ANALYSIS OF EXPOSURE PATHWAYS

Air Emissions

Mechanism: Volatilization from surface soil or ponded surface water
Release Time Frame: chronic
Release amounts:
PGDN - low: vapor pressure = 0.9×10^{-4} atmospheres at 77°F for PGDN in pure liquid form
Cyanide - Low, and requires neutral or acidic pH to be mobilized for air emission. Estimated vapor pressure of HCN for water containing 1 mg/L of cyanide = 0.7×10^{-6} atmospheres at 77°F
Primary Exposure Points:
Future residents within 500 feet of the site
Exposure Route: Inhalation
Pathway Completion: Possible

Mechanism: Fugitive Dust Generation
Release Time Frame: episodic, at times of high wind
Release amounts: low, due to generally wet environment for soils and sediments
Primary Exposure Points:
Future residents within 500 feet of the site
Exposure Route: Inhalation
Pathway Completion: Very unlikely, due to low amounts released

Surface Water Runoff (overland flow and ground water flow discharging into the runoff stream)

Mechanism: Leaching
Release Time Frame: chronic
Release amounts:
PGDN - none: not miscible with water
Cyanide - low, ranging from 0.01 to 1 gram/day, based on observed concentrations and flows
Primary Exposure Points:
Children in the discharge area, drinking from the runoff stream
Exposure Route: Ingestion
Pathway Completion: Possible

Mechanism: Erosion of soil particles
Release Time Frame: episodic, following heavy rainfall
Release amounts: low, only occasional isolated particles have been released, based on sampling results for runoff stream sediments
Primary Exposure Points:
Residents of the Metropolitan Area:
Exposure Route: Ingestion of fish from Lake Erie near shore waters contaminated by sediments transported through the runoff stream, the TAPCO Plant storm sewers and the city of Euclid storm sewers into Lake Erie.

TABLE C-1
(continued)

QUALITATIVE ANALYSIS OF EXPOSURE PATHWAYS

Pathway completion:
Possible, but highly unlikely, due to episodic time frame and isolated individual particles

Ground Water (shallow aquifer)
Mechanism: Leaching
Release Time Frame: chronic
Release amounts:
PGDN - none: not miscible with water
Cyanide - low, based on concentrations below the detection limit observed in the ground water monitoring wells and detectable, but low concentrations found in subsurface soil samples below 1 ft.
Primary Exposure Points:
Drinking water well users downgradient from the site
Exposure Routes: Ingestion and Dermal Absorption
Number of Persons Potentially Exposed:
None: the shallow ground water aquifer is not suitable as a water supply for any significant use. Domestic water supplies in the area use Lake Erie water.
Pathway Completion: not complete

Soils and Sediments containing PGDN and/or Cyanides
Mechanism: Ingestion
Release Time Frame: episodic
Release amounts:
PGDN - low
Cyanide - negligible
Primary Exposure Points:
Children in the discharge area:
Exposure Routes: Ingestion
Pathway Completion: Possible

Mechanism: Dermal Contact
Release Time Frame: episodic
Release amounts:
PGDN - low
Cyanide - negligible
Primary Exposure Points:
Children in the discharge area:
Exposure Routes: Dermal Absorption
Pathway Completion: Possible

Mechanism: Ingestion and/or Dermal Contact
Release Time Frame: episodic
Release amounts:
PGDN - low
Cyanide - negligible

TABLE C-1
(continued)

QUALITATIVE ANALYSIS OF EXPOSURE PATHWAYS

Primary Exposure Points:
Residents of the Metropolitan Area:
Exposure Routes: Ingestion of ducks or geese that browsed for food in the former discharge area
Pathway Completion: Possible, but highly unlikely

Table C-2

BASELINE EXPOSURE POINT CONCENTRATIONS (EPCs) AND APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

Pathways	Cyanides	PGDN
Air/Volatilization/Inhalation		
EPC, mg/m3 (a)	0	0
ARAR, mg/m3	0 (b)	0 (c)
Water/Leaching/Ingestion		
EPC, mg/L	1	not applicable
ARAR,mg/L	0 (d)	n/a (e)
Soil/Ingestion		
EPC, mg/kg	54	4,900
ARAR,mg/kg	20 (b)	n/a
Soil/Animal Contact/Ingestion		
EPC, mg/kg	0	5
ARAR,mg/kg	n/a	n/a
Soil/Dermal Contact		
EPC, mg/kg	54	4,900
ARAR,mg/kg	20 (b)	n/a

(a) Table C-3, calculation for atmospheric stability class E

(b) Preliminary target concentration for clean closure [7]

(c) 2 mg/m3 occupational health standard [3] divided by 42

(d) Drinking Water Standard [1]

(e) no ARAR value currently available [1]

Table C-3

Estimation of Exposure Point Concentrations
Inhalation of Volatilized Cyanides and PCDN

	Cyanides			PCDN		
Transfer coefficient (quiescent)	0.46 mg/hr/m2/(mg/L)			0.016 kg moles/hr/m2/a		
Stability Class	F	E	D	F	E	D
Wind velocity, m/s	1.0	2.0	3.0	1.0	2.0	3.0
Transfer coefficient (wind agitated)	0.85	0.80	0.92	0.023	0.028	0.032
Baseline Case	**Former Discharge Area**					
Maximum Driving Force	1.2 mg/L			9.0E-05 atmosphere		
Transfer Area	92 m2			27 m2		
Volatilization rate	72	88	102	1430	1751	2022
Distance Downwind (x)	0.015 km			0.015 km		
Sigma y, m (horizontal)	0.7	1.0	1.4	0.7	1.0	1.4
Sigma z, m (vertical)	0.6	0.9	1.2	0.6	0.9	1.2
Conc. at (x), mg/m3	0.0155	0.0042	0.0018	0.308	0.084	0.036
Baseline Case	**Border Bing Area**					
Maximum Driving Force	0.12 mg/L			not applicable		
Transfer Area	100 m2					
Volatilization rate	7.8	9.6	11.0			
Distance Downwind (x)	0.015 km					
Sigma y, m (horizontal)	0.7	1.0	1.4			
Sigma z, m (vertical)	0.6	0.9	1.2			
Conc. at (x), mg/m3	0.0017	0.0005	0.0002			

Reference: Superfund Exposure Assessment Manual, OSWER Directive 9285.5-1
Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency, Washington, January, 1986; pp. 4-17 through 4-21

TABLE C-4

CALCULATION OF BASELINE HUMAN INTAKES

Inhalation

20 cu m/day	70 kg adult	0.29 cu m/kg/day-adult
10 cu m/day	17 kg child	0.59 cu m/kg/day-child

Exposure Point Conc.

0.0022 mg/cu Cyanides	0.069 mg/cu m	PGDN

Intake

0.0006 mg/kg/day-adult	0.02 mg/kg/day-adult
0.0013 mg/kg/day-child	0.04 mg/kg/day-child

Ingestion from surface water

0.0 L/day	70 kg adult	0.000 L/kg/day-adult
0.5 L/day	17 kg child	0.029 L/kg/day-child

Exposure Point Conc.

1.2 mg/L Cyanides	0.00 mg/L	PGDN

Intake

0.000 mg/kg/day-adult	0.00 mg/kg/day-adult
0.035 mg/kg/day-child	0.00 mg/kg/day-child

Ingestion from soil and sediments

0.000 kg/day	70 kg adult	0.0E+00 kg/kg/day-adult
0.001 kg/day	17 kg child	5.9E-05 kg/kg/day-child

Exposure Point Conc.

240 mg/kg Cyanides	4900 mg/kg	PGDN

Intake

0.000 mg/kg/day-adult	0.00 mg/kg/day-adult
0.014 mg/kg/day-child	0.29 mg/kg/day-child

Ingestion of Contaminated Game Fowl or Fish

0.50 kg/day	70 kg adult	0.007 kg/kg/day-adult
0.25 kg/day	17 kg child	0.015 kg/kg/day-child

Exposure Point Conc.

0.054 mg/kg Cyanides	4.9 mg/kg	PGDN

Intake

0.0004 mg/kg/day-adult	0.035 mg/kg/day-adult
0.0008 mg/kg/day-child	0.072 mg/kg/day-child

Dermal Contact with Contaminated Soil and/or Sediments

0.0 kg/day	70 kg adult	0.000 kg/kg/day-adult
1.0 kg/day	17 kg child	0.059 kg/kg/day-child

Exposure Point Conc.

0.054 mg/kg Cyanides	4.9 mg/kg	PGDN

Intake

0.0000 mg/kg/day-adult	0.000 mg/kg/day-adult
0.0032 mg/kg/day-child	0.288 mg/kg/day-child

Table C-5

BASELINE RISK CHARACTERIZATION

		Cyanides	PGDN
Adults			
	Inhalation Intake, mg/kg/day	0.0006	0.02
	AIC, mg/kg/day	0.02 (a)	n/a (b)
	Hazard Index	3%	
	Ingestion Intake, mg/kg/day		
	Surface water	0.0000	0.000
	Soil & sediments	0.0000	0.000
	Contaminated fish/fowl	0.0004	0.035
	Total	0.0004	0.035
	AIC, mg/kg/day	0.02 (a)	n/a
	Hazard Index	2%	
	Dermal Intake, mg/kg/day	0.0000	0.000
	AIC, mg/kg/day	n/a	n/a
	Hazard Index	--	
Children			
	Inhalation Intake, mg/kg/day	0.0013	0.04
	AIC, mg/kg/day	0.02 (a)	n/a (b)
	Hazard Index	7%	
	Ingestion Intake, mg/kg/day		
	Surface water	0.035	0.00
	Soil & sediments	0.014	0.29
	Contaminated fish/fowl	0.001	0.07
	Total	0.050	0.36
	AIC, mg/kg/day	0.02 (a)	n/a
	Hazard Index	249%	
	Dermal Intake, mg/kg/day	0.0032	0.288
	AIC, mg/kg/day	n/a	n/a
	Hazard Index	--	

(a) Reference Dose Value (RfD) [1]

(b) no AIC value available

Table C-6

PROPOSED EXPOSURE POINT CONCENTRATIONS (EPCs) AND
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

Pathways	Cyanides	PGDN
Air/Volatilization/Inhalation		
EPC, mg/m3	0.0003 (a)	not applicable
ARAR, mg/m3	0.07 (b)	n/a (c)
Water/Leaching/Ingestion		
EPC, mg/L	0.1 (a)	not applicable
ARAR,mg/L	0.2 (d)	n/a
Soil/Ingestion		
EPC, mg/kg	4 (a)	not applicable
ARAR,mg/kg	20 (b)	n/a
Soil/Animal Contact/Ingestion		
EPC, mg/kg	0.004 (a)	not applicable
ARAR,mg/kg	n/a	n/a
Soil/Dermal Contact		
EPC, mg/kg	4 (a)	not applicable
ARAR,mg/kg	20 (b)	n/a

(a) EPC values for Cyanides from Table C-2, reduced by 92%

(b) Preliminary target concentration for clean closure [7]

(c) no ARAR value currently available [1]

(d) Drinking Water Standard [1]

TABLE C-7

CALCULATION OF HUMAN INTAKES FOR PROPOSED REMEDIAL ACTION

Inhalation

20 cu m/day	70 kg adult	0.29 cu m/kg/day-adult
10 cu m/day	17 kg child	0.59 cu m/kg/day-child

Exposure Point Conc.

0.00018 mg/cu Cyanides	0.0055 mg/cu m	PGDN

Intake

0.00005 mg/kg/day-adult	0.002 mg/kg/day-adult
0.00010 mg/kg/day-child	0.003 mg/kg/day-child

Ingestion from surface water

0.0 L/day	70 kg adult	0.000 L/kg/day-adult
0.5 L/day	17 kg child	0.029 L/kg/day-child

Exposure Point Conc.

0.096 mg/L Cyanides	0.0000 mg/L	PGDN

Intake

0.0000 mg/kg/day-adult	0.0000 mg/kg/day-adult
0.0028 mg/kg/day-child	0.0000 mg/kg/day-child

Ingestion from soil and sediments

0.000 kg/day	70 kg adult	0.0E+00 kg/kg/day-adult
0.001 kg/day	17 kg child	5.9E-05 kg/kg/day-child

Exposure Point Conc.

19 mg/kg Cyanides	392 mg/kg	PGDN

Intake

0.0000 mg/kg/day-adult	0.000 mg/kg/day-adult
0.0011 mg/kg/day-child	0.023 mg/kg/day-child

Ingestion of Contaminated Game Fowl or Fish

0.50 kg/day	70 kg adult	0.007 kg/kg/day-adult
0.25 kg/day	17 kg child	0.015 kg/kg/day-child

Exposure Point Conc.

0.0043 mg/kg Cyanides	0.4 mg/kg	PGDN

Intake

0.00003 mg/kg/day-adult	0.003 mg/kg/day-adult
0.00006 mg/kg/day-child	0.006 mg/kg/day-child

Dermal Contact with Contaminated Soil and/or Sediments

0.0 kg/day	70 kg adult	0.000 kg/kg/day-adult
1.0 kg/day	17 kg child	0.059 kg/kg/day-child

Exposure Point Conc.

0.0043 mg/kg Cyanides	0.4 mg/kg	PGDN

Intake

0.00000 mg/kg/day-adult	0.000 mg/kg/day-adult
0.00025 mg/kg/day-child	0.023 mg/kg/day-child

Table C-8

RISK CHARACTERIZATION FOR PROPOSED REMEDIAL ACTION

	Cyanides	PGDN
Adults		
Inhalation Intake, mg/kg/day	0.00005	not applicable
AIC, mg/kg/day	0.02 (a)	n/a (b)
Hazard Index	0.24%	
Ingestion Intake, mg/kg/day		not applicable
Surface water	0.00000	
Soil & sediments	0.00000	
Contaminated fish/fowl	0.00003	
Total	0.00003	
AIC, mg/kg/day	0.02 (a)	n/a
Hazard Index	0.16%	
Dermal Intake, mg/kg/day	0.00000	not applicable
AIC, mg/kg/day	n/a	n/a
Hazard Index	--	
Children		
Inhalation Intake, mg/kg/day	0.0001	not applicable
AIC, mg/kg/day	0.02 (a)	n/a
Hazard Index	0.5%	
Ingestion Intake, mg/kg/day		not applicable
Surface water	0.0028	
Soil & sediments	0.0011	
Contaminated fish/fowl	0.0001	
Total	0.0040	
AIC, mg/kg/day	0.02 (a)	n/a
Hazard Index	20%	
Dermal Intake, mg/kg/day	0.0003	not applicable
AIC, mg/kg/day	n/a	n/a
Hazard Index	--	

(a) Reference Dose Value (RfD) [1]

(b) no AIC value available

APPENDIX C

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   NOTE: Reprints are provided of References [4] and [5], in Appendices D and E, respectively.

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CYANIDES IN THE ENVIRONMENT WITH PARTICULAR ATTENTION TO THE SOIL

by
Wallace H. Fuller[1]

ABSTRACT

The frequency in the identification of groundwater and other environment contamination has placed an additional burden on the already overburdened land in the volume of waste that must be accepted for ultimate disposal. If the soils are not effective in confining the wastes, migration of hazardous constituents into groundwater and food chains will occur. As a result of this vulnerability, the soil as a waste treatment/utilization system must receive special research attention. Cyanide-yielding wastes contain some of the hazardous chemicals demanding immediate attention for this soil treatment/utilization effort.

The purpose of this presentation is to provide information regarding the behavior of cyanide and cyanide-yielding chemicals in soils and the surrounding environment under anaerobic and aerobic conditions. In aerobic soils, the most prominent reactions of environmental concern involve nitrification and, in general, the fate of ammonia, nitrite, nitrate, and nitrogen gas. Under anaerobic soil conditions, the most prominent reactions of environmental concern involve attenuation, precipitation as complexes, denitrification, and transport. This presentation centers on these concerns with respect to utilization of cyanide nitrogen by plants at different loading rates, and considers the factors affect nitrification of cyanamid, dicyanodiamid, guanidine and guanidine nitrate, dicyanodiamidine sulfate (guanylurea sulfate), thiourea, and melamine under different soil conditions. In addition, the mobility of KCN (simple form), $K_3Fe(CN)_6$ (complex form) in aqueous solution, and KCN in natural municipal solid-waste landfill leachate (mixed forms) through five soils of varying physical and chemical properties at rates of 100 and 200 ppm CN^- is described. The soil characteristics that govern the movement of the various cyanide forms in soils are also described and evluated.

INTRODUCTION

New sensitivity toward nature requires us to search for new answers about the environment that surrounds us. A busy area of research, presently, involves the study of toxic wastes in soils. The soil, like the air, is a most abundant natural environmental system

[1] Wallace H. Fuller, Professor, Soils, Water and Engineering, The University of Arizona, Tucson, AZ. 85721.

with which human beings make contact not only directly but indirectly by dust that is breathed, water that infiltrates soil and is pumped for drinking, through food nourished bythe soil, as are plants, and animals nourished in turn by plants. The soil has proven to be an acceptable waste receptacle. Cyanamide as a waste is not an exception. Soils will always play an important part in waste disposal despite trends toward recycling of waste constituents. Moreover, the air, rivers and streams must be recognized as overloaded vehicles of waste transport back to the land. Recent sensitivity to and restrictions on disposal methods used heretofore, such as ocean dumping, serve to emphasize the burden that the land must assume. The threat of contamination in underground water resources and food chains can worsen as disposal volume paces populations and industrial expansion. Control measures must be expanded to lessen the threat of environmental pollution. The soil is a key factor in this control.

The soil is the oldest and most effective chromatographic column in the history of the world. Soil is the unconsolidated outer cover of the earth and represents the weathered product of environmental factors at any specific location. Soils differ in characteristics just as do plants and animals. Thus there are prairie and forest soils; thin soils on steep slopes and thick soils on broad ridges; alluvial, residual, and presoils. Soils differentiate into horizons, A, B, C, with depth. Each horizon is quite different from the other. Soils also differ greatly from one place to another, yet they perform the same unique activities of biodegrading, precipitating, attenuating, sorbing/desorbing, structuring, and integrating every chemical behavior known, or still unknown, to mankind.

To realize the effectiveness of soil in a waste disposal system as a barrier (though a leaky one) to migration, one should begin with an understanding of the soil properties and the way they interact with wastes and their leachates, and specific pollutants such as toxic constituents. There are three major components of the waste disposal environment which interact in any waste that reaches the earth's surface. These must be identified, described, and quantitatively evaluated. They are:

1. The porous medium through which the constituents are transported (e.g. soil, clay, sand, gravel),
2. The vehicle of transport that carries the polluting constituents or is itself the pollutant (e.g. aqueous leachates, organic solvents, oil etc.), and
3. The specific polluting constituent itself (e.g. soluble heavy metal salts, radionucleides, organic compounds, carcinogens, etc.).

All three are important in management of wastes since they are involved in attenuation of the polluting constituents, interact with each other, and change with time.

CYANIDE VERSATILITY

Cyanides appear in a great variety of forms and in a great number of classes of organic and inorganic compounds in nature. Each of the classes contain a cyano group (C=N) as part of its molecule.

Taras (1971) refers to cyanide in industrial waste as all of the CN^- groups present in the cyanide compound that can be determined as cyanide ion, CN^-, by the Liebig distillation method. The CN^- ion is a negatively charged, diatomic species with a sigma bond, two pi bonds, and two empty pi anti-bonding orbitals. These bondings give cyanides unusual properties, particularly in metal-cyanide complexes (Huiatt, et al., 1983).

Cyanides may be classified into four broad groups for this discussion:

1. Free cyanides - CN^- and HCN
   In solution the relationship is highly pH dependent
   $$CN^- + H_2O \rightleftharpoons HCN + OH^-$$
   (Figure 1). The pKa of HCN is at pH 9.367 where the concentrations of CN^- and HCN are equal.
2. Simple cyanides - $A(CN)_x$ where A is an alkali or a metal and x is the valence of A and represents the number of cyano groups present. Cyanide ions are released when alkali cyanides ionize according to:
   $$A(CN)_x \rightleftharpoons A^{+x} + x\ CN^-$$
   $$KCN + H_2O \rightleftharpoons KOH + HCN^-$$
3. Complex cyanides - $AyM(CN)_x$ where: A is the alkali, y is the number of alkalies (Na, K, NH_4); M is the heavy metal)(Fe^{+++}, Fe^{++}, Cd^{++}, Cu^{++}, Ni^{++}, Ag^{++}, etc.) and x is the number of CN groups equal to the valence of A taken y times plus the valence of the heavy metal. Soluble complex cyanides dissociate into complex ions and not CN groups (e.g.):
   $$AyM(CN)_x;\ [M(CN)_x]^{-yw}$$
   W is the oxidation state of A in the original molecule. Further dissociation can take place releasing CN^- ions. Again this reaction is highly pH dependent (Figure 1).

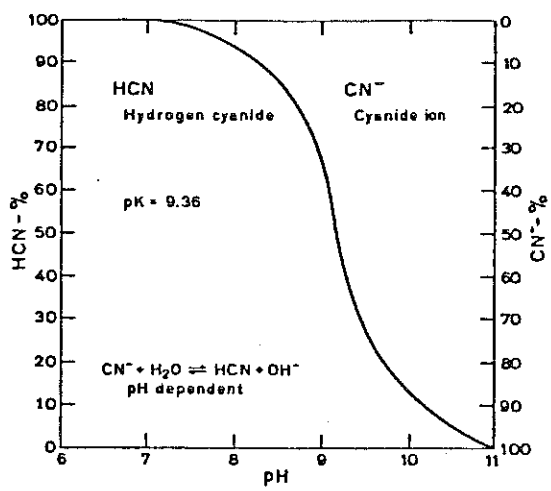


Figure 1. The effect of pH on dissociation of hydrogen cyanide.

4. Organic cyanide-yielders - Represented by cyanogenic (nitriles) glycosides. Glycosides yield one (or more) sugar and one (or more) other compound (e.g. aglycones) when hydrolyzed in vitro by dilute mineral acids or in vivo by enzymes. They are widely distributed in nature.

Cyanides vary in stability in water as illustrated in Table 1 (Scott, 1981). Because of the toxicity of CN^-, the formation of a more stable cyanide has been a significant factor in the activity of biological systems. At the normal pH's and temperatures of streams, the dissociated cyanide ion (CN^-) is toxic to most species of fish at a level of 0.1 mg/liter. Complexed cyanides are far less toxic, and discharge of relatively large concentrations of these compounds to receiving streams is not immediately harmful. Consequently, it has been suggested that cyanide be complexed with metals such as iron, prior to discharge, to reduce toxicity.

CYANIDE DISTRIBUTION IN NATURAL ENVIRONMENTS

PLANTS

Cyanide-yielding organic compounds are introduced naturally into the environment, particularly the soil, by a great number of living systems. One of the most common natural sources originates from plants (Table 2). Over 800 species of plants (70 to 80 families) synthesize cyanogenic glycosides (Knowles, 1976). They are characterized most abundantly by the glycosides that yield hydrocyanic acid (HCN) upon hydrolysis. One of the best known cyanogenetic (or cyanophoric) glycosides occurs in members of the Rosaceae family and are called amygdalin (Kingsbury, 1964). The chemical reaction is diagrammed in Figure 2. The amount of amygdalin glycogen accumulated by a single plant varies between species, depending on environmental conditions--for example, plants that have wilted, frosted, or have been stunted are most suspect in the incidence of HCN rumen poisoning than unstressed plants.

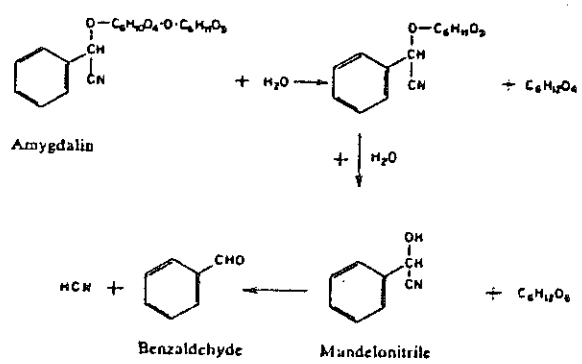


Figure 2. Pathways in the hydrolysis of a cyanogenic glycoside, Amygdalin, yielding HCN

Higher plants have the capacity to metabolize sublethal doses of

administered cyanide (Towill, et al., 1978), as have animals. There is belief that all higher plants possess this ability through a reaction between various forms of sulfur (polysulfides and thiosulfate) such as:

$$S_x^{2-} + CN^- \rightleftharpoons [S_{(x-1)}]^{2-} + SCN$$

$$S_2O_3^{2-} + CN^- \rightleftharpoons SO_3^{2-} + SCN^-$$

TABLE 1. Relative stabilities of some common cyanide complexes in water

Stability ratings in water	Examples of cyanides in processing solutions
1. Free cyanide	CN^-, HCN
2. Simple compounds	
a. readily soluble	NaCN, KCN, $Ca(CN)_2$, $Hg(CN)_2$
b. relatively insoluble	$Zn(CN)_2$, CuCN, $Ni(CN)_2$, AgCN
3. Weak complexes	$Zn(CN)_4^{2-}$, $Cd(CN)_3^-$, $Cd(CN)_4^{2-}$
4. Moderately strong complexes	$Cu(CN)_2^-$, $Cu(CN)_3^{2-}$, $Ni(CN)_4^{2-}$, $Ag(CN)_2^-$
5. Strong complexes	$Fe(CN)_6^{4-}$, $Co(CN)_6^{4-}$, $Au(CN)_2^-$

TABLE 2. Selected Plants with Cyanogenic Potential

Species name	Common name
Acacia greggii	catclaw
Bahia opositifolia	bahia
Cercocarpus spp.	mountain mahogany
Florestina tripteris	florestina
Glyceria striata	fowl mannagrass
Holcus lanatus	velvet grass
Hydrangea spp.	hydrangea
Linum spp.	flax
Lotus corniculatus	birdsfoot trefoil
Manihot esculenta	cassava
Phaseolus lunatus	lima bean
Prunus spp.	cherries
Pyrus malus	apple
Sorghum spp.	sudan grass, Johnsongrass, etc.
Stillingia treculeana	queen's delight
Suckleya suckleyana	poison suckleya
Trifolium repens	white clover
Triglochin spp.	arrowgrass
Vicia sativa	vetch seed
Zea mays	maize, corn

MICROORGANISMS

It has been postulated that cyanides accumulate in soils via biological degradation of plants that produce abundant cyanogenic glycosides, such as sorghum (Raugaswami, et al., 1962). Cyanides may also be generated by a great number of soil microorganisms including fungi, bacteria, actinomycetes, and algae. Bach (1956), for example, identified 31 fungal species and many genera that elaborate cyanogenic glycosides. Many well known bacteria possess this capacity (Michael and Corpe, 1965; Knowles, 1976).

When the hypothesis for cyanide accumulation was tested by Strobel (1967) using $^{14}C^{15}N$, he found that the soils most active in utilizing cyanides were those associated with plants that produced cyanogenic glycosides most abundantly. Moreover, nonsterile soil converted cyanide to carbonate and nitrate, whereas sterile soil did not appreciably alter cyanide. Many bacteria, fungi, and algae are capable of utilizing cyanides (Strobel, 1967; Allen and Strobel, 1966; Ware and Painter, 1955; and Towill, et al., 1978, to name a few). Not only is there chemical evidence for cyanide transformation and degradation but there is enzymatic evidence. Cyanides do not accumulate in soils under natural conditions.

SOILS

Cyanides are introduced into the soil from natural sources and through the activities of mankind. The cyanides from natural sources do not persist in the soil. The relatively small amounts produced are readily attached by soil microorganisms and converted to carbonate and ammonia. The soil microorganisms rarely, if ever, leave organic compounds immune to biodegradation. Some cyanide may be released to the atmosphere and dispersed depending on the pH and red/ox of the soil environment. For example, an anaerobic autotrophic actinomycetes species common to sewage, was identified (Ware and Painter, 1955) which grows well on silica gel containing only KCN as a carbon and nitrogen source. The high chemical reactivity of most cyanide also does not permit the accumulation of any significance. Cyanide (CN^-), up to 200 ppm at least, is readily converted to fertilizer nitrogen in the soil (Fuller, et al., 1950a). In fact, levels of many cyanides equivalent to the nitrogen requirements of cultivated crops support plant response, which is almost identical to that from other nitrogen sources such as sodium or ammonium nitrate on an equivalent N basis (Fuller, et al., 1950b).

Cyanide is one of nature's most toxic substances. The level of toxicity of the more stable cyanides depends on the metal present and on the proportion of CN^- groups converted to simpler alkali cyanides. The estimated concentration of cyanide (CN^-) in waste streams of cyanide users, varies from 100 to 50,000 mg/ℓ depending on the efficiency of the manufacturer and process used (Rudolph, 1953). Although the numerous cyanides discharged as wastes differ from each other with respect to their impact on the environment, the loading rate in soil is the paramount factor determining toxicity to microorganisms or hazard for movement into groundwater and food chains. High concentrations in the environment usually are associated with accidental spills or improper waste disposal (Towill et al., 1978).

Because of the high reactivity, low levels do not exist in the soil. Some of the reactions attributed to the low levels of cyanides in soils are:

- Biological dissemination and assimilation
  (metabolism)
- Microbial transformation to CO_2, H_2O, NH_3, and metals
  (hydration and oxidation)
- Dispersion to the atmosphere as gases and/or to water sources
  (translocation, volatilization, and dispersion)
- Complex formations with metals
  (chelation)
- Chemical combination and precipitation
  (precipitation)
- Adsorption to surfaces
  (surface physical chemistry)
- Photodegradation

WATER

Cyanides have not appeared in drinking water sources except for a rare few accidents in history. Nevertheless, threshold limits of drinking water (0.01 HCN/ℓ) have been suggested (U.S. PHS, 1961; U.S. EPA, 1980). Because of the notorious toxicity of cyanide, mining wastes receive treatment before exposure to the surrounding environment. Leaching of mining overburden and gangue does not contribute to cyanide pollution of water. Waters containing leachate from mine tailings where cyanides were used have produced no significant cyanide pollution to surrounding waters. However, during 1980 and 1981 the Public Health Service staff, I am told, became concerned over cyanide-leach-mining that expanded with the high gold and silver prices. Several important references (Resnick et al., 1958; Towill, 1978; and Ecological Analysts, Inc., 1979; Scott, 1981; and Huiatt, 1983) will bring the reader up to date on cyanides in water. Adequate knowledge is available for controlling cyanide pollution in water environments.

AIR

Cyanides find a way into the atmosphere or air primarily from free cyanides in wastewaters collected in lagoons and ponds. Cyanide can enter the atmosphere readily from free-water surfaces. Both HCN and CN^- are in equilibrium in water at a pH of 9.36. HCN is a weak acid with a dissociation constant of 4.365×10^{-10} at 20C and a boiling point of 25.7C. The molecular HCN, therefore, has a high vapor pressure and consequently volatilizes readily into the atmosphere. Factors affecting rate of volatilization include:

- pH value - lower pH levels favor volatilization,
- Temperature - higher temperatures favor volatilization,
- Liquid turbulence - higher turbulences favor volatilization,
- Liquid surface area - higher surface-area ratio to depth of liquid favors volatilization, and
- Concentration of free cyanide - higher solution concentrations favor volatilization.

According to The Chester Engineers (1979) cyanide volatilizes at a rate of 0.021 mg CN/ft^2-hr from still water surfaces containing a concentration range of 0.1 to 0.5 mg/ℓ.

CYANIDE REACTIONS IN THE SOIL

NATURAL SOURCES

The soil as a weathered system does not contain cyanides nor does it generate cyanides, except indirectly in supporting the growth of microorganisms, plants, and other intimate soil life. In fact, soil organic matter inactivates the toxic effects of cyanide as a result of its affinity for combining. Cyanides that enter the soil from the low-level natural sources are rapidly biodegraded and quickly metabolized by soil microorganisms. Strobel (1967) was unable to isolate cyanides from soils growing sorghum, a plant that not only produces cyanogenic glycosides in abundance but grows luxuriously to yield large amounts of plant residue.

PESTICIDES

Pesticides are examples of many cyanides and cyanide-yielding substances that end up in the soil environment over large areas for beneficial use. A list of pesticides, grouped according to six general classes that either contain cyanide radicals or may be metabolized into yielding cyanide radicals, has been compiled in Table 3. Four general groups were identified: dithiocarbamate, triazine, triazol, and pyrethroid. In addition, cyanide capsules and calcium cyanide are used for special purposes. Despite their regular use on agricultural crops and noncrops, cyanides do not accumulate. They biodegrade easily and convert readily to harmless constituents, and some of them even end up becoming valuable nitrogen (HN_4^- and NO_3^-) plant nutrients. The soil microorganisms quickly take advantage of the low levels of readily metabolizable energy sources that reach the soil as a result of pest control applications. Because of this, the compounds listed in Table 3, which represent at least 24 individual marketed pesticides, are considered as among the safest commercial agricultural chemicals used to improve food and fiber production.

FERTILIZERS

Establishment of Cyanides as Fertilizers

The realization that cyanides can be used as fertilizers for agricultural crops is not new. Pioneers of this practical application date back to Miller, 1906; Robine, Lenglen, and LeClere, 1906; Cowie, 1919a,b). And again in 1945a,b. At about this same time, an extensive laboratory and field study was undertaken in Arizona to compare the nitrifying characteristics of some cyanides and cyanide-yielding compounds (Table 4) for commercial fertilizer purposes (Fuller et al., 1950a,b). Calcium cyanamide, dicyanodiamide, guanidine nitrate, guanylurea sulfate, and thiourea were found to nitrify rapidly and compare favorably with the more conventional fertilizers, ammonium sulfate and urea, in Arizona soils when applied at a rate of 100 and

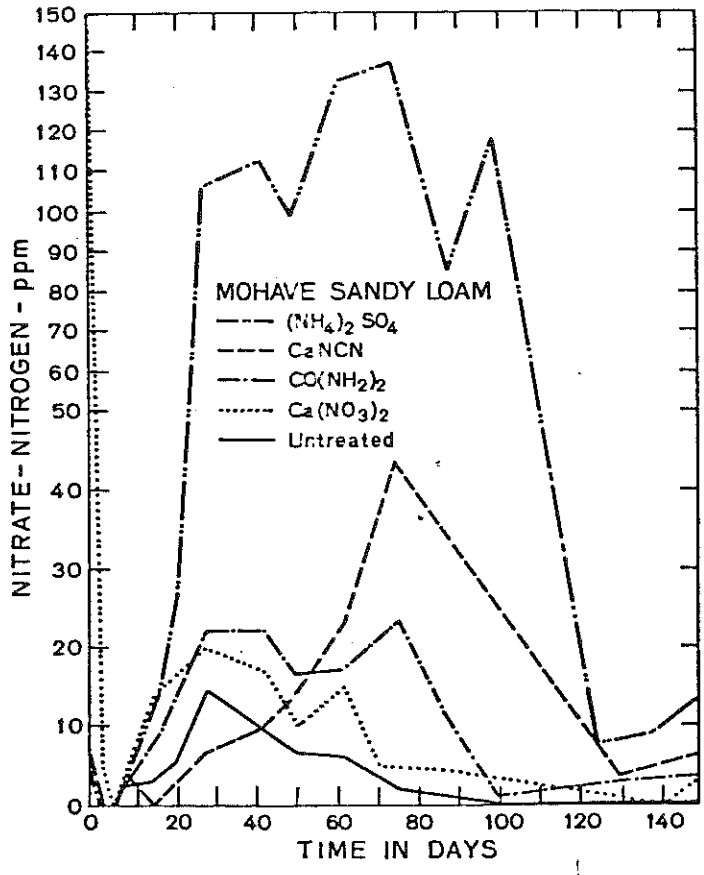


Figure 3. Change with time of nitrate-nitrogen in Mohave sandy loam treated with various nitrogen fertilizers.

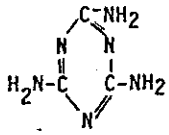
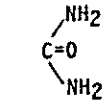
APPENDIX D

"CYANIDES IN THE ENVIRONMENT WITH PARTICULAR ATTENTION TO THE SOIL"
(REPRINT)

TABLE 3. A list of pesticide categories that either contain cyanide radicals or may be metabolized into yielding cyanide radicals.

Chemical Class	Name	Use	Application
1	Dithiocarbamate	fungicide	fruits, melons, grains, vegetables, fiber crops
2	Triazine	herbicide	non-crops, grains, alfalfa, fiber crops
3	Triazine	fungicide	melon, vegetables
4	Triazole	herbicides	non-crops, grains, ornamentals
5	Triazole	fungicides	apples, barley, grapes, wheat
6	Pyrethroid	insecticides	experimental use, cotton, apples, corn, pecans

TABLE 4. Selected nitrogen and/or cyanide yielding compounds that have soil fertilizer value.

Name	Formula
• Ammonium Sulfate	$(NH_4)_2SO_4$
• Cyanamide	$H_2N\text{-}C{\equiv}N$
• Dicyanodiamide	$NH_2\cdot C(=NH)\cdot NH\cdot CN$
• Guanidine Nitrate	$CH_5N_3\cdot HNO_3$ $\quad HN{=}C(NH)NH\cdot HNO_3$
• Guanylurea Sulfate or Dicyanodiamidine Sulfate	$(NH_2\cdot C(=NH)\cdot NH\cdot C(=O)\cdot NH_2)\cdot H_2SO_4\cdot 2H_2O$
• Thiourea or Thiocarbamide	$H_2N\cdot C(=S)\cdot NH_2$
• Melamine or Cyanurotriamide	
• Uramon or Urea	

200 ppm N (Tables 5 and 6). Melamine biodegrades so slowly it has questionable value as a fertilizer (Table 5). Calcium cyanamide, added to soil in amounts of 50- to 100 lbs N/A-6 inches under field conditions of wheat and barley production, was also found to be approximately equivalent to conventional commercial fertilizers, Figure 3, (Fuller, et al., 1950a,b). The nitrification rate of calcium cyanamid, for example, compared favorably with urea (Fuller, et al., 1950b; Fuller, 1963; and Volk, 1950). Application of 140 and 250 lbs N/A in the form of calcium cyanamid to Yuma Superstition sand and Mesa Laveen clay loam, supported highly significant barley grain yields over the no-fertilizer control soil (Table 7).

Nitrification Rates of Cyanide-Yielding Compounds

Some inhibition in the rate of conversion from ammonia to nitrate occurred with cyanamide, dicyanodiamide, and thiourea at an application of 200 ppm N but not at the 100-ppm N rate under laboratory conditions. The data clearly revealed that certain cyanogenic compounds were inhibitory to the nitrosomonas and nitrobacter that convert ammonia to nitrate but did not inhibit the microorganisms that transformed the compounds to ammonium (Tables 5 and 6). Since the NO_3^- ion is much more mobile than NH_4^+, the principle of slowing down the nitrification of NH_3 led to the commercial development of compounds that would inhibit nitrate formation from ammonia to delay or reduce fertilizer loss by migration through soils beyond the reach of plant roots. This favorable fertilization principle is demonstrated in the residual effect of nitrogen to the second-season crop from thiourea and cyanamid when applied to barley in field experiments, Table 7 (Fuller et al., 1950a), but this effect did not occur when the fertilizers were ammonium sulfate or urea.

Simple Cyanides as Fertilizers

Sodium cyanide was reported to be only slightly less effective than sodium nitrate as a nitrogen fertilizer for corn, tobacco, and mustard when used on nitrogen-deficient soils (McCool, 1945a,b). Potassium cyanide also has soil fertilizing qualities since it nitrifies rapidly in soils to yield CO_2 and NH_3 (Strobel, 1967). Cyanides may be fixed by soil organisms in several ways. All give rise to some organic nitriles, which in turn yield ammonia with the corresponding organic acids (Strobel, 1967).

Anaerobic Cyanide Reactions

Microbial reactions under anaerobic soil conditions (e.g. waterlogging) are quite different from those under aerobic conditions. Soil microorganisms responsible for degrading cyanide under anaerobic conditions are believed to be more sensitive to the concentrations tolerated under aerobic conditions. The limit of tolerance for effective anaerobic degradation was suggested by Coburn (1949) as 2 ppm. Thus, the opportunity for cyanides to move through soil is expected to be greater under anaerobic than aerobic environmental conditions. Since denitrification of cyanides under anaerobic soil environments is not well known, it is not wise to speculate too freely

Table 5. Changes with time in pH value, ammonium-, nitrite-, and nitrate-nitrogen content of Mohave fine sandy loam receiving various cyanide-yielding organics applied at 200 ppm.

Incubation Period	Ammonium Sulphate 200 p.p.m.* of N				Uramon 200 p.p.m. of N				Cyanamid 200 p.p.m of N				Dicyanodiamid 200 p.p.m. of N				Guanidine Nitrate 200 p.p.m. of N			
	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N
days		ppm*	ppm	ppm		ppm*	ppm	ppm		ppm*	ppm	ppm		ppm*	ppm	ppm		ppm*	ppm	ppm
0	7.8	200	1	0	8.0	20	Trace	1	9.1	16	Trace	†	7.8	8	0	†	7.6	8	Trace	69
5	7.3	186	8	13	7.7	165	4	7	8.4	97	0	0	7.6	15	0	9	7.6	16	1	69
7	7.2	90	78	77	7.3	101	92	88	---	---	---	---	---	---	---	---	---	---	---	---
9	7.3	44	84	93	7.3	59	107	67	8.1	129	Trace	17	7.9	12	0	15	7.6	11	Trace	63
12	7.2	6	2	149	7.0	10	70	109	---	---	---	---	---	---	---	---	---	---	---	---
16	7.4	13	Trace	179	7.4	8	Trace	192	8.1	140	Trace	18	7.9	17	0	18	7.6	10	Trace	81
22	7.8	6	Trace	223	7.7	9	Trace	208	8.2	133	Trace	21	8.0	17	0	23	7.8	10	0	95
29	---	---	---	---	---	---	---	---	8.0	143	Trace	21	---	---	---	---	---	---	---	---
36	---	---	---	---	---	---	---	---	8.1	137	Trace	23	7.9	19	0	34	7.5	7	Trace	153
43	---	---	---	---	---	---	---	---	8.1	126	Trace	24	---	---	---	---	---	---	---	---
57	---	---	---	---	---	---	---	---	8.1	129	0	21	---	---	---	---	---	---	---	---
81	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
69	---	---	---	---	---	---	---	---	8.1	133	0	16	8.1	28	0	22	7.6	15	0	157
90	---	---	---	---	---	---	---	---	8.1	109	0	25	8.1	23	0	21	7.5	3	0	224
97	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
111	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
120	---	---	---	---	---	---	---	---	---	---	---	---	7.9	22	0	15	7.6	1	0	374
159	---	---	---	---	---	---	---	---	---	---	---	---	8.1	36	0	14	---	---	---	---
202	---	---	---	---	---	---	---	---	---	---	---	---	8.2	37	Trace	17	---	---	---	---
248	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
370	---	---	---	---	7.5	Trace	Trace	340	---	---	---	---	---	---	---	---	---	---	---	---

*Parts per million on basis of soil.
†Nitrate-nitrogen values were negative for reasons not yet understood.

Incubation Period	Guanylurea Sulphate 200 p.p.m. of N				Thiourea 200 p.p.m. of N				Melamine 200 p.p.m. of N				Untreated			
	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N	pH	NH_3-N	NO_2-N	NO_3-N
days		ppm*	ppm	ppm		ppm*	ppm	ppm		ppm*	ppm	ppm		ppm*	ppm	ppm
0	7.7	9	Trace	3	7.8	10	0	†	7.9	8	Trace	†	7.8	6	Trace	3
5	7.8	18	0	6	8.0	11	0	†	7.7	8	0	8	7.8	6	Trace	6
7	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
9	7.8	12	Trace	20	8.0	25	0	0	7.8	8	0	22	7.8	4	Trace	16
12	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---
16	7.8	14	0	23	8.1	39	0	8	7.9	6	0	30	7.6	5	0	21
22	7.8	13	0	31	8.0	50	0	4	8.0	9	0	37	7.9	6	0	37
29	---	---	---	---	7.9	115	0	0	---	---	---	---	---	---	---	---
36	7.9	13	0	37	7.8	66	0	†	7.5	6	0	41	7.8	6	0	41
43	---	---	---	---	7.6	78	0	†	---	---	---	---	---	---	---	---
57	---	---	---	---	7.7	113	0	15	---	---	---	---	---	---	---	---
81	---	---	---	---	7.7	135	0	12	---	---	---	---	---	---	---	---
69	7.8	7	0	39	7.8	136	0	12	7.8	2	0	41	7.6	13	0	33
90	7.4	3	0	126	7.9	160	0	18	7.8	1	0	43	7.8	6	0	44
97	7.4	2	0	179	---	---	---	---	---	---	---	---	7.5	1	0	54
111	7.4	3	0	243	---	---	---	---	---	---	---	---	---	---	---	---
120	7.5	4	0	246	---	---	---	---	7.8	0	0	48	7.6	4	0	54
159	---	---	---	---	---	---	---	---	---	---	---	---	7.7	2	0	59
202	---	---	---	---	---	---	---	---	7.8	6	0	59	---	---	---	---
248	---	---	---	---	---	---	---	---	7.7	4	Trace	56	7.7	8	1	56
370	---	---	---	---	---	---	---	---	7.7	0	Trace	70	7.7	2	Trace	70

*Parts per million on basis of soil.
†Nitrate-nitrogen values were negative for reasons not yet understood.

TABLE 6. Changes with time in pH value, ammonium-, nitrite-, and nitrate-content of Mohave fine sandy loam receiving cyanamide and thiourea applied at 100 ppm.

Incubation Period	Cyanamide 100 p.p.m.* of N				Thiourea 100 p.p.m. of N			
	pH	NH_4-N	NO_2-N	NO_3-N	pH	NH_4-N	NO_2-N	NO_3-N
days		ppm*	ppm	ppm		ppm*	ppm	ppm
0	8.7	28	Trace	15	8.0	11	Trace	1
4	8.1	79	Trace	15	8.0	3	0	1
11	8.2	76	2	17	8.0	29	0	1
14	8.0	73	Trace	23	8.0	48	0	1
18	8.1	62	1	20	8.0	57	0	4
39	7.9	56	0	37	7.9	87	Trace	18
61	—	—	—	—	—	—	—	—
70	7.6	1	0	104	7.5	45	0	24
79	7.7	16	0	100	7.5	36	Trace	64
90	—	—	—	—	—	—	—	—
125	—	—	—	—	—	—	—	—
152	—	—	—	—	—	—	—	—
198	—	—	—	—	—	—	—	—
322	—	—	—	—	—	—	—	—

*Parts per million on basis of soil.
†Nitrate-nitrogen values were negative for reasons not yet understood.

TABLE 7. The influence of some cyanogenic fertilizers on barley grain yields from two calcareous soils.

Material Added	Increase in Barley Due to Nitrogen Application: Laveen clay loam	Superstition sand
	%	%
None	...	...
Dicyanodiamide	3.1	...
Guanylurea sulfate	7.5	...
Guanidine nitrate	27.8*	0.5
Ureaform N-20	30.6*	8.0
Ammonium sulfate	32.6*	38.8*
Ureaform N-40	40.3*	20.8*
Cyanamide	45.3*	52.4*
Thiourea	62.3*	62.4*

*Highly significant increase, 1% level.

and interpret significance much beyond what is actually known. But there is evidence that the denitrification process does occur in certain soluble cyanides and that it yields N_2 gas, probably through nitrates under limited free O_2 conditions, and particularly, where sulfur compounds are available (Huiatt, 1983, Ch.2).

LANDFILLS

Untreated cyanide disposals to landfills are not allowed under the present regulations. However, cyanide wastes that have been placedin drums during some former period may pollute the soil environment through leakage. Should such occur, remedial procedures must be initiated to confine the chemical (Tolman et al., 1978). The real problem centers around toxicity since concentrations may be expected to be higher than just discussed with soil fertilization. Microbial degradation rates and the attenuation capacity of the soil could be exceeded.

LAGOONS, PONDS, AND WASTE WATERS

One of the oldest methods of confining mining and plating cyanides, preventing their movement to the surrounding environment, is the establishment of shallow earth lagoons and ponds. Such facilities designed for deep soils of fine textures, clay-lined and deep watertables, have been quite successful in confining cyanides. Shallow ponds of low-level cyanides exchange gases readily with no appreciable limitation of oxygen sufficient to convert cyanides readily to nitrates. In fact, the accumulation of nitrates may pose a greater problem to underground water quality than cyanides. Fortunately, another mechanism is available in properly designed mining lagoons and ponds that is centered in the clay lining and acts as an anerobic denitrifying barrier to underground flow similar to that in a rice paddy. The nitrates denitrify at this low red/ox juncture in the bottom of the pond with the discharge of harmless N^2 gas into the atmosphere.

The threshold limit of CN^- toxicity on biological activity of aqueous systems varies widely with such environmental factors as water quality, temperature, type and size of the organism. Thus, definite effects cannot be established except in terms of the nature of the effects. For example, Lockette and Griffiths (1947) report that 5.0 ppm of CN^- in sewage treated by the activated process had a marked depression effect on the purification process, whereas Ludzack et al. (1951) found inhibition effects as low as 0.3 ppm under certain other conditions. In concentrations of 6% CN^-, all waters studied were purified up to 50% or more of the control within 10 days of incubation.

Of particular interest because of its toxicity to the cytochrome system is the utilization of cyanide by specific microorganisms found in wastewaters. Ware and Painter (1955) isolated an aerobic autotrophic actinomycete from sewage which is capable of growing on silica containing only KCN as a source of carbon and nitrogen. This organism can utilize concentrations of CN^- up to 15 mgm/100 ml but grows more favorably at 4 mgm/100 ml concentrations. The rate of utilization in colony culture approached a maximum of 0.5 mgm CN/day. Presumably the general reaction proceeds as follows:

$$2KCN + 4H_2 + 3O_2 \rightarrow 2KOH + 2NH_3 + 2CO_2$$

Other examples of specific microbial assimilation and transformation of CN^- in synthetic media (not soil) are those given by Reynolds (1924), Strobel (1964), and Allen and Strobel (1966).

CYANIDE MOVEMENT IN THE SOIL

SCOPE

Since many of the cyanide wastestreams, waste ponds, lagoons, and leachates end in an anoxic soil environment, a fundamental research program was undertaken to study cyanides under anaerobic soil conditions with specific objectives:

. To study the rate of degradation of simple and complex cyanide under saturated and unsaturated (70% of field water-holding capacity) soil conditions.

. To evaluate the influence of different organic energy sources on the rate of degradation or transformation of cyanides.

. To study the mobility of certain cyanides, in water and municipal landfill leachate, through soils with distinctly different chemical and physical properties, in order to statistically relate soil parameters to observed attenuation and degradation.

SATURATED ANAEROBIC SOIL CONDITIONS

Experimental

Three sets of four different soils (Table 8) were packed in a pvc column 5 cm in diameter and 12 cm long to a specified bulk density (Fuller, 1982; Fuller and Warrick, 1984a,b). Each set was connected to one of three constant head devices and each one contained a different cyanide solution. Solution #1 contained potassium cyanide in water; solution #2 contained potassium cyanide in a landfill leachate, and solution #3 contained a complex form of cyanide in deionized water alone, Table 9 (Alesii, 1976; Alesii and Fuller, 1976).

TABLE 8. Reference Soils Used in the Cyanide Movement Research

Series* Soil	Order Soil	Clay	Silt	Free Iron Oxides	Soil Paste pH	Cation Exch. Capacity	Elec. Cond.of Extract	Bulk Density
		%	%	%		meg/100g	µmhos/cm	g/cm^3
Molokai	Oxisol	52	25	23.0	6.2	14	1262	1.44
Nicholson	Alfisol	49	47	5.6	6.7	37	176	1.56
Mohave(Ca)	Aridisol	40	28	2.5	7.8	12	510	1.54
Ava	Alfisol	31		4.0	4.5	19	157	1.44

*Oriented on basis of clay content.

The flow of the solution was regulated to provide approximately one pore volume of displacement each day. The displacements were continued until 20 pore-space volumes were collected. The effluent was collected each day in a 125 ml bottle containing 5 ml of 1N sodium hydroxide. The sodium hydroxide was necessary to keep the cyanide that comes through with the solution from volatilizing. The solution collected was analyzed for total cyanide by the Liebig distillation method according to Taras (1971).

The distillation of the sample was required to convert all the complex cyanide in the sample into simple cyanide ions. The sample was then easily analyzed by the Liebig titration method using silver nitrate and Rhodanin indicator (when the concentration was above 1 ppm). When the concentration was below 1 ppm, the Liebig colorimetric method involving pyridine-pyrazalene was used.

TABLE 9. Characteristics of Cyanide Solution Used in the Movement Research

Cyanide solution	pH of solution	Concentration of cyanide in solution mg/L	Type of ion present
KCN in deionized water	10.0	97	$CN^{\ominus}$
$K_3Fe(CN)_6$ in deionized water	8.5	98	$Fe(CN)_6^{\ominus}$
KCN in landfill leachate	5.4	80	Unknown (mixed)

Discussion

The relative mobility of the three cyanide solutions is best illustrated in Mohave (Ca) clay loam and Kalkaska sand (Figure 4). All data are plotted as pore volume versus C/C_{max}, where C/C_{max} is the ratio of effluent concentration to influent concentration. KCN and $K_3Fe(CN)_6$ in deionized water were both found to be very mobile in soils, while KCN in landfill leachate was the least mobile of the three solutions.

The effect of soil type on the movement of the three cyanide solutions is illustrated in Figure 5, showing the amount of KCN in deionized water that was leached through four soils. The $CN^{\ominus}$ was retained most by soils having a high concentration of Mn and hydrous oxides of Fe (Nicholson silty clay and Molokai clay). Korte et al. (1975) found similar results working with the anion forms of As, Cr, Se, and V. This conclusion is further supported by data from Berg and Thomas (1959). They found $Cl^{\ominus}$, which is similar to $CN^{\ominus}$ in its adsorption behavior, attenuated in soils having a high percentage of kaolin clay and iron and aluminum oxides. Schofield (1939) also reports that soils high in these oxides have a high anion exchange capacity. Kamprath (1956) found good retention of SO_4^{2-} by an acidic soil high in oxides and kaolin, whereas the 3-layer minerals appeared to have relatively poor retention for SO_4^{2-}. The acidic soil (Ava silty clay loam) in this study proved, on the contrary, to be a poor attenuator of $CN^{\ominus}$. Texture seems to have little measurable effect on the attenuation of KCN. Free iron oxide and $CaCO_3$ seem to have a greater influence on the movement of KCN in water than either soil pH or texture.

Figure 5 illustrates the movement of $K_3Fe(CN)_6$ in deionized water through four soils (Mohave (Ca) clay loam, Ava silty clay loam, Nicholson silty clay loam, and Kalkaska sandy loam). The ferricyanide ion also migrated most rapidly through soils having a high pH and in the presence of free $CaCO_3$ (Mohave (Ca) clay loam) for the same reason as KCN in water. Ferricyanide moved slowest in soils having a low pH (Ava silty clay loam and Kalkaska sandy loam). A low pH would indicate the clay surface to have a high percentage of positive exchange sites which would attract the $Fe(CN)_6^{3-}$ ion and retain it. Texture seems to play a more important role in this case.

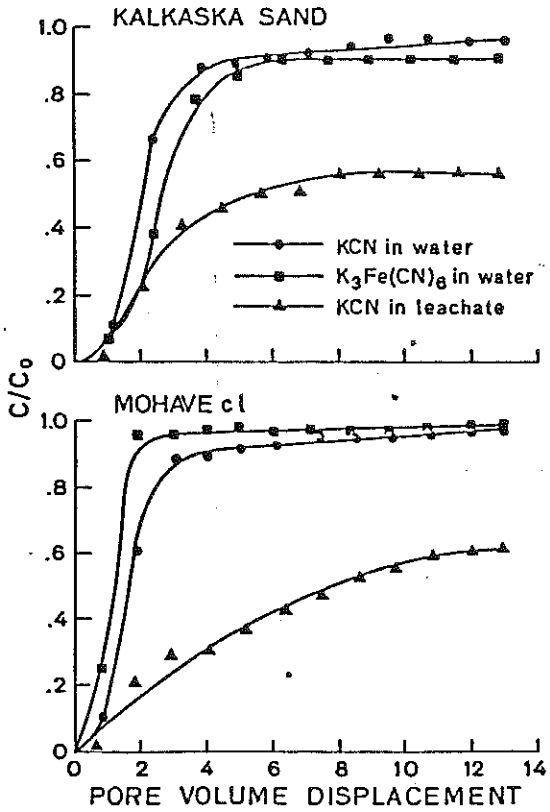


Figure 4. Relative mobility of three cyanide solutions (water and leachate) through Kalkaska sandy loam and Mohave (Ca) clay loam.

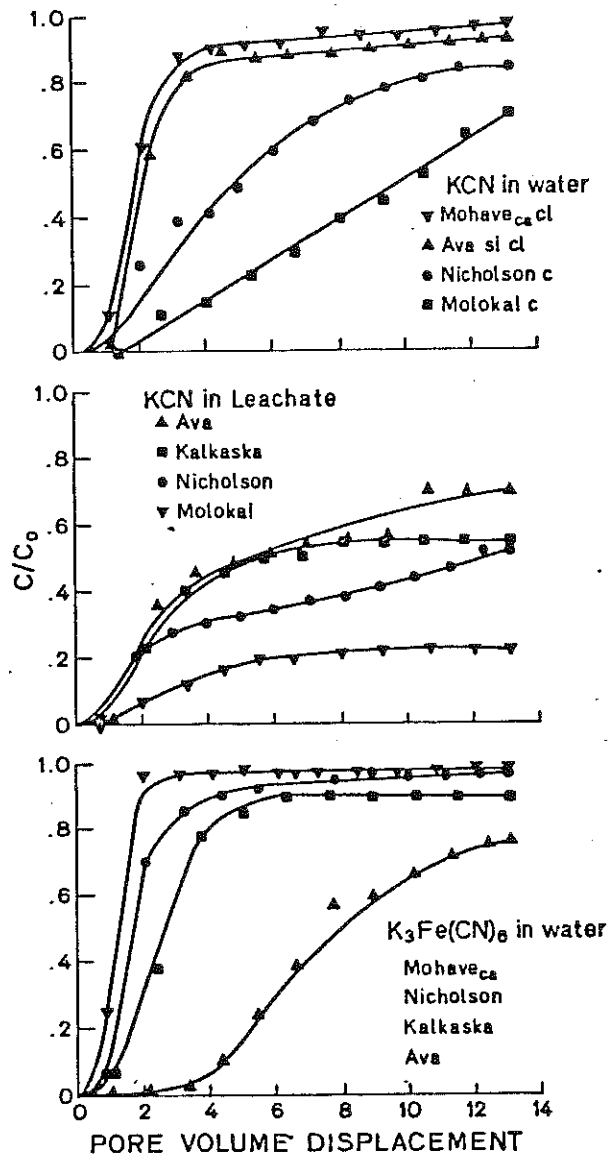


Figure 5. Effects of soil type on the mobility of KCN in water and leachate and $K_3Fe(CN)_6$ in water

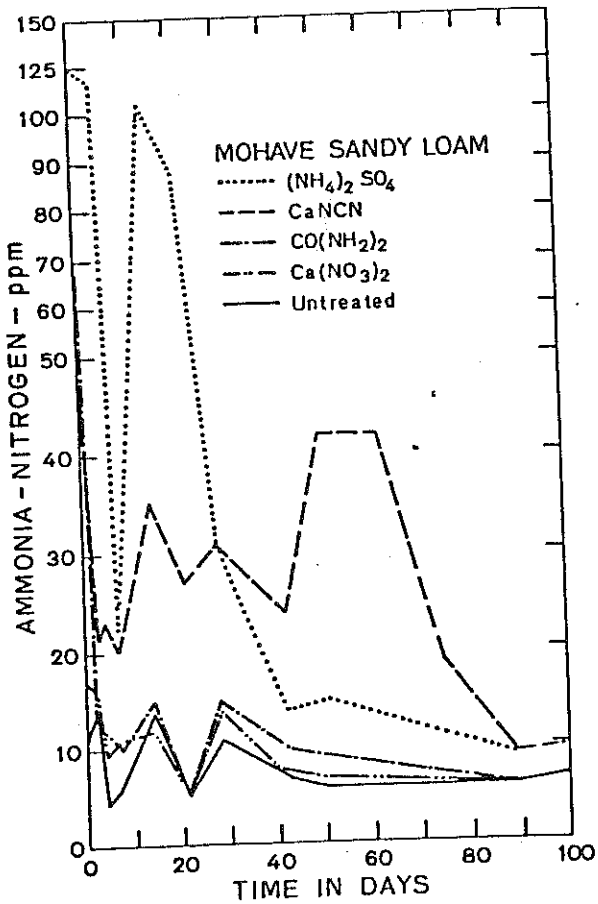


Figure 6. Change with time of ammonia-nitrogen in Mohave sandy loam treated with various nitrogen fertilizers

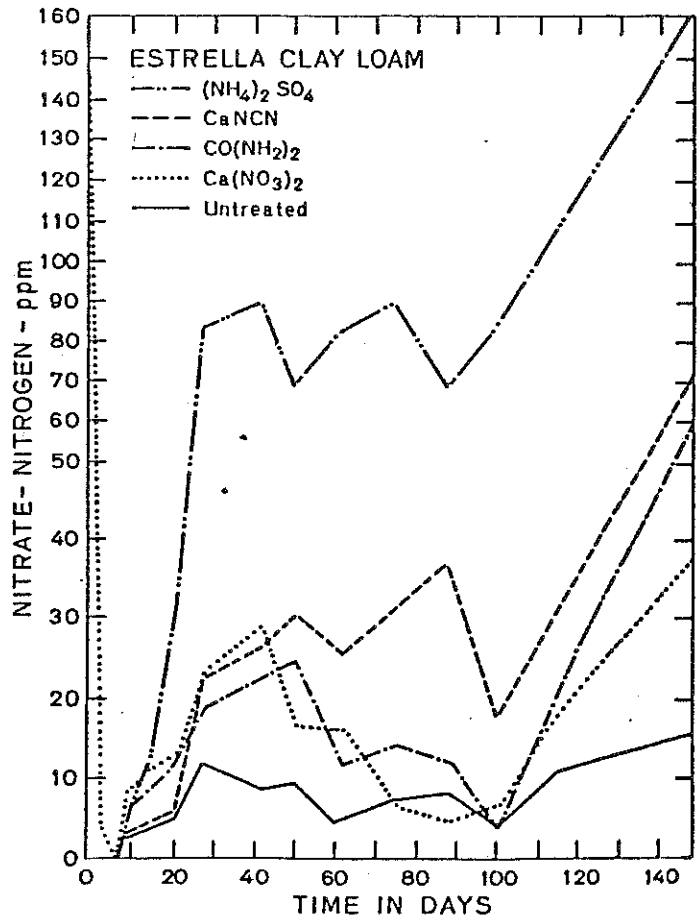


Figure 7. Changes with time of nitrate-nitrogen in Estrella clay loam treated with various nitrogen fertilizers

The high clay content soil (Ava silty clay loam) retained more of the $Fe(CN_6)^{3-}$ than the sandier soil of similar pH (Kalkaska sandy loam). Although iron-oxide seemed to have some affinity for $Fe(CN)_6^{3-}$, its presence was not as effective as soil pH in governing the movement of this form of cyanide.

KCN in MSW landfill leachates migrating through the four soils moved through those with the lowest pH (Ava silty clay loam and Kalkaska sandy loam). Cyanide was retained most extensively by soils having a high concentraton of iron-oxide (Figure 5).

Of the three cyanide solutions, KCN in MSW leachate was found to move through the soils most slowly. This can be explained partly by the precipitation of Prussian blue when KCN was added to the leachate (Robine et al., 1906). This blue precipitate was found infiltrating the top 4 cm of the soil columns. The accumulation indicates that Prussian blue may be quite immobile in soils. The cyanide that came through the soil was the CN^- that did not react with the Fe in solution to form Prussian blue.

The anaerobic state of the soil columns inhibited microbial degradation of cyanide. Microorganisms responsible for degrading cyanide under anaerobic conditions are very sensitive to an elevated concentration of this compound. The limit for effective anaerobic degradation of cyanide was found by Coburn (1949) to be 2 ppm in the wastestream, a concentration much lower than the approximate 100 ppm that passed through the soil columns. The incubation studies, therefore, were negative with respect to cyanide degradation, i.e. degradation did not occur significantly in the water-saturated, anaerobic soil. Nitrate, nitrite, and ammonium were not found as a result of possible CN^- transformation; but there was no measurement of N_2 gas for the detection of denitrification.

UNSATURATED, AEROBIC SOIL CONDITIONS

The cyanides react quite differently under aerobic than anaerobic soil conditions. The differences are apparent by comparing migration or movement in anaerobic soil columns with the same soils under field conditions where cyanide-yielding compounds rapidly ammonify and nitrify. Calcium cyanamide, for example, ammonifies more rapidly than urea and nitrifies comparably to ammonium sulfate and more rapidly than urea in Mohave sandy loam under field conditions (Figures 3 and 6). Nitrification of calcium cyanamide also progresses well in Estrella clay loam (Figure 7). Cyanide was not detected in soil deeper than 20 cm (8 in) or beyond the layer of cyanide incororation. Soils in Mesa and Yuma, Arizona, also were sampled every 10 days throughout the barley growing season for detection of the original material, cyanide, or cyanide-related comounds (Table 5). None of these were found within or below the incorporation layer, except for the traces from the original substances (cyanamide, dicyandiamide, guanylurea sulfate, guanidine nitrate, thiourea) in the 8-inch incorporation layer only, found immediately after being applied. However, nitrate-nitrogen, attributable to the application of fertilizers and cyanides, was detected to a depth of about 30 cm (12 in) after the first irrigation.

Certain conditions in the field, compared with those in soil columns, also delegate against cyanide movement through the soil; such as,

- Molecular oxygen availability is greater in the field,
- Wetting and drying is more prominent in the field,
- Soil microorganisms are more active under natural conditions,
- Photochemical activity is greater in the field,
- Fluctuation in soil moisture levels is greater in the field.

CONCLUDING KEYNOTE STATEMENT

1. Cyanides and cyanide-yielding componds are found well distributed in the total earth surface environment.

2. Cyanides from widespread natural sources of plants, micororganisms, animals, and infrequently identified in soil, water, and air, originating from biological sources, offer little hazard to the inhabitants of the earth surface environment.

3. Low levels of free cyanides in nature do not persist in soils due to many highly reactive indigenous chemical and enzymatic transformations and degradation processes.

4. Cyanide toxicity originating from natural sources through plant consumption by rumens has occurred but proper management of feeding and grazing appears to minimize this hazard.

5. Commercial sources of cyanides have proved useful to agricultural crop production as exemplified by pesticides and fertilizers both of which are readily converted to plant nutrient sources such as ammonia and nitrate. Cyanides used for these purposes do not persist in the soil.

6. Free cyanide is one of nature's most toxic substances. Free cyanide, also, is a very reactive ion readily forming insoluble and very slowly soluble complex compounds. The loading rate in soils, therefore, is the paramount factor in determining the hazard for biological systems and movement to ground waters. Simple cyanides have been applied at rates of 280 kgN/ha to aerobic soils as fertilizers with no hazardous effects. In anaerobic soils the "safe" level drops to a few ppm.

7. Adequate knowledge exists for controlling cyanide poolution in soil, water, and air environments.

8. The soil is the first and main line of defense for accidental cyanide spills and inadvertant overloading of disposal areas.

9. The soil factors most responsible for control of cyanides in the environment are: (a) clay content, (b) depth of soil, (c) hydrous oxides of iron, manganese, aluminum and other metals, (d) pH, (e) aerobic conditions, and (f) presence of soil organic matter.

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DISCUSSION

Comment (W. Fuller): One item I did not bring to your attention, but which is very important, is that as cyanide is used and oxidized, nitrate builds up. Nitrate is a mobile anion, as you know, and the hazard may not be cyanide, but nitrate.

Question (F. DeVries): It seems to me that the levels of cyanide we deal with in disposal problems are an order of magnitude or so less than the hazardous level of nitrates. Is that not correct?

Answer (W. Fuller): I have seen ponds with 500 ppm nitrate in the water, and that is a little high for water to be used as recharge.

Question (F. DeVries): We usually talk about cyanide concentrations in water effluents under a part per million, perhaps less than one tenth of a part per million. My understanding is that nitrate concentrations allowable in potable water approach 10 ppm.

Answer (W. Fuller): That's right, but some of these ponds are continually fed and the nitrate concentration builds up.

Question (P. Saletta): Dr. Fuller, concerning the replacement of soils in the final reclamation of cyanide tailings disposal sites, have there been any studies, that you know of, of possible effects on those replaced soils from the solid waste disposal of cyanide tailings?

Answer (W. Fuller): No, but I'm glad you asked that question. One of the important things about this conference is that, although the soil scientists, the biochemists and the civil engineers are most often located in different buildings and often don't cross-inoculate, here we have finally come to the conclusion that we need to work as a team.

Question: Dr. Fuller, would you say there are any naturally-occurring cyanides in lakes or other water bodies that would build up to toxic levels? If so is that taken into consideration in assessing possible spills?

Answer (W. Fuller): None that I know of.

Comment (R. Walline): I have seen detectable levels of 'natural cyanide', but not toxic levels. So in comparison to a spill, it's usually negligible compared to the industrial component.

Question: Dr. Fuller, theoretically speaking, could it occur?

Answer (W. Fuller): I don't see a great possibility for it. Remember that the high reactivity of cyanides, the biological attack on them and so forth, really limits their accumulation in natural environments. On the other hand, I refer you to Dr. Reed's talk on animals

which may eat plants that have high amounts of glycosides.

Question: If bacteria exist which can decompose cyanide, is it possible that artificial culture of these bacteria might be an eventual solution to the problem of getting rid of cyanide in our tailings ponds?

Answer (W. Fuller): That is a very important item, but there are problems with inoculation. First, the environmental conditions must be specific for that one organism. I gave you an example of an actinomyces that grows in sewage under anaerobic conditions and will grow on potassium cyanide alone. However, if we have the idea of finding that organism and putting it in other sewage, we have to remember that sewages vary considerably. Nevertheless, it's a good point and I'd like to see more research done on it. We have found in biological pure-culture work that it takes a lot of effort and money to support that kind of work, but I would not rule out the possibility. If I find one, I'm going to patent it.

Comment (R. Walline): To follow up on that, later in the week, Terry Mudder from Homestake Mining Company will be speaking. Homestake Mine is using a biological system—a specific bacteria—to treat mining effluent specifically for cyanide, so there is now a system in place doing just what you suggest.

APPENDIX E

"CYANIDE CHEMISTRY" (EXCERPT FROM EPA REPORT)

HEAP LEACH TECHNOLOGY AND POTENTIAL EFFECTS IN THE BLACK HILLS

EPA CONTRACT NO. 68-03-6289
WORK ASSIGNMENT NO. 1

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CLEVELAND ES

PREPARED FOR

U.S. ENVIRONMENTAL PROTECTION AGENCY
WATER MANAGEMENT DIVISION
STATE PROGRAMS BRANCH
999 18th STREET, SUITE 1300
DENVER, COLORADO 80202

SEPTEMBER 30, 1986

PREPARED BY

ENGINEERING-SCIENCE
DESIGN • RESEARCH • PLANNING
1100 STOUT STREET, SUITE 1100
DENVER, COLORADO 80204

WITH ASSISTANCE FROM

HAMMER, SILER, GEORGE ASSOCIATES
1638 PENNSYLVANIA STREET
DENVER, COLORADO 80203

CYANIDE CHEMISTRY

OVERVIEW

Cyanide may occur in many forms. The forms of cyanide relevant to a discussion of heap leach mining are:

Free cyanide - Cyanide ion (CN^-) and molecular hydrogen cyanide (HCN). The distribution between cyanide and HCN is dependent on pH with HCN predominant below pH 9.36 (20° C).

Simple cyanide - an alkali or metal cation and cyanide. An example of a soluble simple cyanide is sodium cyanide (NaCN), which is used in process solutions at heap leach operations.

Complex cyanide - metal cyanide complexes and their salts. Metal cyanide complexes are divided based on their stability into weak complexes containing zinc or cadmium, moderately strong complexes containing copper, nickel, or silver, and strong complexes containing iron, cobalt, or gold. The salts are relatively insoluble.

Cyanogenic glycosides - organic compounds introduced naturally into the soil which release cyanide upon hydrolysis. Plants are one of the most common sources.

Methods for measuring cyanide in water and the species of cyanide detected by each method are:

Free cyanide - measures the amount of HCN and CN^-.

Weak acid dissociable cyanide - measures free cyanide, and complexes of Cd, Cu, Ni, Ag, and Zn.

Total cyanide - measures free cyanide, weakly acid dissociable cyanide and most inorganic complex cyanides including Fe but excluding Au, Co, and some of the Pt metals.

Cyanide amenable to chlorination - measures the difference between total cyanide concentration before and after chlorination.

Researchers have been experimenting with different types of leaching and analytical procedures for cyanide measurement in solid samples such as spent ore.

Cyanide is a very reactive and relatively short-lived contaminant. Processes which tend to degrade or transform free cyanide in the environment are volatilization of HCN, reaction of cyanide to form ammonia and formate, oxidation, complexation with metallic ions, biological activity, conversion to thiocyanate (SCN^-) and sorption. Cyanide may be released from simple and complex cyanides depending on the stability of the specific compound or complex. In addition, iron or cobalt cyanide complexes, which are strong complexes, may undergo photochemical degradation by sunlight and release free cyanide. Cyanide released from simple and complex cyanides will be subject to degradation or transformation processes.

Volatilization is probably the most significant process in the natural degradation of cyanide in surface waters. Generally, free cyanide would be more mobile in surface waters with higher pH, lower temperature, lower levels of metals and sulfide, organic and inorganic suspended matter, and which have little interaction with sediment. Surface water bodies with stagnant, deep conditions and little surface area would promote high mobility of cyanide. Volatilization rates of HCN from ground water may be less than those from surface water. Other processes that tie up cyanide, such as sorption and complexation, may be much more important in limiting the mobility of cyanide in ground water than in surface water. Reaction of cyanide to ammonia and formate may also be an important process to reduce concentrations of cyanide in ground water.

Cyanide is more mobile in soils with anaerobic conditions. The limit for effective microbial degradation of cyanide was found to be 2 mg/l based on studies of a sewage waste sream (Coburn, 1949). Cyanides and cyanide-yielding compounds such as fertilizers and pesticides

applied to aerobic soils readily degrade (Fuller, 1985). Other factors affecting the mobility of cyanide in soil are clay content, depth of soil, content of iron oxides or other metal oxides, pH, and presence of organic matter. Mobility of cyanides is greatest in soils with high pH and low clay content.

The basic chemical process used in a heap leach mining operation is the complexation of Au and Ag from the ore with a sodium cyanide solution. One of two processes, carbon adsorption or zinc precipitation, can be used to recover the precious metals from the pregnant solution.

Neutralization, or a rinsing of the ore heaps, is used to reduce the levels of cyanide remaining in heaps after the ore is spent. Various western states require that the rinsing procedure continue until the cyanide concentration is reduced to a specified level or a certain pH is obtained. The final cyanide concentrations specified by states using free cyanide analyses ranges from 0.2 to 5 mg/l, and from 0.01 mg/l to 100 mg/l in states using total cyanide analyses. Although little data is available, sampling of heaps after the rinsing procedure is completed generally shows less than 10 mg/kg of free cyanide remaining in the heaps. Subsequent sampling shows a decrease of cyanide with time.

A variety of methods are used to destroy cyanide in process solution either during operation or upon closure, and rinsing solution used to neutralize the spent ore heaps. Treatment processes that are, or may be, used at leaching operations are natural degradation, alkaline chlorination, hydrogen peroxide, Inco process, and biological treatment.

Heap leach mining wastes contain free cyanide (HCN and CN^-), metal cyanide complexes, and salts of metal cyanide complexes. The amount of free cyanide in these wastes is dependent upon the rate of volatilization of HCN to the atmosphere. An important control on volatilization is pH; below a pH of 9, HCN is predominant over cyanide ion.

Metal cyanide complexes such as iron, copper, zinc, nickel, cobalt, and cadmium, which are the most common at gold and silver operations (Huiatt, 1985), decompose and release cyanide ion at varying rates. Zinc and cadmium complexes, the least stable complexes, readily decompose during the rinsing process as free cyanide decreases. Strong complexes such as iron cyanide complex may remain in the spent ore. Iron cyanide complexes have been found to degrade in solutions exposed to ultraviolet light, but the photochemical effect on the solid species is unknown. Iron, nickel, cobalt, and copper salts of iron complex cyanide ions are very sparingly soluble and release very small amounts of free cyanide in the spent heap pile.

In addition to volatilization directly from the mining wastes, there is a secondary transport process whereby cyanide and any soluble metal cyanide complexes may be leached from the mining wastes and transported into the environment if uncontained. The accidental release of cyanide process solution is also possible. Several chemical and biological processes have the potential to attenuate cyanide when it is released to the environment.

CHEMICAL FORMS OF CYANIDE

A large number of organic and inorganic chemical compounds contain cyanide. Cyanide occurs as a cyano group (CN) in the molecular structure of the compound. In solution, the cyanide ion (CN^-) is a negatively charged, diatomic species, which may complex with both inorganic and organic compounds. Since most metals tend to form positive ions, they may readily react with cyanide. The characteristics of cyanides, particularly the high level of stability for some of the metal cyanide complexes, can be explained by its bonding properties. For the purposes of this report, four different forms of cyanide, free cyanides, simple cyanides, complex cyanides, and cyanogenic glycosides (organic compounds containing cyanide) will be discussed below.

Free Cyanide

Free cyanide in solution is the total concentration of cyanide ion (CN) and dissolved molecular hydrogen cyanide (HCN). Hydrogen cyanide is a colorless gas or liquid with a boiling point of about 25.5 °C (77.9° F). The gas is less dense than air and flammable.

HCN or hydrocyanic acid, a weak acid, has a dissociation constant of 4.365×10^{-10} at 20 °C (68° F) for the hydrolysis reaction between cyanide ion and water:

$$CN^- + H_2O = HCN + OH^- \quad (1)$$

The relative amounts of CN^- and HCN as predicted by this relationship are strongly dependent on the pH of the solution (Figure B-1). The concentration of CN^- and HCN are equal at pH 9.36, the pK (log of the equilibrium constant) of HCN at 20 °C (68° F) (Broderius, 1974). At pH values below 9.36 and at 20° C (68° F), most cyanide exists as molecular HCN; 69.6 percent at pH 9; 95.8 percent at pH 8; and greater than 99 percent at pH 7. In natural waters most of the free cyanide concentration would be in the form of HCN. Since HCN has a high vapor pressure it readily evaporates depending on the solution concentration, temperature, and pH. Higher temperatures and solution concentrations, and lower pH values promote generation of gaseous HCN.

Simple Cyanides

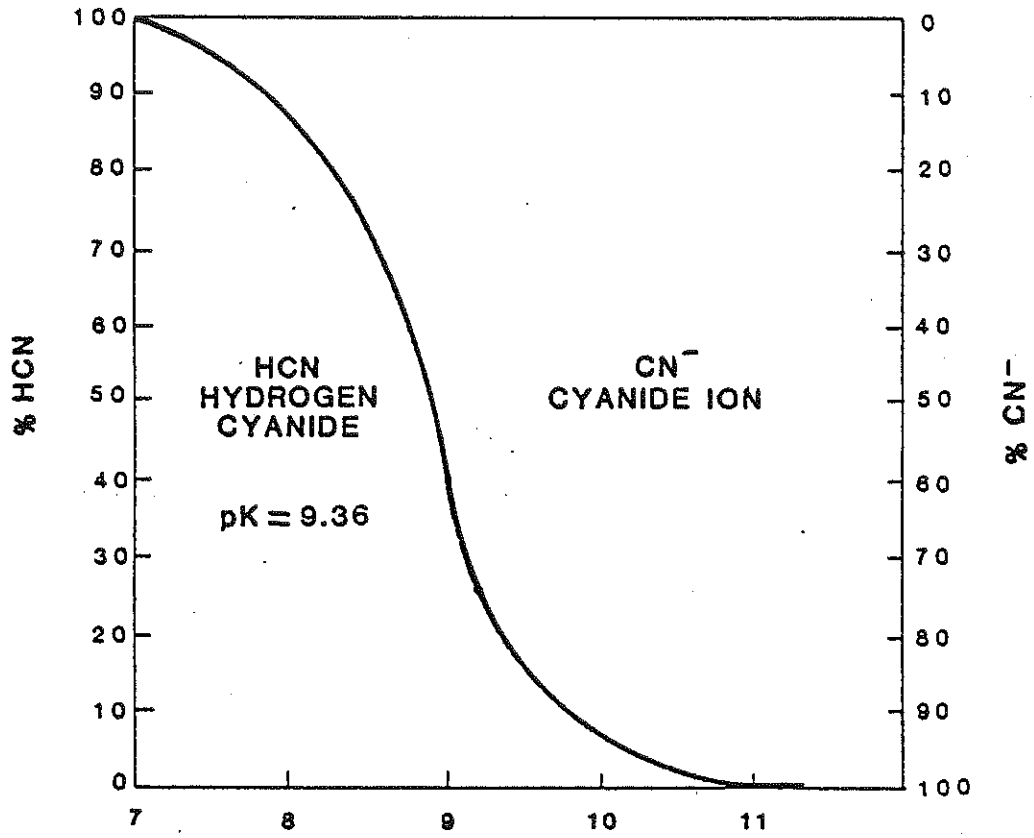
Simple cyanides consist of an alkali (sodium, potassium) or metal cation and cyanide. They can be represented by the formula $A(CN)_x$, where A is an alkali or metal, and x, the valence of A, represents the number of cyano groups present. Solubilities of the simple cyanides are a function of pH and temperature. Soluble compounds (particularly the alkali cyanides) ionize to release cyanide as shown:

$$A\ (CN)_x = A^{+x} + xCN^- \quad (2)$$

Cyanide ions released would undergo hydrolysis as shown in equation (1). An example of a simple cyanide used in heap leaching mining operations is sodium cyanide (NaCN) which would dissolve and readily hydrolyze as shown:

FIGURE B-1

THE EFFECT OF pH ON DISSOCIATION OF HYDROGEN CYANIDE



$$Na^+ + CN^- = HCN + Na^+ + OH^- \quad (3)$$

Complex Cyanides

Alkali-metallic cyanides are represented as $A_yM(CN)_x$, where A is the alkali such as sodium of potassium, y is number of alkalies, M is the heavy metal (ferrous or ferric iron, gold, copper or others), and x is the number of cyano groups. The valence of the alkali (A) taken y times plus the valence of the metal (M) is the value of x. Soluble alkali-metallic cyanides dissociate to release the metal cyanide complex ion, $(M(CN)_x)^{-yw}$, by the reaction:

$$A_y\ M(CN)_x = yA^{+(x)} + (M(CN)_x)^{-yw} \quad (4)$$

where w is the oxidation state of A in the original alkali-metallic cyanide compound. The metal cyanide complex ion released may undergo further dissociation and release cyanide ion. Another type of compound with a similar formula is the complex ferro or ferric cyanide salts, where A and M would be a heavy metal and either Fe^{2+} (ferrous) or Fe^{3+} (ferric), respectively. Some examples of metal cyanide complex ions which may be found in process solutions of heap leach mining operations are $Fe(CN)_6^{3-}$, $Cu(CN)_2^-$, and $Zn(CN)_4^{2-}$.

Cyanogenic Glycosides

Organic compounds yielding cyanide are introduced naturally into the environment, particularly the soil. One of the most common natural sources is from plants. A large number of plants (800 species) naturally synthesize cyanogenic glycosides (Knowles, 1976). The general formula is:

$$\begin{array}{c} CN \\ R_1 - C - OR_3 \\ R_2 \end{array}$$

where R_1 = an alkyl or aryl group

R_2 = a hydrogen atom or methyl group

R_3 = usually, D-glucose.

One of the best known cyanogenic glycosides, called amygdalin, occurs in seeds and leaves of many members of the Rosaceae (rose) family (Kingsbury, 1964). Many common vegetables also contain cyanogenic glycosides such as maize, millet, field bean, kidney bean, sweet potato, and lettuce (Oke, 1969). Generally, the glycoside is harmless, but becomes toxic only when in vivo conditions permit hydrolysis of the compound to liberate hydrogen cyanide (refer to Appendix C for a discussion of toxicity).

ANALYTICAL METHODS

Standard methods for measuring cyanide that are most relevant to the mining industry are described below. These methods include total cyanide, free cyanide, weak acid dissociable cyanide, and cyanide amenable to chlorination. Several problems associated with the analytical methods are also presented.

Methods for Water Samples

Total Cyanide

The acid reflux/distillation method measures the free cyanide and the cyanide contained in complex iron cyanides, weakly acid dissociable cyanide, and most inorganic complex cyanides except gold, cobalt, and some of the platinum metals. The ASTM method (1981) uses a catalytic agent to facilitate the breakdown of the metal cyanide complexes. The hydrogen cyanide liberated by the distillation is collected in an alkaline absorbing solution and can be measured by titration, colorimetry, or specific ion electrode. The lower limit of detection for the three methods are 1.0, 0.03, and 0.03 mg/l, respectively.

Modifications to the ASTM method to eliminate interferences caused by thiocyanate have been developed. In the acid distillation technique, decomposition agents such as hydrochloric acid/hydroxylamine, tartaric acid, or phosphoric acid (Knechtel and Conn, 1981; Huiatt et al., 1983) are used.

The EPA procedures were last revised in 1984 as Method 335.2 (STORET No. 00720). This method is either a titrimetric or a spectrophotometric analytical procedure similar to ASTM. Single laboratory precision is reported as 85 percent and 102 percent recovery at 0.28 and 0.62 mg/l CN, respectively. These recoveries were apparently reported for water samples.

Free Cyanide

The methods for determining free cyanide include solvent extraction or sparging the HCN from solution and collecting it for later measurements (Broderius, 1975, Montgomery et al., 1969; Schneider and Freund, 1962).

Weak Acid Dissociable Cyanides

The method accepted by ASTM as a standard procedure for determining weak acid dissociable cyanides is called Method C, a variation of one proposed by Roberts and Jackson (1971). The reagents used in the distilling flask are acetic acid-sodium acetate solution buffered at pH 4.5 and zinc acetate. Gonter (1975) reported that cyanide was totally recovered from cadmium, copper, nickel, silver, and zinc complexes. Test work reported by Conn (1981) suggests that some (two percent) breakdown of ferrocyanide could occur. No interference occurs in this method by the presence of thiocyanate.

Cyanide Amenable to Chlorination

Cyanide amenable to chlorination is the difference between total cyanide measurements before and an alkaline chlorination treatment. Chlorination treatment oxidizes cyanide, HCN, cyanide from weakly dissociated and moderately strong metal complexes, and thiocyanate, but does break down the iron cyanide complexes or other stable complexes. Refer to the section entitled, Complexation with Metallic Ions for the stabilities of metal cyanide complexes. The sample is separated into two portions; one is analyzed for total cyanide and the other is analyzed for total cyanide after a treatment with sodium hypochlorite at an alkaline pH for one hour. EPA uses Method 335.1 (STORET No. 00722) to determine cyanide amenable to chlorination.

Methods for Solid Samples

EPA Method 9010 (U.S. Environmental Protection Agency, 1982) may be used to analyze for total and chlorine amenable cyanides in solid wastes or leachate. A draft testing method has just been released by EPA to determine whether a waste is hazardous due to cyanide reactivity (U.S. Environmental Protection Agency, 1986). The memo stated that on a interim basis wastes releasing more than 250 mg HCN/kg waste should be regulated as hazardous waste. Other methods for cyanide analysis in environmental samples are currently being tested. The literature shows that particular methods are suited to specific types of samples depending on the sample composition. Hendrix et al. (1985) has developed a method producing reproducible results suitable for tailings samples. After drying and thorough mixing, 5 grams of sample were mixed with 20 millimeters of 1 N NaOH and about 200 milligrams of $PbCO_3$, and filtered into a distillation flask. The filtrate was analyzed for total cyanide by the ASTM method. Free cyanide was analyzed directly without the caustic filtration pretreatment. J.L. Hendrix (University of Nevada at Reno, personal communication, 1986) is also developing analytical methods to determine the amounts of specific metal cyanide complexes present.

Several different leachate solutions, deionized water, 1 N KNO_3 in water, and 1.25 N NaOH in water, were tested on samples from heap leach piles by Ray (1985). The procedure for analysis consisted of leaching a 20 gram sample in 100 millimeters of leachate solution for 24 hours in the dark. After leaching, the sample was filtered (Whatman GF/C or equivalent) until the final volume was 100 millimeters. The leachate was then analyzed by the distillation/destruction method with a colorimetric finish. The results for direct analysis (0.5 gram sample in distillation flask) and the three leachate methods are presented in Table B-1. Only the NaOH solution solubilized cyanide at a level similar to that found in the direct analysis. The data also show that reproducibility of results is greatly increased with the larger sample sizes.

Snodgrass, 1985). The total cyanide concentration of the iron cyanide complex solution was 10 mg/l after 15 days. The decay rate of the nickel cyanide complex solution was so slow that the concentration had not decreased to less than 30 mg/l even after nine days.

Photochemical Degradation

The iron cyanide complexes, $Fe(CN)_6^{4-}$ and $Fe(CN)_6^{3-}$, in water produce free HCN from photochemical degradation by sunlight (Broderius and Smith, 1980). The lower the concentration of the iron complex ions, the faster the rate of photodegradation. The amount of HCN formed will increase with increasing concentration of the photolabile iron cyanide. The maximum amount of total cyanide (complexed cyanide) converted to free cyanide was 85 percent and 49 percent for $Fe(CN)_6^{4-}$ and $Fe(CN)_6^{3-}$, respectively. Photodegradation rates decrease rapidly with depth in natural water systems. The ultraviolet radiation from the midday sun on a Minnesota lake during summer accelerated the decomposition of ferricyanide to a resultant half life of 20 minutes (Broderius, 1973). During the fall the half-life increased to 50 minutes. Simovic et al. (1985) research with degradation of metal cyanide solutions showed that of the variables, temperature, aeration, and presence of ultraviolet light, ultraviolet light had the largest effect on the iron cyanide solution. The results of tests by both Moggi et al. (1966) and Kelada et al. (1985) showed that cobalt III cyanide complex also is broken down by ultraviolet radiation.

Cyanogenic Glycosides Transformation and Degradation Processes

Cyanide may be released from cyanogenic glycosides subjected to hydrolysis *in vitro* by dilute mineral acids or *in vivo* by enzymes. One of the best known cyanogenic glycosides, amygdalin, occurs in the *Rosaceae* (rose) family. The hydrolysis of amygdalin is shown in Figure B-2. The HCN released from cyanogenic glycosides may undergo any of transformation or degradation processes described above for free cyanide.

TABLE B-1
COMPARISON OF LEACHING METHODS
FOR TOTAL CYANIDE DETERMINATION IN SOLID SAMPLES

Run #	Direct Analysis[a/] (mg/kg)	Leaching Method: DI Water (mg/kg)	1 N KNO_3 (mg/kg)	1.25 N NaOH (mg/kg)
1	45.2	0.8	0.6	142
2	125	0.6	0.4	47.9
3	77.5	<0.2	<0.2	43.2
4	57.3	<0.2	<0.2	109
5	179	0.6	<0.2	106
6	114	0.2	0.4	91.9
7	129			116
8	88.1			114
9	98.3			
10	170			
11	196			
12	104			
13	114			
14	59.9			
15	65.1			
Mean	108	0.4	0.2	96.2[b/]
± 1 S.D.	45.9	0.3	0.3	34.3

a/ Analysis of 0.5 g sample.

b/ If values from runs #2 and #3 are omitted, the mean is 113 ± 16.5 (± 1 S.D.).

Source: Modified from Ray, 1985.

Several other examples which illustrate the diverstiy of methods used for solid samples are described below:

Engelhardt (1985) and Milligan (1985a) - 200-gram split of spent heap material (reprocessed tailings) was agitated for one hour with 200 milliliters of distilled water; after filtering, the pH was adjusted to 12.0 with sodium hydroxide, and then analyzed for free and total cyanide.

Stotts (1985) - 25 grams of spent heap material was placed in 50 millimeters of 20 percent NaOH solution and allowed to mix until delivered to the laboratory which was 12 to 24 hours later; solution was then analyzed for free cyanide.

The actual data from these examples on cyanide concentrations in spent heap leach piles is presented in the section, Cyanide in Spent Leach Piles.

Problems Associated with Analyses

Problems can occur with sample preservation for water samples containing solids. A clear, filtered sample preserved by the addition of sodium hydroxide to a pH of 12 and stored in the dark at 4° C (40° F) will be stable for at least two weeks (Huiatt et al., 1983). There is, however, no guaranteed method of preservation when solids are present (Conn, 1981). Samples with solids can be filtered and preserved or analyzed immediately. If a sample is known to contain sulfides, these should be removed by precipitation with lead carbonate before raising the pH for preservation.

There are many potential sources of interference in analytical determinations for cyanide including sulfides, oxidizing materials, thiocyanates, nitrate-nitrite, carbonate-bicarbonate, metal cations, aldehydes, fatty acids, and potential cyanide-forming materials. ASTM (1981) states that it is beyond their scope to describe procedures for overcoming all the interferences that may be encountered.

Some other problems that have been noted in the literature is that the cyanide ion-selective electrode can be attacked by cyanide solutions which causes inaccurate results (Frant, et al., 1972). Sulfide also causes problems by deactivating the surface of the electrode.

ENVIRONMENTAL FATE OF CYANIDE

Cyanide is a very reactive and relatively short-lived contaminant unlike many pollutants which may enter the environment. Research work on natural destructive mechanisms and rate of degradation for cyanide in the environment has begun recently. This section will focus on the transformation and degradation process for free cyanide, simple cyanides, complex cyanides, and cyanogenic glycosides thought to be most significant to the environmental aspects of a mining operation, and will conclude with a discussion of the factors influencing the mobility of cyanide in surface water, ground water, and soils.

Free Cyanide Transformation and Degradation Processes

Volatilization

The most important mechanism in the natural degradation of cyanide in water is recognized as volatilization of HCN (Simovic et al., 1985). As discussed above, molecular HCN is the dominant species of cyanide at pH values below 9.36. Since molecular HCN has a high vapor pressure, it can readily be volatilized to the atmosphere. Volatilization of HCN was found to be influenced by pH, temperature, interfacial surface area, and concentration (Dodge and Zabbon, 1952). Stripping coeffecients were greatly reduced in stagnant solutions compared to agitated solutions since the process became dependent on molecular diffusion. The Chester Engineers (1977) studied dilute cyanide solutions in the range of 0.1 to 0.5 mg/l. The volatilization rate was 0.04 kg-mole/-hr-m^2-atm (0.009 lb-mole/hr-ft^2-atm) in still waters, which is equivalent to the volatilization of 0.23 milligram CN/m^2-hr (0.021 milligram CN/ft^2-hr) from a 0.5 mg/l cyanide solution at room temperature. Volatilization rates in agitated waters were up to three times as fast.

Palaty and Horokova-Jakubu (1959) examined several factors, pH, temperature, solution depth, presence or absence of aeration and the rate of aeration, which affect HCN removal. The experiment involved HCN removal from an unbuffered, synthetic simple cyanide solution (KCN) at relatively low concentrations (10-50 mg/l CN) over a period of 11 days. The HCN removal rate increased with decreasing pH down to 5; an order of magnitude difference in the rates of HCN removal existed between aerated and nonaerated solutions; and a temperature increase of 10° C (50° F) from 0.8 to 11° C (33 to 52° F) caused the HCN removal rate to increase by greater than 40 percent.

Broderius (1977) conducted experiments on the volatilization of cyanide from natural water using concentrations of cyanide from 25 to 200 ug/l. The concentrations of cyanide in the water were measured during a 6-hour period, from which half lives of 8.8 to 55.5 hours were calculated for HCN disappearance. Disappearance of HCN became negligable when the samples were sealed and closed off from the atmosphere.

Simovic et al. (1985) studied the rate of cyanide degradation from a NaCN solution as well as from solutions containing a single metal cyanide complex and mixtures of metal cyanide complexes. Data from the solutions containing metal cyanide complexes and metal complex mixtures will be presented in the following section, Complex Cyanide Transformation and Degradation Processes. The initial total cyanide concentration for the NaCN solution at 4° C (40° F) was 200 mg/l. Air was bubbled through the solution and the solution was exposed to ultraviolet light. A phosphate buffer was added to maintain a constant pH of 7.0. The total cyanide concentration decayed to less than 1 mg/l after about 230 hours (9.6 days). The decay rate was initially much higher during the first 80 hours (2.1 mg/l per hour).

Reaction of Cyanide to Formate and Ammonia

Cyanide in water reacts to form ammonia and formate ions. Reaction products from an acidic cyanide solution are formic acid and ammonium salts and from a basic solution are formate salts and volatile ammonia. Reaction of HCN in strongly acidic solutions (pH <1) was

found to proceed with half-lives ranging from 10 to 1000 hours (Kreible and McNally, 1929). The rate constants for the reaction of cyanide ion under alkaline conditions range from 2×10^{-8} sec^{-1} to 2×10^{-6} sec^{-1} at temperatures between 33 and 65° C (91 and 150° F) (Wiegand and Tremelling, 1972).

Oxidation

Direct oxidation of cyanide to cyanate (CNO^-) requires mineralogical, biochemical or photochemical catalysis. The reaction is:

$$2\ CN^- + O_2 \xrightarrow{\text{catalysis}} 2\ CNO^- \qquad (5)$$

Another route for oxidation is by hydrolysis to HCN and subsequent oxidation:

$$2\ HCN + O_2 \longrightarrow 2\ HCNO \qquad (6)$$

In water cyanic acid (HCNO) can hydrolyze to produce cyanate (CNO^-). Hendrickson and Daignault (1973) have shown that cyanic acid can be hydrolyzed to carbon dioxide and ammonia. The hydrolysis reaction is:

$$HCNO + H_2O = NH_3 + CO_2 \qquad (7)$$

This reaction is pH dependent, and occurs at a pH up to 8.5, but is greatly accelerated at lower pH values. Further oxidation of ammonia would form nitrate.

According to Schmidt et al. (1981) oxidation processes may have accounted for about 11 percent of the decrease in cyanide from a relatively shallow holding pond for mill cyanide process solutions over a six month period during the warm season.

Complexation with Metallic Ions

Some 28 elements are capable of forming 72 possible metal cyanide complexes (Ford-Smith, 1964). The relative stabilities of some of the common cyanide complexes in water are given in Table B-2. The stronger or more stable the cyanide complex, the less free cyanide ion required to maintain it in solution and the less readily it dissociates to yield cyanide ions.

TABLE B-2

RELATIVE STABILITIES OF SOME CYANIDE COMPOUNDS AND COMPLEXES IN WATER

Term	Examples of Cyanides in Processing Solutions
1. Free Cyanide	CN^-, HCN
2. Simple Compounds	
a) readily soluble	NaCN, KCN, $Ca(CN)_2$, $Hg(CN)_2$
b) relatively insoluble	$Zn(CN)_2$, CuCN, $Ni(CN)_2$, AgCN
3. Weak Complexes	$Zn(CN)_4^{2-}$, $Cd(CN)_3^-$, $Cd(CN)_4^{2-}$
4. Moderately Strong Complexes	$Cu(CN)_2^-$, $Cu(CN)_3^{2-}$, $Ni(CN)_4^{2-}$, $Ag(CN)_2^-$
5. Strong Complexes	$Fe(CN)_6^{4-}$, $Co(CN)_6^{4-}$, $Au(CN)_2^-$

Source: Adapted from Scott and Ingles, 1981.

The dissociation of a complex cyanide ion involves a number of intermediate reactions, some of which may be rate limiting steps. At a given temperature, pH and the concentration of the complex ion influence the dissociation rate (Broderius, 1973). Rates of dissociation generally increase with either decreasing pH or decreasing total cyanide concentration. Dissociation of metal cyanide complex ions will be discussed further in the section, Dissocation of Metal Cyanide Complex Ions.

Biological Degradation

Biological destruction appears to be a significant means of reducing cyanide concentration. Numerous studies have shown that many bacteria, fungi, and algae are capable of utilizing cyanides, converting cyanide to carbon dioxide and ammonia. Biochemical degradation of cyanide may occur under both aerobic and anaerobic conditions over a wide pH range (Towill et al., 1978). Under aerobic conditions cyanide decomposes to carbon dioxide and ammonia biochemically as shown by either in equation (5) or (6), and equation (7). Cyanide decomposes to thiocyanate (SCN^-) under anaerobic conditions as shown:

$$HCN + S^{2-} = HSCN \tag{8}$$

Thiocyanate may hydrolyze to produce hydrogen sulfide, carbon dioxide and ammonia. Schmidt et al. (1981) suggests the general pathways for anaerobic decomposition are as follows:

$$HCN + S^{2-} = HCNS \tag{9}$$

$$HCNS + 2H_2O = H_2S + CO_2 + NH_3 \tag{10}$$

Higher plants and animals have the capacity to metabolize sublethal doses of administered cyanide to thiocyanate (Towill et al., 1978). Activated sludge treatment can result in virtually complete removal of cyanide (Ludzack and Schaffer, 1962; Kostenbalder and Flecksteiner, 1969), but Raef et al., (1977b) thought that most of the loss of cyanide in such systems is due to stripping (volatilization).

Conversion to Thiocyanate

If sulfide (S^{2-}) or thiosulfate ($S_2O_3^{2-}$) is present in the environment, cyanide can react to form thiocyanate (SCN^-). This chemical process would occur where sulfide minerals are oxidizing. Metal thiocyanate complexes may be formed but the formation potential for metal cyanide complexes is much greater then for metal thiocyanate complexes. If free cyanide is absent, than metal thiocyanate complexes will form. Many of metal thiocyanate complexes found in ore processing solutions are insoluble. This process may play a role in removing some cyanide and metals from solution.

Sorption

Sorption of free cyanide, as well as complexed cyanides, to clays (Cruz et al, 1974; Schenk and Wilke, 1984), soils (Alesii and Fuller, 1976; Fuller, 1985), sludge (Raef et al, 1977a) and plant debris (Schenk and Wilke, 1984) occurs to a small extent.

Simple Cyanide Transformation and Degradation Process

The relative solubility of several simple cyanides is shown in Table B-2. The soluble compounds can readily release free cyanide, which may be subjected to the degradation processes described above. However, $Zn(CN)_2$, CaCN, $Ni(CN)_2$, and AgCN are relatively insoluble in water.

Complex Cyanide Transformation and Degradation Processes

Solubilities of Complex Cyanides Salts

The solubilities of iron cyanide salts are listed in Table B-3. Most of these compounds are relatively insoluble. If an iron cyanide salt dissolves, the products are an alkali or heavy metal ion and either a ferrocyanide or ferricyanide complex, which are strong complexes. The dissociation of metal cyanide complexes such as ferrocyanide and ferricyanide is discussed below.

TABLE B-3

SOLUBILITIES OF FERROCYANIDE AND FERRICYANIDE SALTS

Name	Formula	Solubility (g/l)[a/]
Ammonium Ferricyanide	$(NH_4)_3Fe(CN)_6$	very soluble
Ammonium Ferrocyanide	$(NH_4)_4Fe(CN)_6 3H_2O$	soluble
Barium Ferrocyanide	$Ba_2Fe(CN)_6 6H_2O$	1.7 (15°C)
Cadmium Ferrocyanide	$Cd_2Fe(CN)_6 : xH_2O$	insoluble
Calcium Ferrocyanide	$Ca_2Fe(CN)_6 \cdot 12H_2O$	868 (25°C)
Cobalt Ferricyanide	$Co_3(Fe(CN)_6)_{-2}$	insoluble
Cobalt Ferrocyanide	$Co_2Fe(CN)_6 \cdot xH_2O$	insoluble
Copper (I) Ferricyanide	$Cu_3Fe(CN)_6$	insoluble
Copper (II) Ferricyanide	$Cu_3(Fe(CN)_6)_2 \cdot 14H_2O$	insoluble
Copper (II) Ferrocyanide	$Cu_2Fe(CN)_6 \cdot xH_2O$	insoluble
Iron (II) Ferricyanide	$Fe_3(Fe(CN)_6)_2$	insoluble
Iron (III) Ferricyanide	$Fe\ Fe(CN)_6$	--
Iron (II) Ferrocyanide	$Fe_2\ Fe(CN)_6$	insoluble
Iron (III) Ferrocyanide	$Fe_4\ (Fe(CN)_6)_3$	2.5×10^{-4} b/
Lead Ferricyanide	$Pb_3\ (Fe(CN)_6)_2 \cdot 5H_2O$	slightly soluble
Magnesium Ferrocyanide	$Mg_2Fe(CN)_6\ 12H_2O$	330g
Manganese (II) Ferrocyanide	$Mn_2Fe(CN)_6 \cdot 7H_2O$	insoluble
Nickel Ferrocyanide	$Ni_2Fe(CN)_6 \cdot xH_2O$	insoluble
Potassium Ferricyanide	$K_3Fe(CN)_6$	330 (4°C)
Potassium Ferrocyanide	$K_4Fe(CN)_6 \cdot 3H_2O$	278 (12°C)
Silver Ferricyanide	$Ag_3Fe(CN)_6$	0.00066 (20°C)
Silver Ferrocyanide	$Ag_4Fe(CN)_6 \cdot H_2O$	insoluble

(Continued)

TABLE B-3 (Continued)

Name	Formula	Solubility (g/l)[a/]
Sodium Ferricyanide	$Na_3Fe(CN)_6 \cdot H_2O$	189 (0°C)
Sodium Ferrocyanide	$Na_4Fe(CN)_6 \cdot 10H_2O$	318.5 (20°C)
Strontium Ferrocyanide	$Sr_2Fe(CN)_6 \cdot 15H_2o$	500
Thallium Ferrocyanide	$Tl_4Fe(CN)_6 \cdot 2H_2O$	3.7 (18°C)
Tin (II) Ferricyanide	$Sn_3 (Fe(CN)_6)_2$	insoluble
Tin (II) Ferrocyanide	$Sn_2Fe(CN)_6$	insoluble
Tin (IV) Ferrocyanide	$SnFe(CN)_6$	insoluble
Zinc Ferrocyanide	$Zn_2 Fe(CN)_6$	insoluble
Zinc Ferricyanide	$Zn_2 (Fe(CN)_6)_2$	2.6×10^{-5} b/
Zinc Ferrocyanide	$Zn_3 (Fe(CN)_6)_2$	2.2×10^{-5} b/

Source: Weast, 1969

a/ Source unless otherwise noted is from Weast , 1969.

b/ Source: Mezey and Neuendort, 1981.

Dissociation of Metal Cyanide Complex Ions

A stability constant is a measure of the affinity or tightness of the binding of the complex between the cyanide radical and a metal. The reaction between a metal ion and cyanide to form a metal cyanide complex is

$$M^{y+} + x(CN)^{-} = M(CN)_x^{(x-y)-} \tag{11}$$

where M = metal with valence y; and

x = number of cyanide groups in the complex.

The stability constant or the inverse of the stability constant, the dissociation constant, is expressed as follows:

$$K_s = \frac{[M(CN)x^{(x-y)-}]}{[M^{y+}] \quad [CN^{x-}]} = \frac{1}{K_d} \tag{12}$$

where K_s = stability constant;

K_d = dissociation constant; and

[ ] = concentration units in moles per liter.

The values for the stability constants for metal cyanide complex ions are shown in Table B-4.

In a solution containing different metals where more than one complex can form, a cumulative or gross constant, B_n, is used to describe the reactions between the metals and cyanide:

$$M + n(CN) = M(CN)_n \tag{13}$$

The cumulative constant, B_n, is expressed as follows:

$$B_n = \frac{[M(CN)_n]}{[M] \quad [CN]^n} \tag{14}$$

where the concentration units, [ ], are moles per liter.

The cumulative constant for specific metals can be quantified by the results of potentiometric titrations conducted both in the presence of and absence of the metal. Cumulative constants for individual metal ions are presented in Table B-5. The B_n values indicate the relative

TABLE B-4

STABILITY CONSTANTS OF METAL-CYANIDE COMPLEX IONS

COMPLEX ION	STABILITY CONSTANT[a/]
$Cr(CN)_6^{3-}$	10^{33}
$Cr(CN)_6^{4-}$	10^{21}
$Fe(CN)_6^{4-}$	$10^{35.4}$
$Fe(CN)_6^{4-}$	10^{47} b/
$Co(CN)_6^{4-}$	10^{50}
$Ni(CN)_4^{2-}$	10^{30}
$Pd(CN)_4^{2-}$	10^{42}
$Pt(CN)_4^{2-}$	10^{40}
$Cu(CN)_2^{-}$	$10^{23.9}$
$Cu(CN)_3^{2-}$	$10^{29.2}$
$Cu(CN)_4^{2-}$	$10^{30.7}$
$Ag(CN)_3^{2-}$	$10^{20.4}$
$Ag(CN)_3^{2-}$	$10^{21.9}$
$Au(CN)_2^{-}$	10^{37}
$Au(CN)_4^{-}$	10^{85} (estimate)
$Zn(CN)_4^{2-}$	10^{21}
$Cd(CN)_4^{2-}$	10^{19}
$Hg(CN)_4^{2-}$	10^{39}

a/ Source unless otherwise noted is from Sharpe, 1976.

b/ Source: Broderius, 1973.

TABLE B-5
CUMULATIVE CONSTANTS, B_n, FOR VARIOUS METALS
FOUND IN PRECIOUS METAL ORES

Metal	Valence	a_n a/	Log (10) of B_n	Log (10) of [CN]
Cadmium	+2	4	16.85	-1.6
Cobalt	+2	6	19.09	-1.5
Cobalt	+3	6	64	-9.0
Copper	+1	4	27.3	-4.3
Gold	+1	2	47.5	-18.6
Gold	+3	4	56	-11.4
Lead	+2	4	10.3	0
Mercury	+2	4	41.4	-7.8
Nickel	+2	4	31	-5.2
Silver	+1	4	21.1	-2.7
Zinc	+2	4	16.9	-1.7

a/ a_n = number of cyanide molecules in the metal-cyanide complex.

Source: Milligan, 1985b.

strength of the metal cyanide complex. To get an idea of how much cyanide in solution is needed to form a specific metal cyanide complex, Milligan (1985b) assumed a cyanide-metal complex to metal ratio equal to 2.0×10^{10}, and then solved for free cyanide content. Lead, for example, requires a free cyanide content of 1 mole per liter, while all other metals (Table B-5) would be dissolved and leached from the ore when mixed with smaller quantities of free cyanide. Certain minerals containing these metals in the ore may be more stable than the cyanide complex, and therefore the metal cyanide complex may not form.

The equations for cumulative constant or dissociation constant can be combined with the equation for dissociation of hydrogen cyanide to calculate equilibrium hydrogen cyanide concentration at given pH values and initial concentrations of the metal complex. A decrease in pH accelerates the reaction as does a decrease of initial concentration.

The rate of dissociation of metal cyanide complexes is also an important factor. The dissociation of a synthetic solution of single metal cyanide complexes (Cu, Zn, Ni, and Fe) was studied by Simovic et al. (1985). The test solutions (initially 200 mg/l total cyanide) were aerated, illuminated with ultraviolet light, and maintained at pH 7 (phosphate buffer). There was an initial rapid decrease in the total cyanide concentrations within the first 48 to 72 hours, which was attributed to volatilization of hydrogen cyanide. The total cyanide concentration continued to decline, but at a slower rate. The metal cyanide complex decay coefficient was determined for the two different temperatures tested (Table B-6). The half life for each metal cyanide complex was calculated from this data. Zinc cyanide complex had the fastest decay rate, followed by copper, iron, and nickel complexes. Only the decay rate of iron cyanide complex was affected by ultraviolet light (which is discussed in the next section). Other data from these studies, showed that residual total cyanide concentrations decreased to less than 1 mg/l within four days for the zinc cyanide complex solution and within 12 days for the copper cyanide complex solution (Simovic and

TABLE B-6

DEGRADATION OF METAL CYANIDE COMPLEXES IN PHOSPHATE BUFFER AT pH 7[a/]

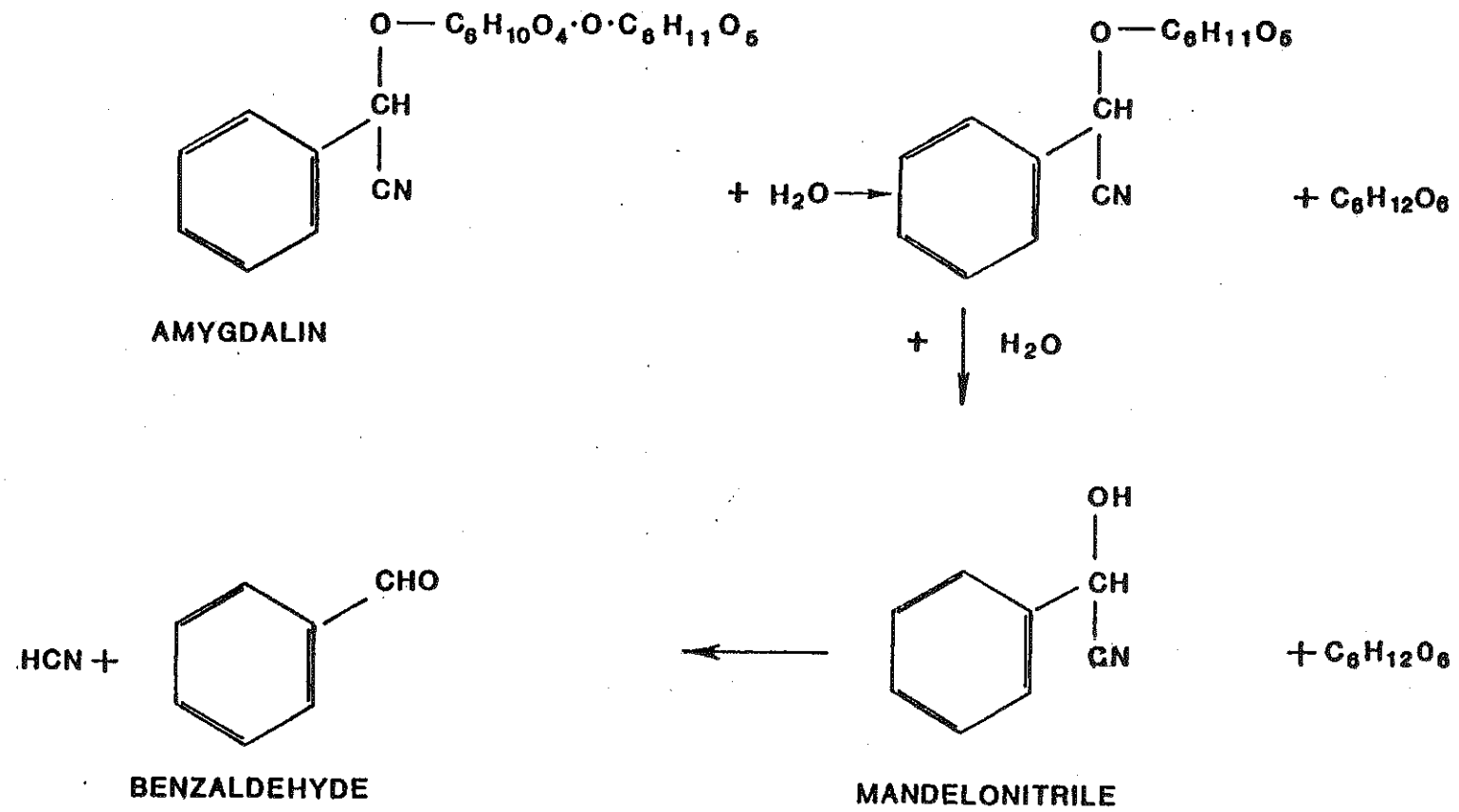
	$k_1 \times 10^2$ (4 °C) (hr^{-1})	$t_{1/2}$[b/] (4 °C) (days)	$k_1 \times 10^2$ (20 °C) (hr^{-1})	$t_{1/2}$[b/] (20 °C) (days)
$Zn(CN)_4^{2-}$	1.78	1.6	4.49	0.64
$Cu(CN)_3^{2-}$	0.29	9.9	0.75	3.8
$Fe(CN)_6^{3-}$	0.14	20.6	0.47	6.1
$Ni(CN)_4^{2-}$	0.04	72.1	0.09	32.0

a/ Initial concentration is 200 mg/l. Adapted and modified from Simovic et al., 1985.

b/ Half-lives were calculated from the rate constants (Versar Inc., 1986).

FIGURE B-2

THE HYDROLYSIS OF A CYANOGENIC GLYCOSIDE, AMYGDALIN



(MODIFIED FROM FULLER, 1985)

Mobility of Cyanide in Surface Water

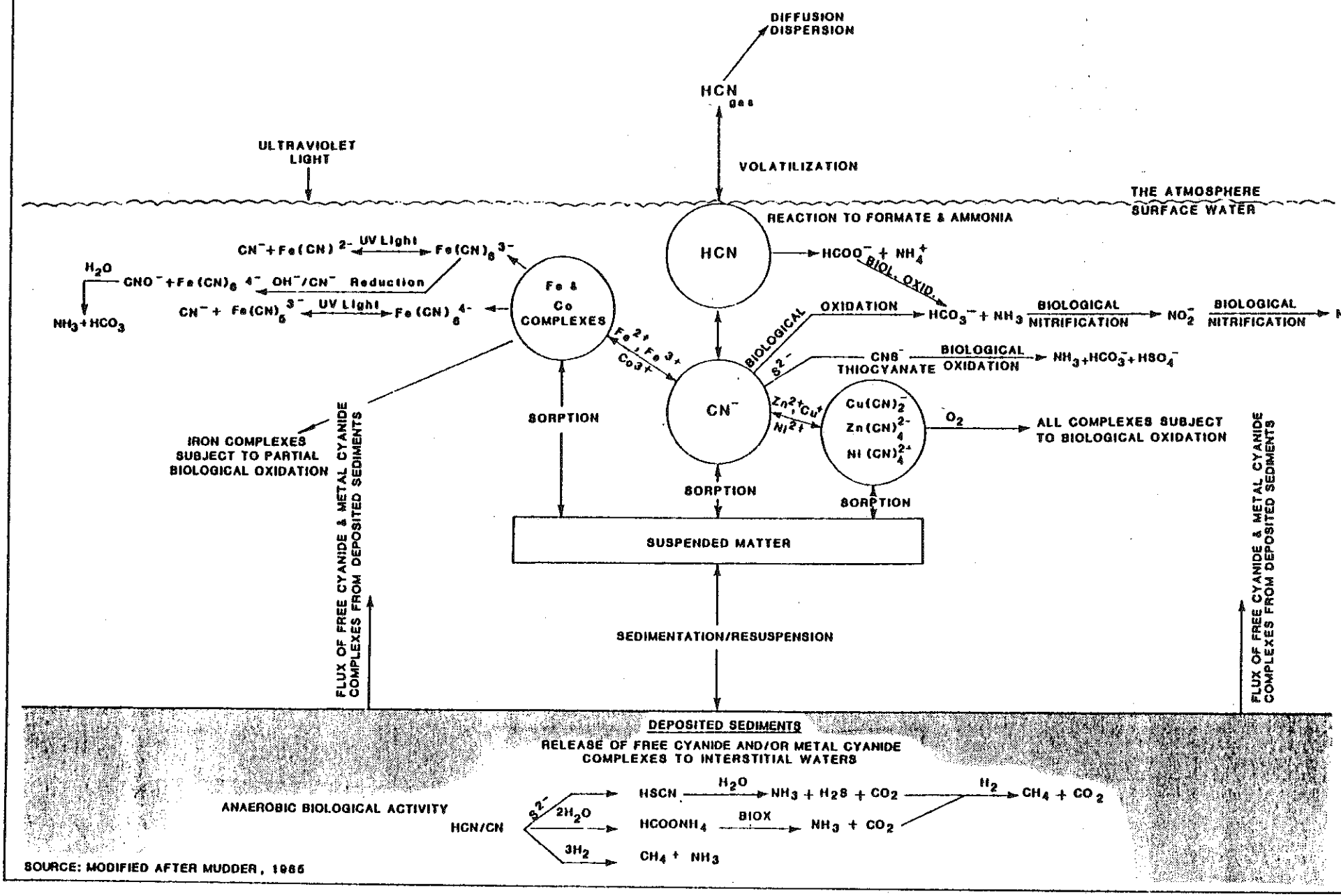
Figure B-3 summarizes cyanide reactions in surface water. The mobility of cyanide in surface water will be dependent on a large number of factors, including pH, temperature, concentration and type of metals and resulting metal cyanide complexes, properties of the water body (depth, surface area, amount of turbulence or aeration), presence of ultraviolet light, and quantities and forms of transported organic and inorganic suspended matter, and interchange with sediment. The different mechanisms for cyanide degradation have been discussed above; each location will have its own set of factors which may tend to release or immobilize cyanide. Generally, free cyanide ion will be more mobile in waters with higher pH, lower temperature, lower levels of metals, organic and inorganic suspended matter, and little interaction with sediment. The properties of a water body that would promote higher mobility of cyanide are stagnant, deep conditions with little surface area. Cyanide will more readily volatilize in highly aerated waters with lower pH's. Free cyanide will be less mobile in waters where there are higher concentrations of metals, sulfide, and organic and inorganic matter. If iron or cobalt complexes are present, then the presence of ultraviolet light may be a factor in increasing the mobility of cyanide.

No predictive models have been developed for the mobility of cyanide in streams. However, several models have been developed to predict the natural degradation of cyanide in gold mining effluents (refer to the section, Degradation of Cyanide at Heap leach Operations).

Mobility of Cyanide in Ground Water

The mobility of cyanide in ground water is also dependent on many factors such as pH, temperature, concentration and type of metals present and subsequent formation of metal cyanide complexes, amount of aeration, and interaction with soil or rock particles. Volatilization rates of HCN from ground water are probably reduced compared to surface water. Volatilization, however, may be an important process in the

FIGURE B-3
CYANIDE REACTIONS IN SURFACE WATER



SOURCE: MODIFIED AFTER MUDDER, 1985

vadose zone. Several researchers have showed that stripping coefficients for stagnant cyanide solutions were greatly reduced compared to agitated solutions, since the process becomes dependent on molecular diffusion. On the other hand, processes that tend to tie up cyanide such as sorption and complexation may be more important processes for ground water than surface water. Ground water flow is generally much slower than surface water which allows more time for interaction of the water with soil or rock minerals. Reaction of cyanide to ammonia and formate ions may also be an important process to remove cyanide from ground water. The other factors such as pH and temperature are also important and vary in the same way as for surface water; that is cyanide is more mobile at higher pH values and lower temperatures. Iron and cobalt cyanide complexes will not undergo photochemical degradation in ground water; however, if ground water is discharged to surface water this process may become important.

Mobility of Cyanide in Soils

The mobility of cyanide in soils is largely dependent on soil clay content, depth of soil, content of hydrous oxides of iron, manganese, aluminum and other metals, pH, presence of aerobic or anaerobic conditions, and presence of soil organic matter (Fuller, 1985). Alesii and Fuller (1976) and Fuller (1985) found cyanide in water as $Fe(CN)_6^{3-}$ and CN^- to be very mobile in soils, whereas cyanide as KCN in natural landfill leachate (which contained metals) was less mobile in soils. During this experiment, the anaerobic state of the soil columns inhibited microbial degradation of cyanide. The limit for effective anaerobic degradation of cyanide was found to be 2 mg/l in studies of a sewage wastestream (Coburn, 1949), which is considerably lower than 100 mg/l used in the experiment. The high clay content soil retained more ferricyanide than the sandier soil of similar pH. Ferricyanide was retained the most in soils having a low pH, which was explained by the clay surface having a high percentage of positive exchange sites. The KCN solution leached most rapidly in the soil having the lowest pH.

Cyanide was retained most by soils having a high concentration of hydrous oxides. Mobility of cyanides is greatest in soil at high pH and low clay content.

Cyanide-yielding compounds rapidly ammonify and nitrify in the same soils under aerobic field conditions (Fuller, 1985). In fact, despite regular use of pesticides and fertilizers containing low levels of cyanides or cyanide-yielding compounds, cyanides do not accumulate in the soil.

Wharf Resources Inc. (1982) conducted tests of effluent from cyanide solutions applied to soil columns containing native soil from the Annie Creek Mine area in the Black Hills, South Dakota (Table B-7). Results from the 150 mg/l total cyanide solution showed that both total and free cyanide were reduced to less than half the concentration of the originally applied solutions during the test and continued to decline over the next 6 weeks.

Research is being conducted by DuPont on soil collected from below heap leach pads at two mining operations (F. DeVries, Dupont Company, personal communication, 1986). Besides describing soil mineralogy, they are conducting two types of tests including 1) stirred reaction with cyanide, and 2) column tests with cyanide. Data from these tests will be incorporated into a model used to predict the mobility of cyanide in soils.

CYANIDE CHEMISTRY OF HEAP LEACH OPERATIONS

Cyanidation

In the cyanidation process, precious metals are leached from ores with a cyanide solution. In most mineral leaching operations in the United States, the leaching solution is prepared from sodium cyanide. The sodium cyanide in solution will dissociate to sodium and cyanide ion as discussed above (equation 3). The optimum pH process solution for leaching purposes is 10.3 (Barsky et al., 1962), so cyanide ion remains predominant (refer to Figure B-1). The leaching solution contains sodium cyanide at a concentration of 0.05 percent (equivalent

TABLE B-7

RESULTS OF TESTS WITH CYANIDE SOLUTIONS (in mg/l) ADDED TO COLUMNS CONTAINING NATIVE SOIL FROM THE AREA OF ANNIE CREEK MINE, SD[a/]

Test Conditions	Test 4-SS (Nominally 150 mg/l) Date	Free CN	Total CN	Test 5-SS (Nominally 1 mg/l) Date	Free CN	Total CN
Influent solution	8/16 - 8/19/82	36.5	149	8/25 - 8/27/82	1.0	1.0
Effluent	8/17	4.5	65	8/26	<0.01	0.03
Effluent	8/18	17	46.5	8/27	<0.01	<0.01
Effluent following fresh-water flush	10/4	2.4	29	10/4	<0.05	<0.05

Source: Wharf Resources Inc., 1982.

a/ Cyanide solutions added to soil columns at about 20 $l/min/m^2$ (0.5 $gal/min/ft^2$) for 3 days.

TABLE B-7

RESULTS OF TESTS WITH CYANIDE SOLUTIONS (in mg/l) ADDED TO COLUMNS CONTAINING NATIVE SOIL FROM THE AREA OF ANNIE CREEK MINE, SD[a/]

Test Conditions	Test 4-SS (Nominally 150 mg/l) Date	Free CN	Total CN	Test 5-SS (Nominally 1 mg/l) Date	Free CN	Total CN
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Effluent following fresh-water flush	10/4	2.4	29	10/4	<0.05	<0.05

Source: Wharf Resources Inc., 1982.

a/ Cyanide solutions added to soil columns at about 20 $l/min/m^2$ (0.5 $gal/min/ft^2$) for 3 days.

to about 250 mg/l free cyanide) Chamberlain and Pojar (1984). At some operations, the cyanide concentration is much higher (600 to 1000 mg/l) for the first few days of leaching and subsequently drops to approximately 200 mg/l. The rate of dissolution depends on cyanide concentration, oxygen availability, temperature and solution pH. The efficiency of leaching depends on the type of ore. Ore that contains clean, free fine-sized gold particles, little clay content, and no cyanicide impurities that may destroy cyanide or inhibit its reaction provides the most efficient leaching situation. Since the reaction is temperature sensitive, the leaching rate of precious metals during colder conditions may be only 70 percent of the leaching rate during summer operating conditions (Milligan, 1985b). Examples of cyanicides are sulfide and ferrous or ferric iron. Details of two example cyanide leaching operations are provided in Appendix A.

The reaction for dissolution of gold and complexation with cyanide is (Heinen et al., 1978):

$$2Au + 4CN^- + O_2 + 2H_2O = 2Au(CN)_2^- + H_2O_2 + 2\ OH^- \qquad (15)$$

A lesser amount of gold is solubilized as shown in the Elsner's equation:

$$4Au + 8CN^- + O_2 + 2H_2O = 4Au(CN)_2^- + 4\ OH^- \qquad (16)$$

The equations for silver dissolution are similar.

Other metal cyanide complexes may be present in the leaching solution depending on the various metals and their forms in the ore. If the metals in the ore are in the form of compounds less stable than the cyanide complex and the metals are exposed to the leaching solution, then the rate of metal dissolution by cyanide increases directly in proportion to the free cyanide concentration present in the solution. Eventually, a limit is reached at the maximum dissolution rate of the metal cyanide complex; further increases in the free cyanide concentration may have a slight retarding effect on the dissolution rate of the complex (Milligan, 1985b).

The pregnant solution (process solution containing complexed precious metals) is processed through carbon adsorption columns and/or zinc precipitation units in order to recover the gold and silver. In the carbon process the metal cyanide complexes adsorb to the carbon surface. When the carbon columns reach a certain loading capacity, the metals are stripped from the carbon with an alcohol-caustic-cyanide solution. The gold and silver from this solution is removed by electrowinning.

Alternatively, zinc dust is added to the pregnant solution to precipitate the gold and silver cyanide complexes in the zinc precipitation process. Gold and silver precipitation are improved by adding lead acetate or lead nitrate to the solution. The precipitation reaction for gold is:

$$NaAu(CN)_2 + 2NaCN + Zn + H_2O = Na_2Zn\ (CN)_4 + Au + H^+ + NaOH \quad (17)$$

The solution containing the precipitate is filtered and dried for smelting.

Cyanide in Spent Leach Piles

Very little data exists on the amounts and forms of cyanide in spent leach piles. It is difficult to compare the limited data that exists since researchers are not using a standardized method of sampling the spent ore heaps or leaching the solid sample before analysis. The cyanide content and forms in spent leach piles will depend on the ore mineralogy, ore pH, heap permeability, the thickness of the heap, cyanide concentration in process solution, solubility and dissociation rate of metal cyanide complexes, temperature, the type and application of rinsing solutions, and the rate of release of cyanide from the pile. Volatilization is probably the most important process for the removal of cyanide from spent ore heaps after the heaps have been rinsed. Atmospheric sampling data are not available for the low level release of HCN from spent leach piles.

Research is currently being conducted by J. Hendrix (University of Nevada, personal communication, 1986) on cyanide in spent leach piles. His research consists of 1) experimentation with a leaching column containing ore in the laboratory and 2) collection of samples (representative sampling on a grid) from spent leach piles. Dr. Hendrix is also developing analytical methods to determine the amounts of specific metal cyanide complexes present.

Engelhardt (1985) and Milligan (1985a) studied the decay of cyanide after the heap leaching of some tailings (15 percent plus-100 mesh) that were formerly processed for lead, zinc, and silver (sulfide and oxide circuit) in the 1940's and 1950's. The location of this operation was in a desert area. Approximately 5,400 kilograms (12,000 pounds) or 11.5 percent of the cyanide remained in the spent heaps, after rinsing the 76,000 metric tons (84,000 short tons) of ore. A time-series study was initiated to examine the natural dissipation of cyanide levels in the ore. Samples were collected from 11 areas on the heap by driving a 3.8 centimeters (1.5 inch) pipe through the heap to the pad. Samples were agitated for one hour with distilled water and the slurry was filtered to recover the solution. After adjusting the pH to 12.0, the samples were analyzed for free cyanide. Sampling was conducted in January (3 months after the leaching process ceased), March, June, and September, 1983 and 6 months later in March, 1984. The pH in the heaps fell from 10.5 at the cessation of the operation to approximately 9 in late 1984. Results showing substantial decreases in free cyanide concentrations between the initial and final sampling periods are presented in Table B-8. Total cyanide data was not reported but it is stated that total cyanide was almost the same as free cyanide implying that there are no significant amounts of complexes. The data showed little correlation of cyanide concentration with depth. Based on these data (relatively few data points), the authors stated that at the present rate of degradation, it would take approximtely four years for the cyanide concentration of the spent heap pile to decay to 1 mg/kg.

TABLE B-8

FREE CYANIDE CONCENTRATIONS IN ELEVEN LOCATIONS IN THE DARWIN HEAP

Darwin ID No.	Heap No.	Percent Moisture Jan 83	Percent Moisture Mar 84	Free Cyanide (mg/kg) Jan 83	Free Cyanide (mg/kg) Jan 84	Percent Loss of Free Cyanide During 15 Months
Q3S2	1	14.6	14.6	102.6	<6.8	93.4
Q3S3	2	14.0	13.0	118.8	13.4	88.7
Q3S4	3	16.4	15.5	196.2	23.8	87.9
Q6S1	4	14.7	14.6	144.8	22.2	84.7
Q6S2	5	14.6	12.5	87.2	20.0	77.1
Q6S3	6	15.9	14.3	155.0	28.4	81.7
Q6S4	7	15.2	12.0	91.4	<6.8	92.6
Q9S1	8	14.3	12.2	146.8	37.5	74.5
Q9S2	9	14.8	11.9	34.7	<6.8	80.4
Q9S3	10	14.5	11.8	8.5	<6.8	21.2
Q9S4	11	13.4	11.4	7.7	<6.8	16.9

Source: Engelhardt, 1985; Milligan, 1985a.

Research on the destruction of cyanide in the leached heaps was conducted at the Stibnite Mine in Idaho (Stotts, 1985). After leaching was completed, a solution containing chlorine and lime was sprayed on the heaps. The effluent from the rinsing was recycled through the neutralization system until it contained a free cyanide concentration of 0.2 mg/l. After a 0.2 mg/l concentration was reached, hourly testing of the solution was done over a period of 24 hours. If the 24 hour average free cyanide concentration did not exceed 0.2 mg/l and no single sample exceeded 1.0 mg/l, then the heap was environmentally suitable for disposal as required by the operator's agreement with the U.S. Forest Service. If, however, the 24 hour test failed to meet these requirements, the entire procedure was repeated. An analysis for a sample from the chlorine pond (rinsing solution) is given in Table B-9. This table shows the metals associated with the ore at Stibnite, some of which may form salts of metal cyanide complexes and remain in the spent ore. After treatment with chlorine, the spent ore was hauled to an old tailings site and spread out in thin layered lifts of 0.3 to 0.6 meters (1 to 2 feet).

Ten locations in the spent ore were sampled at 15 to 30 centimeters (6 to 12 inches) below the surface at one, five, and ten day intervals. Cyanide was analyzed from the leachate produced from the mixing of 25 grams of ore placed in 50 milliliters of cyanide-free caustic soda (NaOH) solution at 20 percent strength. The ore was leached for 12 to 24 hours. Results of the time series decay of cyanide for eight of the samples are shown in Figure B-4. The average 10-day decrease was approximately 50 percent of the content on the first day, with a range from about 10 percent for the samples with a very low starting concentration to a high of nearly 80 percent for samples having a higher starting concentration.

Ray (1985) sampled various heap leach piles in the southeastern desert of California and found that total cyanide levels were highly dependent upon the mineral composition of the ore (Table B-10). The sampling procedure was not described. The total cyanide analysis was conducted on a 20 gram sample that was subjected to a 24-hour leaching

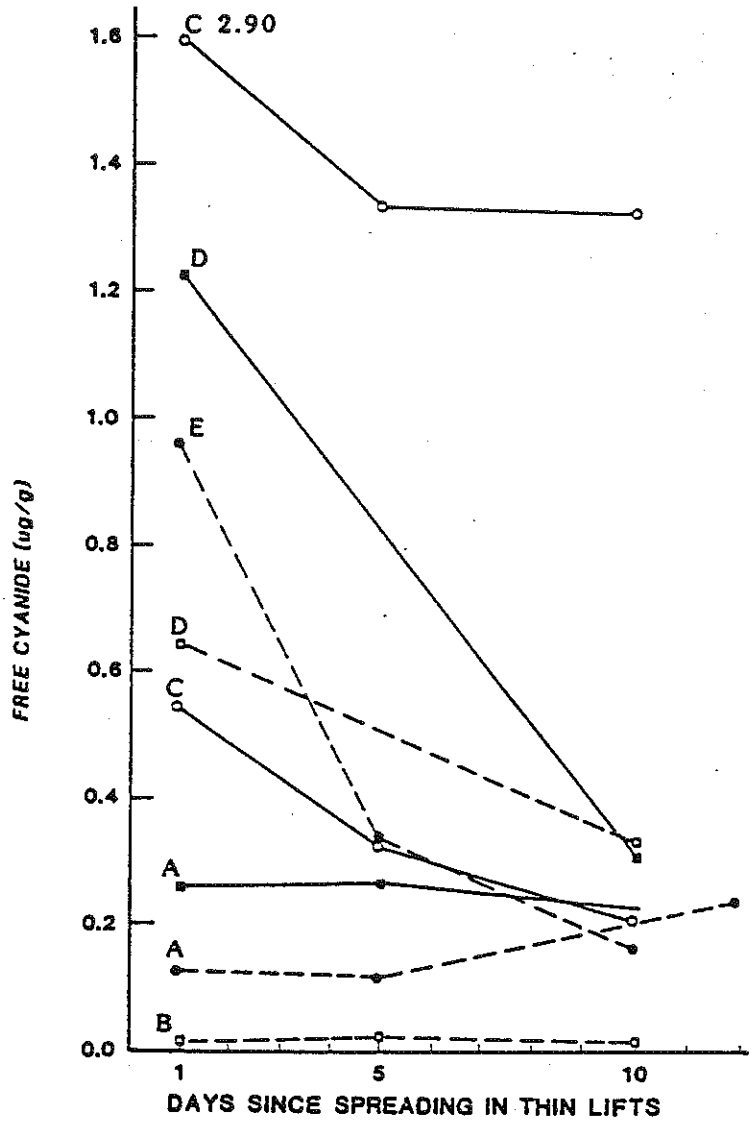
TABLE B-9
SOLUTION SAMPLE OF CHLORINE POND AT STIBNITE MINE, IDAHO
August 24, 1983

Chloride	1,724 mg/l
Arsenic	0.271 mg/l
Antimony	0.021 mg/l
Calcium	560 mg/l
Copper	0.071 mg/l
Iron	0.590 mg/l
Lead	0.034 mg/l
Mercury	0.357 mg/l
Sodium	135 mg/l
Zinc	0.030 mg/l
Cadmium	0.016 mg/l

Source: Stotts, 1985.

FIGURE B-4

CYANIDE DEGRADATION IN TREATED WASTE ORE FROM STIBNITE MINE, IDAHO



NOTE: THE LETTERS (A to E) REPRESENT LOCATIONS. TWO SAMPLES WERE TAKEN FROM SEVERAL LOCATIONS (A, C, AND D). THE SOLID AND DASHED LINES ARE FOR CLARITY.

(MODIFIED FROM STOTTS, 1985)

TABLE B-10

TOTAL CYANIDE CONCENTRATIONS FOR VARIOUS HEAP LEACH OPERATIONS IN CALIFORNIA

Description of Ore Samples	Run No.	mg/kg
Samples low in iron	1	0.97
	2	0.41
	3	0.24
	4	0.42
	5	0.12
	6	0.27
	7	1.5
	8	0.90
Samples high in iron and copper	9	75
	10	34
	11	9.0
Samples high in iron, mined for silver	12	17.1
	13	5.9
	14	11.2
	15	105
Samples high in copper	16	41
	17	83
	18	91
	19	5.7
Samples low in cyanicides	20	0.82
	21	<0.05
	22	<0.05
	23	<0.05
	24	1.0
	25	0.07
	26	<0.05
	27	0.12
	28	0.20
	29	<0.05
	30	<0.05

Source: Ray, 1985.

in the dark using a 1.25 N NaOH solution, filtration, and analysis of the filtrate by the EPA (1979) distillation/destruction method, followed by colorimetric measurement.

The California Regional Water Quality Control Board, Colorado River Basin, Region 7 (1985) use to require a 1.0 mg/kg limit on the total cyanide found in abandoned heap leach piles. After reviewing the literature, specifically fish toxicity studies and cyanide environmental chemistry, they have changed the limit to 10 mg/kg. Their rationale is that because iron is the major metal atom available for complexation, iron cyanides are expected to be the only strong complexes formed. Other complexes are weaker and can be expected to degrade readily to cyanide ion. Therefore, the major species to consider in heap leach piles are iron cyanides and cyanide ion. Since iron cyanides are considered to be of low toxicity and have proven to be generally non-leachable, only cyanide ion content should be considered. A cyanide level of 0.02 mg/l was acceptable to the Regional Board and after multiplying by 100 (their usual practice when accounting for dilution in the environment), a level of 2.0 mg/l was obtained. The analysis of the sample is performed by leaching 1 part solid to 5 parts liquid; using this ratio and 2.0 mg/l, the acceptable limit for a solid is 10 mg/kg. Based on this rationale requirements from the Regional Board, the Mesquite Mine was required to rinse as follows when abandoning heap leach piles: 1) 90 percent of at least 10 samples shall contain less than 10 mg/l free cyanide and 2) none of the samples shall contain more than 20 mg/l free cyanide.

A sample collected from leached ore (with pH of 8.3) at the Zortman and Landusky heap in Montana had a concentration of 4.5 mg/kg for both total cyanide and cyanide amendable to chlorination (ERCO, 1984). The method of analysis was that prescribed by the EPA (1982). Concentrations of total cyanide and cyanide amendable to chlorination in the inactive heap leach material (with pH of 8.8) from the Pinson Mine in Nevada were both less than 2 mg/kg.

The sample extraction or leaching method prior to analysis may determine the content of cyanide in the sample. Spent heap leach wastes from Tombstone Silver Mines, Inc. (Arizona) were sampled and 75 grams of sample were leached with 150 milliliters of water and 0.1 gram of lime (CaO) for 1 hour (Pahlman, 1986). Most of the values were less than 0.1 mg/l with a range of less than detectable to 0.40 mg/l. An assay method from the U.S. Bureau of Mines, in which extraction was allowed for 12 hours on 40 gram of sample with 200 milliliters of water and 1 gram of sodium hydroxide, gave cyanide values that were 2 to 10 times greater than the previous method. The range of cyanide concentrations was less than 0.25 to 0.86 mg/kg with more than half the values below the detection limit of 0.25 mg/kg.

Sampling was conducted of the runoff from test heaps at the Annie Creek Mine (South Dakota) that were neutralized with hypochlorite followed by water (McGrew, 1985). After the first month (1982) there was more than a 10-fold decrease in both total cyanide and weak acid dissociable cyanide with decreases of 300 to 3.4 mg/l and 300 to 10 mg/l, respectively. Values continued to decrease with a range of 0.2 to 0.01 mg/l weak acid dissociable cyanide for sampling in December, 1983 to June, 1985. The test heaps were also sampled with depth up to 1.8 meters (6 feet). Of a total of 30 samples analyzed for total cyanide at 0.3 meter (1 foot) intervals, 21 samples were less than the detection limit of 0.5 mg/l, five analyses were between 0.5 and 0.6 mg/l, three between 0.6 and 0.7 mg/l, and one was higher than 0.7 mg/l. Of the 30 samples, for weak acid dissociable cyanide, 28 were below the detection limit of 0.5 mg/l and 2 were between 0.5 and 0.6 mg/l. Samples were also taken of the clay liner directly below the heaps. Cyanide did not penetrate below a depth of 10 centimeters (4 inches) based on 23 samples analyzed at 5-centimeter (2-inch) depth intervals. Of the 23 total cyanide concentrations, only 5 had detectable levels which ranged from 1.29 to 2.92 mg/l in the 0- to 5-centimeter (0- to 2-inch) and 5- to 10-centimeter (2- to 4-inch) clay samples. Weak acid dissociable cyanide was detected in only one sample at 0.83 ppm in a 5 to 10 centimeter (2- to 4-inch) interval.

There also is little information on the content and forms of cyanide in leachate from spent heap leach piles. As a part of the study by Engelhardt (1985) and Milligan (1985a) described above, the entrained solution in the heaps was also sampled for cyanide content. The moisture content in the first sampling (January, 1983) ranged from 13.5 to 16.4 percent and the final sampling (March, 1984) ranged from 11.4 to 15.5 percent. The average values for the two sampling periods were 340 mg/l and 106 mg/l free cyanide, respectively.

Degradation of Cyanide at Heap leach Operations

During the course of operation and at closure, cyanide in spent ore piles and process solutions must be rendered harmless. There has been very little published on the treatment of cyanides in spent ore piles, while extensive literature exists on the treatment processes for solutions containing cyanide.

Spent Leach Heap Piles

Upon closure of spent heaps operators are using several different methods to expedite the destruction of cyanide in the heaps. The requirements for neutralization vary by state (Table B-11). Generally, the rinsing procedure consists of either applying fresh water or an alkaline solution containing chlorine to the heap. The resulting effluent is recyled through the heap after the rinseate is treated with a method to destroy cyanide. This process is repeated until the cyanide concentration required in the effluent is obtained. Methods for neutralizing cyanide in water are described in detail below. Examples of the amounts of cyanide remaining in spent piles after rinsing were discussed above.

Natural degradation processes including volatilization, photodecomposition, oxidation, adsorption, and biodegradation continue to reduce levels of cyanide in the spent heaps after rinsing. Examples of some rates of cyanide degradation in spent heaps were discussed above.

TABLE B-11

WESTERN STATE REGULATIONS OR GUIDELINES FOR NEUTRALIZATION OF SPENT HEAP LEACH PILES

State	Required Cyanide Content of Rinseate
Arizona	Require the operators to show evidence there is no free cyanide; no recommendations for rinsing process (J. McCutchan, Arizona State Mine Inspector, personal communication, 1986).
California	Guidelines vary between Regional Boards. Region 5 - 0.35 mg/l free cyanide (D. Heiman, California Regional Quality Control Board - Region 5, personal communication, 1986). Region 6 - 0.2 mg/l free cyanide or 10 mg/kg total cyanide (M. Watkins, California Regional Water Quality Control Board - Region 6, personal communication, 1986). Region 7 - 2.0 mg/l or 10 mg/kg free cyanide (California Regional Water Quality Control Board, 1985).
Colorado	Considering developing guidelines. Recommend 2 mg/l free cyanide; in sensitive areas recommend 0.75 mg/l. Recommend fresh water or hydrogen peroxide for rinsing method (A. Baldridge, Colorado Mined Land Reclamation Division, personal communication, 1986).
Idaho	Developing regulations (I. Nautch, Idaho Water Quality Bureau, personal communication, 1986). Requirements for Stibnite (0.2 mg/l free cyanide); recommend hypochlorite rinse.
Montana	Developing regulations/guidelines (D. Smith, Montana Department of State Lands, personal communication, 1986).
New Mexico	Guidelines; 45 kg (100 lb) sample rinsed can not have more than 100 mg/l total cyanide (A. Die, New Mexico Environmental Improvement Division, personal communication, 1986).
Nevada	Required to rinse with water until pH of rinse water is 8.5 for three consecutive days (H. Van Drieun, Nevada Division of Environmental Protection, personal communication, 1986).

(Continued)

TABLE B-11 (Continued)

State	Required Cyanide Content of Rinseate
Oregon	Guidelines of 0.01 mg/l total cyanide; recommend hypochlorite rinse (K. Ashbaker, Oregon Department of Environmental Quality, personal communication, 1986).
South Dakota	Guidelines for Wharf Resources (0.75 mg/l total cyanide); currently working on rinsing method recommendation (B. Townsend, South Dakota Department of Natural Resources, personal communication, 1986).
Utah	Guidelines for Mercur Mine (5 mg/l free cyanide); no recommendations for rinsing method (C. Dietz, Utah Water Pollution Control, personal communication, 1986).
Washington	Developing regulations/guidelines (B. Lingley, Washington Department of Natural Resources, personal communication, 1986).
Wyoming	No regulations or guidelines (C. Bosco, Wyoming Land Quality Division, personal communication, 1986).

Process Cyanide Solutions

Barren solution should be subject to cyanide destruction upon closure. In addition, during fall some barren solution may need to be treated and released (possibly as a land application) in anticipation of winter precipitation to meet water balance requirements. The rinsing solution used to neutralize the spent ore heaps will also require a treatment process. The methods described below are based on volatilization (natural degradation), oxidation (alkaline chlorination, hydrogen peroxide, Inco process), and biological processes. The major treatment processes that are used or may be used at leaching operations are summarized here; these and other processes are described in more detail in Huiatt et al. (1983) and Scott (1985).

Natural Degradation. The results of studies of barren and tailings ponds in Canada (Simovic et al., 1985; Schmidt et al., 1981) show that natural degradation of cyanide occurs with over 90 percent of cyanide decrease attributed to volatilization of molecular HCN. For example, the cyanide content of a waste barren pond decreased from 64 mg/l in March to 0.05 mg/l in the following August and the pH dropped from 10.5 to 7.0 (Schmidt et al., 1981). The pH drop was a result of natural carbonation and the hydrolysis of thiocyanate. Some photodecomposition of ferrocyanides occurred.

A model has been developed to predict the natural degradation of cyanide in gold mill effluents, specifically barren solution and tailings pond water (Simovic et al., 1985; Simovic and Snodgrass, 1985). The model utilized the results from the synthetic solutions described in the section, Dissociation of Metal Cyanide Complex Ions, and assumed that the decay rate of a metal cyanide complex and subsequent volatilization of HCN control the disappearance of total cyanide from solution, with metal cyanide complex decay being the rate controlling factor. The model was used to predict degradation times for representative wastewater systems at two Canadian gold mills. The degradation of cyanide from tailings pond water was predicted very closely, but the model needs further calibration for the barren solutions.

Alkaline Chlorination. The most developed of all the available methods in regards to background experience, operational simplicity, control techniques, availability of equipment, and engineering expertise, is alkaline chlorination (Ingles and Scott, 1981). The complete oxidation of cyanide to nitrogen and bicarbonate requires two stages (Scott, 1985). In the first stage cyanide undergoes oxidation and hydrolysis at a minimum pH of 10.5 as shown:

$$NaCN + Cl_2 \longrightarrow CNCl + NaCl \tag{19}$$

$$CNCl + 2NaOH \longrightarrow NaCNO + NaCl + H_2O \tag{20}$$

During the second stage of the process, cyanate is further oxidized to nitrogen and bicarbonate at a pH of about 8.5, which can be represented by the overall reaction:

$$3Cl_2 + 2NaCNO + 6NaOH \longrightarrow 2NaHCO_3 + N_2 + 6NaCl + 2H_2O \tag{21}$$

Metal cyanide complexes are oxidized during the first stage of the process as shown for the zinc cyanide complex:

$$Na_2Zn(CN)_4 + 10NaOH + 4Cl_2 \longrightarrow 4NaCNO + 8NaCl + Zn(OH)_2 + 4H_2O \tag{22}$$

The alkaline chlorination method destroys free cyanide ion, hydrogen cyanide, and cyanide from most metal cyanide complexes with the exception of iron cyanide complexes. Table B-12 presents the advantages and disadvantages of alkaline chlorination.

Hydrogen Peroxide. The hydrogen peroxide method, which is well known and widely used in the treatment of effluents from the steel hardening and other industries, is now being applied to the gold mining industry. The hydrogen peroxide method is favorable from the environmental view since no toxic by-products are generated nor are additional chemicals added which may be detrimental to the environment (Knorre and Griffiths, 1985). In addition, metals are precipitated as hydroxides. The reaction for the oxidation of cyanide to cyanate is:

$$CN^- + H_2O_2 \longrightarrow CNO^- + H_2O \tag{23}$$

TABLE B-12

ADVANTAGES AND DISADVANTAGES OF ALKALINE CHLORINATION

ADVANTAGES OF ALKALINE CHLORINATION

1) Very widely-used method, expertise is available.
2) Influent to process already basic.
3) Reactions complete and reasonably rapid.
4) Toxic metals removed.
5) Chlorine readily available in several different forms.
6) Readily adaptable to either continuous or batch operation.
7) Capital outlay relatively low.
8) Good fail-safe control.
9) Easily controlled to first stage of oxidation, if disposal of CNO^- is permitted.

DISADVANTAGES OF ALKALINE CHLORINATION

1) Reagent costs are high, particularly if complete oxidation is required. Thiocyanate, thio-salts and ammonia are additional heavy consumers of chlorine.
2) Requires careful control of pH to prevent formation of cyanogen chloride which is very toxic.
3) Cyanide is not recovered.
4) Hexacyanoferrates are not usually decomposed.
5) Metal content is not recovered.
6) The chloride content of the effluent is increased in direct proportion to the amount of chlorine added.
7) There is a possibility of forming toxic chlorine derivatives (e.g. chlorinated organic compounds) which will require further treatment.
8) Residual excess chlorine can be toxic to aquatic species.[a/]

a/ Clean-up of excess chlorine is readily accomplished with $S_2O_3^{2-}$ or H_2O_2, but an extra step is needed.

Source: Adapted from Ritcey and McNamara, 1978; cited by Ingles and Scott, 1981.

The cyanate formed in this reaction hydrolyzes further to form ammonium and carbonate ions:

$$CNO^- + 2H_2O \longrightarrow CO_3^{2-} + NH_4^+ \quad (24)$$

The reaction for the precipitation of metals is:

$$Me(CN)_4^{2-} + 4H_2O_2 + 2OH^- \longrightarrow (Me(OH)_2N) + 4CNO^- + 4H_2O \quad (25)$$

Complex iron cyanides are too stable to be oxidized but they may be precipitated by the addition of copper:

$$2\ Cu^{2+} + Fe(CN)_6^{4-} \longrightarrow (Cu_2Fe(CN)_6) \quad (26)$$

The hydrogen peroxide method destroys hydrogen cyanide, cyanide ion, and cyanide in copper, zinc, and nickel cyanide complexes. If copper is added, iron cyanide complexes may be precipitated.

Inco Process. This method was originally developed for base metal mining operations, but is now used by a number of gold mines in Canada. Oxidation by SO_2 in air in the presence of a copper catalyst causes the rapid removal of cyanide and metal cyanide complexes. The overall reaction is the oxidation of cyanide to cyanate which is described by the equation:

$$CN^- + O_2 + SO_2 + H_2 = CNO^- + H_2SO_4 \quad (27)$$

Iron cyanide complexes are removed by precipitation as copper or zinc ferrocyanides. The metals except for iron are precipitated as metal hydroxides. Thiocyanate is not removed.

Biological Treatment. Homestake Mining Company has recently developed a biological treatment method for removing cyanide and metal ions from effluents (Mudder and Whitlock, 1983). An essential requirement for successful operation of this process is the ability to blend mine water at 21 to 29° C (70 to 85° F) with tailings impoundment water at 1.1 to 21° C (34 to 70° F) to maintain a year round combined wastewater temperature sufficiently warm at 10 to 18° C (50 to 65° F) to sustain effective biological process rates. The two stages of the the methods are 1) bacterial oxidation of cyanide and thiocyanate to carbon dioxide, sulfate, and ammonia concurrent with the adsorption of metals

by the bacteria and 2) bacterial nitrification of ammonia to nitrate. The only reagents added are soda ash as an inorganic carbon source to aid nitrification, and phosphorus as a trace nutrient. Total cyanide is reduced to 0.30 mg/l from an influent concentration of 2.0 mg/l; thiocyanate content is reduced to less than 0.10 mg/l from 50.0 mg/l. Metals are returned to the tailings pond.

Environmental Fate of Cyanide in Heap Leach Mining Wastes

The chemical and biological processes controlling the fate of cyanide in heap leach mining operations are summarized in Figure 20 (Chapter 4). These processes were discussed in detail in the section entitled, Environmental Fate of Cyanide. Heap leach mining wastes may contain free cyanide (HCN and CN^-), metal cyanide complexes, and salts of metal cyanide complexes. The process controlling the fate of free cyanide in these wastes is volatilization of HCN to the atmosphere. HCN will diffuse upward through the troposphere and is destroyed in the stratosphere (Singh et al., 1984). An important control on volatilization is pH; below a pH of 9, HCN is predominant over cyanide ion.

Metal cyanide complexes such as iron, copper, zinc, nickel, cobalt, and cadmium, which are the most common at gold and silver operations (Huiatt, 1985), decompose and release cyanide ion at varying rates. Zinc and cadmium complexes, the least stable complexes, readily decompose as free cyanide decreases during the rinsing process. Strong complexes such as iron cyanide complex may remain in the ore. Iron cyanide complexes have been found to degrade in solutions exposed to ultraviolet light, but the photochemical effect on the solid species is unknown. As the concentration of free cyanide decreases below the concentration of metal cyanide complexes, the slower rate of decomposition of metal cyanide complexes becomes the rate controlling step for the volatilization of free cyanide. Other compounds that may be very sparingly soluble in water are iron, nickel, cobalt, and copper salts of iron complex cyanide ions. Until the presence of these complexes and compounds is exhausted, very small amounts of free cyanide may be released in the spent heap pile.

Besides volatilization directly from the mining wastes, a secondary transport process is the leaching of cyanide and any soluble metal cyanide complexes from the mining wastes and their transport into the environment if uncontained. Also possible would be the accidental release of cyanide process solution through pond overflows and pad or pond leaks (refer to Appendix D for reported accidents at heap leach mining operations). Volatilization is an important process for removing cyanide from surface water whereas other processes (biodegradation, reaction of cyanide to ammonia and formate, sorption, complexation, and others) may be more important for soil and ground water. The discussion of the mobility of cyanide in surface water, ground water, and soils is contained in the final part of the section, Environmental Fate of Cyanide.

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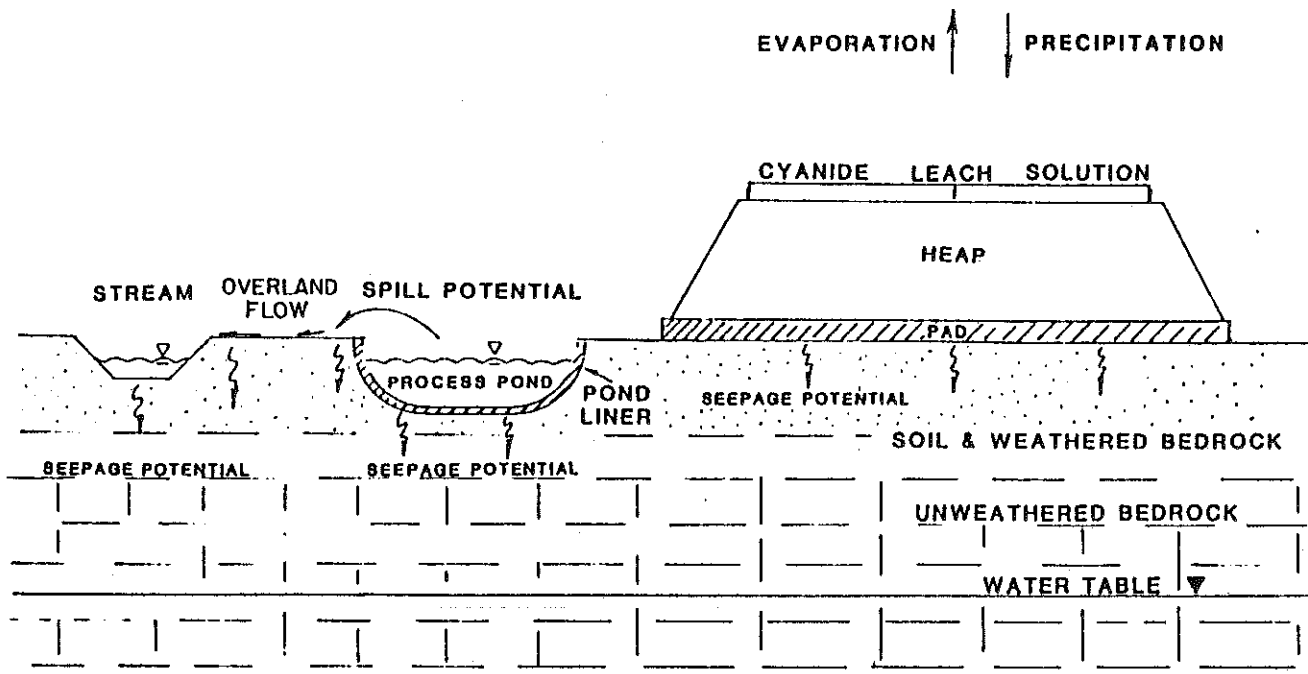
FIGURE 20

SUMMARY OF POTENTIAL DEGRADATION AND TRANSFORMATION PROCESSES FOR CYANIDE AT A TYPICAL HEAP LEACH MINING OPERATION



Degradation and Transformation Processes For Cyanide [a]

Surface Processes:

Volatilization, Reaction to Ammonia and Formate, Oxidation, Metal Complexation, Biodegradation, Sorption, Formation of Simple & Complex Compounds, Photodegradation of Fe & Co Complexes

Unsaturated Zone:

Volatilization, Reaction to Ammonia and Formate, Oxidation, Metal Complexation, Biodegradation, Sorption, Formation of Simple & Complex Compounds

Saturated Zone:

Reaction to Ammonia and Formate, Metal Complexation, Sorption, Formation of Simple and Complex Compounds, (Volatization & Biodegradation - may be less significant)

[a] IF SULFIDE PRESENT:FORMATION OF THIOCYANATE

CLOSURE PLAN

DOCK 2-B, BUILDING 45 AND BUILDING 49 AT THE FORMER TRW INC. TAPCO FACILITY

SUBMITTED TO

TRW

INCORPORATED

NOVEMBER, 1987

ENGINEERING-SCIENCE

DESIGN • RESEARCH • PLANNING

19101 VILLAVIEW ROAD, SUITE 301, CLEVELAND, OHIO 44119 • 216/486-9005

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CLOSURE PLAN

DOCK 2-B, BUILDING 45
and
BUILDING 49

at the
FORMER TRW INC. TAPCO FACILITY

Submitted to

TRW INCORPORATED
Lyndhurst, Ohio

NOVEMBER 1987

Submitted by

ENGINEERING-SCIENCE
19101 Villaview Road - Suite 301
Cleveland, Ohio 44119

8710DDR/103:39

CLOSURE PLAN

DOCK 2-B, BUILDING 45
and
BUILDING 49

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APPENDIX 1 - RCRA Interim Status Permit for the Tapco Facility

ATTACHMENT 1 - Analytical Laboratory Reports
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1. DESCRIPTION OF FACILITY

The TAPCO facility, formerly owned by TRW Incorporated, is located about two miles south of Lake Erie, in the City of Euclid, Cuyahoga County, Ohio. As shown in Figure 1.1, the property boundaries include more than 200 acres on both sides of Euclid Avenue. All of the buildings are located on the north side of Euclid Avenue.

Construction of the TAPCO facility was started in the 1940s by the then Thompson Aircraft Products Company, later TRW Incorporated. Over a period of more than forty years, numerous and varied manufacturing operations took place on the site, including forging, heat treatment, machining, metal finishing and electroplating. Additional activities, including aircraft engine and weapons testing, took place under contract to the Federal government.

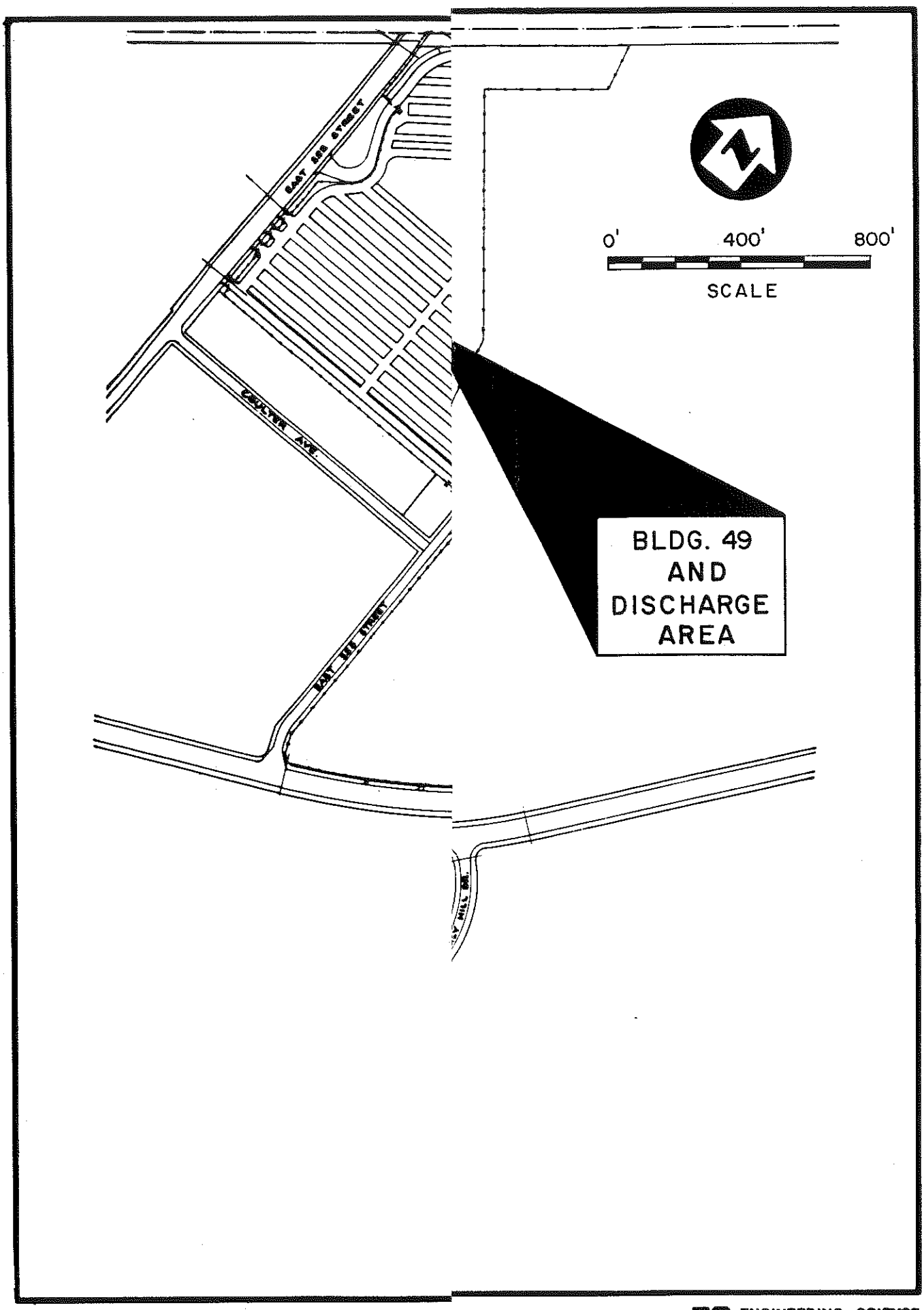
TRW submitted a RCRA Part A Permit Application for the TAPCO facility on 17 November 1980. An Interim Status Permit was granted 14 May 1982. (The EPA Facility Identification Number for TAPCO is OHD004179-453). An application for revision, which was filed on 4 June 1984, was withdrawn 21 December 1984. TRW requested that the TAPCO facility be removed from the treatment, storage and disposal facility category, because it was only a 90-day generator. Appendix 1 includes a copy of the interim status permit.

In 1986, the TAPCO property and the manufacturing and contract testing facilities there were sold by TRW Incorporated. ARGO-TECH Inc. purchased the property and a portion of the manufacturing and testing facilities, effective 20 October 1986. Airfoil Forging Corporation (now, Airfoil Forging Textron) purchased other manufacturing facilities effective 29 August 1986.

Pursuant to the purchase agreements, TRW Incorporated will proceed with closure of those portions of the TAPCO facility which had been granted interim status. ARGO-TECH and Aircraft Forging Textron are generators of most of the same hazardous waste materials formerly generated by TRW, but they do not plan to store any hazardous waste materials on-site for periods longer than 90 days.

The sections that follow present the Closure Plan for the three hazardous waste management units on the TAPCO site which are to be closed. The units are Dock 2-B, Building 45 and Building 49.

FIGURE 1.1



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2. DESCRIPTION OF WASTE MANAGEMENT UNITS TO BE CLOSED

Figure 1.1 shows the TAPCO site and the locations of the units to be closed. Dock 2-B, Building 45 and Building 49 are all in the northern portion of the property. Dock 2-B and Building 45 were used for storage up to 90 days of drummed hazardous wastes generated on-site. The Building 49 area includes a fenced compound used for torpedo testing. Torpedo fuel and liquid residues remaining after test firing were stored in drums and a 1000 gallon underground tank at Building 49. Accidental discharges of fuel residue and cyanides generated by test firing occurred onto a swampy area to the south of the fenced compound.

The descriptions that follow are based in part on information included in the interim status RCRA permit and the application for revision (Appendix 1). Additional information from a sampling and laboratory analysis program at the units to be closed, which was undertaken in conjunction with preparation of this Closure Plan, is presented in Section 5.

2.1 Dock 2-B

Dock 2-B is the site of a hazardous waste storage area for 55 gallon drums. This 8100 sq.ft. area is located near the northwest corner of the TAPCO facility, adjoining Building 26. It consists of a concrete base covered by wood block flooring. When originally built, about 1950, this was a general purpose shipping and receiving dock serving the site.

Since about 1981, Dock 2-B has been used mainly for storage and subsequent shipment of hazardous wastes in drums. As shown in Figure 2.1, an area of about 1200 sq.ft. at the southeast corner of the Dock has been used for secured storage of hazardous wastes from all hazardous waste generating activities at the TAPCO facility. This area is enclosed by a metal cage about 9 ft high, with a locked sliding gate. In TRW's application for the interim status permit, Dock 2-B was marked as a "Drum Storage Area" in the sketch provided on Page 5. Its process design capacity was listed as 23,100 gallons (i.e., 420 drums) on Page 1 (See Appendix 1).

Effective 20 October 1986, ARGO-TECH, Inc. assumed responsibility for operation of this area. TRW Inc., pursuant to its purchase agreements with ARGO-TECH, plans to close the original Dock 2-B caged area and to provide a new storage area with facilities for spill containment and control. ARGO-TECH

will continue to use Dock 2-B for storage of hazardous waste generated on-site for periods not exceeding 90 days.

A second caged area was added to the west of the original area. This new area is operated by Airfoil Forging Textron (AFT), specifically for hazardous waste generated by AFT manufacturing operations.

2.2 Building 45

Building 45 is located in the north-central portion of the TAPCO site. As shown in Figure 2.2, this long, narrow building adjoins Building 26 and extends about 450 ft northeastward into a fenced compound. It was constructed of concrete during the 1940s, specifically for rifle test firing ranges. A wall along the entire length of the building separates Range A, on the north side, from Range B.

The Target House near the eastern end is separated from the main building by a firing tunnel. It is provided with security doors, originally to prevent accidental entry during firing tests. A pit located to the east of the Target House, originally for recovery of spent bullets, and a target trench to the west, isolate the Target House floor.

The former Target House was put into use for storage of drummed hazardous waste prior to 1980 and continued through 1985. It was selected for this, partially on the basis of distance from plant operations and limited access. The Range A side provided about 315 sq.ft., and the Range B side provided an additional 420 sq.ft. In TRW's application for the interim status permit, the Building 45 Target House was marked as a "Drum Storage Area" in the sketch provided on Page 5. Its process design capacity was listed as 4,400 gallons (i.e., 80 drums) on Page 1 (See Appendix 1).

As noted in Figure 2.2, the concrete floor was built sloping downward to the east. Metal dike plates were installed along the eastern edge of the floor and grouted, to prevent any spillage from leaking into the former water pit. The square concrete extensions of the Target House floor along the north and south walls each have a 55 gallon sump to collect spillage.

The Building 45 Target House Hazardous Waste Storage Area was removed from service, and the last 55 gallon drum containers of hazardous waste that had been stored there were removed prior to the sale of the property by TRW Incorporated. ARGO-TECH Inc., has no plans for further use of Building 45 as a hazardous waste storage area at present.

2.3 Building 49

Building 49 is located in the northeastern portion of the TAPCO facility, inside a fenced compound which isolated torpedo testing activities. Building 49 was built in 1965, originally containing one cell for test firings; a second cell was added later. The storage area for virgin fuel was located on the eastern side of the building. The other buildings within the compound include a locker room and laundry for torpedo test personnel (Building 48) and storage buildings (Buildings 42, 43, 50 and 51). See Figure 1.1.

Wastewater containing liquid fuel residue and cyanides is generated by the torpedo test firing. Until late 1985, the wastewater was discharged through a 1000 gallon underground steel separation tank. Liquid residues of unburned fuel were separated in the tank and stored there until hauled off-site for disposal by incineration within 90 days.

In TRW's application for the interim status permit, the Building 49 Area was marked as a "Waste Fuel Storage Area" in the sketch provided on Page 5. The process design capacity for the storage tank there (S02) was listed as 1000 gallons on Page 1 (See Appendix 1).

Unintentional discharges from the separator tank containing cyanides and liquid residues of unburned torpedo fuel were discovered in 1985 in a swampy area on the south side of the fence. The National Response Center was notified, and TRW authorized studies of the discharge area, to define the extent of the soil affected. The study report is enclosed as Attachment 2. The principal findings are summarized in Section 5.3.

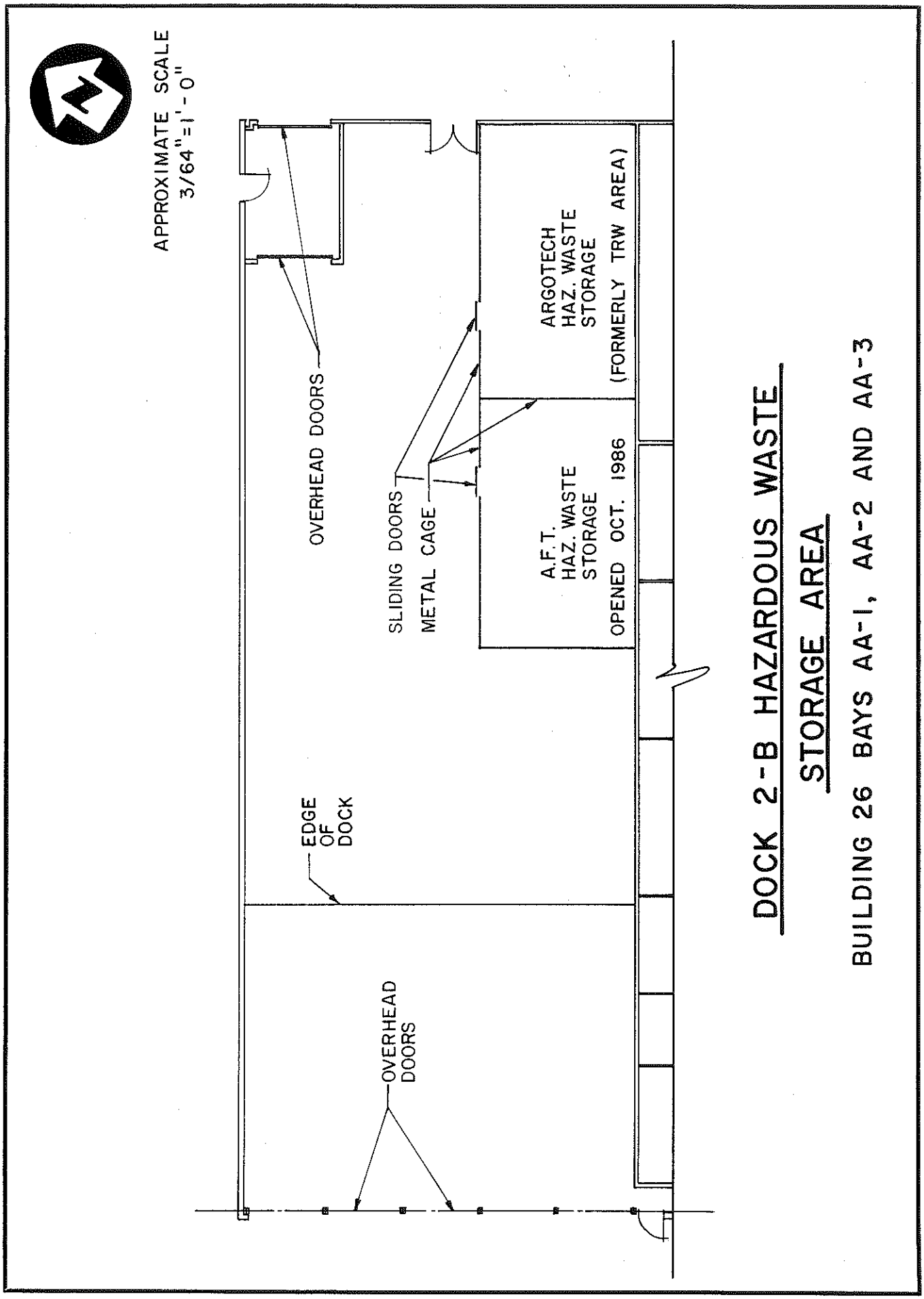
Since the discovery of the discharge, all wastewater from torpedo testing has been collected and stored in holding tanks on the west side of Building 49 until hauled for off-site disposal within 90 days. A new torpedo test facility has been built elsewhere on the TAPCO Site (Building 33), and all torpedo testing activities will be shifted to that location.

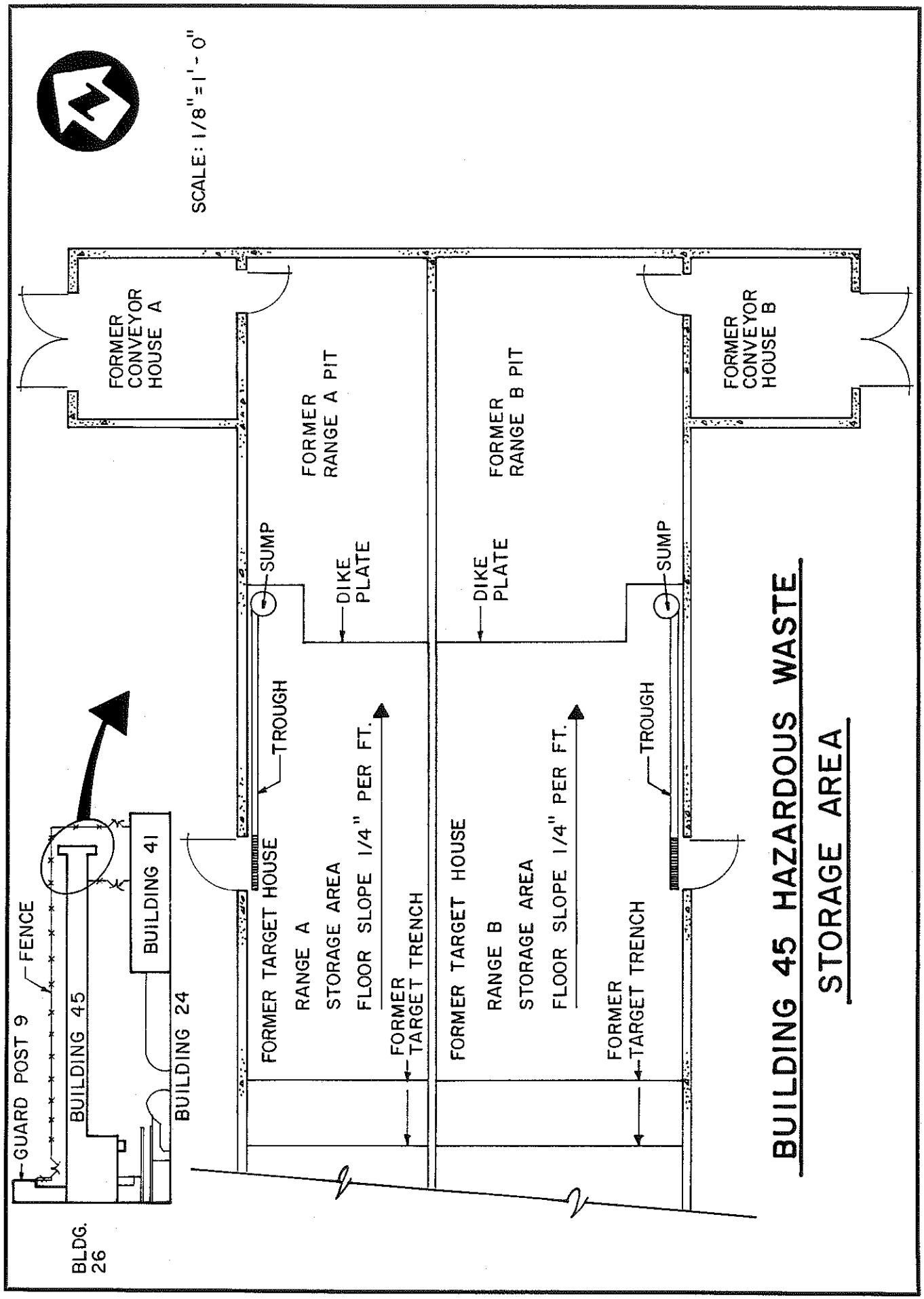
2.4 Topography and Soils

The hazardous waste management units to be closed lie in the lake plain, which resulted from deposition of clay, silt and fine sands during a stage of glacial lake inundation. The area is characterized as nearly level to gently sloping. The undisturbed vegetative cover would be thick grass, brush and trees. Drainage is poor, due in part to the flat topography and to the low permeability of the predominant silty soils.

The surface soils in the lake plain are generally derived from very fine silt and clay sediments deposited from past higher lake stages, except where beach sand remnants remain. These lacustrine (lake) surface deposits are typically about 10 feet in thickness. These surface soils are generally considered to be very poor sources of ground water supply. Most of the soil at the former TAPCO site is classified as urban land, since a large proportion of the surface is covered by buildings and asphalt or concrete pavement.

Underlying the surface soils is a variable thickness of tight glacial till composed of hard clayey to sandy silt with angular gravel and rock fragments. The consolidated deposits underlying the former TAPCO site consist of a series of shale formations of low permeability, together more than 800 ft thick. These shales are of Mississippian and Devonian age. The formations are not considered to be productive for ground water supply.


APPROXIMATE SCALE
3/64"=1'-0"
OVERHEAD DOORS
SLIDING DOORS
METAL CAGE
ARGOTECH
HAZ. WASTE
STORAGE
(FORMERLY TRW AREA)
A.F.T.
HAZ. WASTE
STORAGE
OPENED OCT. 1986
EDGE
OF
DOCK
OVERHEAD
DOORS
DOCK 2-B HAZARDOUS WASTE
STORAGE AREA
BUILDING 26 BAYS AA-1, AA-2 AND AA-3


SCALE: 1/8" = 1'-0"
FORMER CONVEYOR HOUSE A
FORMER RANGE A PIT
FORMER RANGE B PIT
FORMER CONVEYOR HOUSE B
SUMP
DIKE PLATE
DIKE PLATE
SUMP
TROUGH
TROUGH
FORMER TARGET HOUSE
RANGE A
STORAGE AREA
FLOOR SLOPE 1/4" PER FT.
FORMER TARGET TRENCH
FORMER TARGET HOUSE
RANGE B
STORAGE AREA
FLOOR SLOPE 1/4" PER FT.
FORMER TARGET TRENCH
BUILDING 41
BUILDING 24
BUILDING 45
FENCE
GUARD POST 9
BLDG. 26
BUILDING 45 HAZARDOUS WASTE
STORAGE AREA

3. MAPS OF FACILITY

FIGURE 1.1 - Tapco Site: Areas To Be Closed

FIGURE 3.1 - Topographic Map of the Tapco Facility (Aerial Photo Base)
Scale 1" = 200'

OVER-SIZED DOCUMENT TARGET

At this point in this file

a large document,

such as a map

or

engineering drawing

occurred

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This type of media is not compatible with this film format,

which would require that the over-sized document be folded

and filmed in multiple frames.

To enable the user to see this over-sized document

as a single entity,

it has been microfilmed on 35mm film,

and

can be located by cross referencing

the same microfilm address.

4. DETAILED DRAWINGS OF THE UNITS TO BE CLOSED

FIGURE 2.1 - Dock 2-B Hazardous Waste Storage Area

FIGURE 2.2 - Building 45 Hazardous Waste Storage Area

5. LIST OF HAZARDOUS WASTES HANDLED

According to the RCRA Interim Status Permit and the Application for Revision, the wastes stored in Building 45 and Dock 2-B included (F002) trichloroethane recovery still bottoms and (F006) wastewater treatment sludges from electroplating operations, containing cyanides and metal hydroxides. The torpedo fuel residues at Building 49 were listed as reactive (in their virgin state). (See Appendix 1.)

In the course of preparing this Closure Plan, sampling and chemical analysis were undertaken, to define further the characteristics of hazardous wastes and residues which may be involved in the Closure. A copy of the laboratory reports is provided as Attachment 1. The results are discussed in the paragraphs that follow.

5.1 Dock 2-B

The uncaged area flooring was sampled on 28 May 1987, by removal of wood blocks at the centers of eight randomly selected areas defined by the 10 ft spacing grid shown in Figure 5.1 and scraping the wood surfaces with a chisel. A composite sample of the scrapings was submitted for laboratory analysis to determine priority pollutants and RCRA Hazard Characteristics. The wood blocks in the caged former TRW storage area can be expected to have similar characteristics. Since hazardous waste was stored in this area and other materials may have been absorbed, these blocks will be removed. However, the wood blocks outside this area are still serving their original purpose and will not be removed.

The results, as summarized in Table 5.1, show characteristics which would require that any flooring removed from the former TRW Hazardous Waste Storage Area during closure must be disposed of as a hazardous waste. A spectrum of priority pollutant organics was detected. These organics, which include both volatile organics and polynuclear aromatics (base/neutral extractable semi-volatiles), are believed to be preservative chemicals which were applied to the wood blocks by the manufacturer.

However, those were the only characteristics which would be considered to be hazardous. The TCLP (Toxicity Characteristic Leaching Procedure) extraction did not yield detectable concentrations of any regulated PCBs, pesticides or herbicides. None of the regulated heavy metals was present at a concentration which would render the flooring material EP Toxic. Corrosivity and sulfide reactivity tests were both negative. Cyanide was detected, but not at a hazardous concentration.

5.2 Building 45

The Target House flooring was sampled on 29 May 1987, by scraping the concrete flooring surfaces with a chisel at the centers of eight randomly selected areas defined by the 5 ft spacing grid shown in Figure 5.2. A composited sample of the scrapings was submitted for laboratory analysis to determine priority pollutants and RCRA Hazard Characteristics.

The results, as summarized in Table 5.1, show characteristics which would require that any concrete flooring removed from the Target House during closure must be disposed of as a hazardous waste. The scrapings are EP Toxic, due to the presence of high TCLP extraction chromium concentrations.

However, the other characteristics would not be considered hazardous. The tests of corrosivity, ignitability and sulfide reactivity were negative. No priority pollutant organics, PCBs or TCLP extraction herbicides and pesticides were present at detectable concentrations.

5.3 Building 49

In 1985, an unintentional discharge into the swampy area to the south of Building 49 was found. The National Response Center was notified, and TRW authorized studies of the discharge area, to define the extent of the soil affected. The study report is enclosed as Attachment 2. The principal findings in that study are as follows (See Figure 5.3):

- An irregularly shaped 300 sq.ft. area around the former discharge pipe was found to contain detectable concentrations of Propylene Glycol Dinitrate (PGDN), the principal component of the torpedo fuel. The average PGDN concentration for the top 1 ft of soil in this area was 1900 mg/kg. Overlapping this was a larger area, about 600 sq.ft. of soil containing detectable cyanides, with an average concentration of 10 mg/kg for the top 1 ft of soil. (The detection limits were, respectively, 25 mg/kg for PGDN and 0.25 mg/kg for total cyanides.)

- Migration of the chemical residues away from the soils near the former discharge pipe was attributed principally to erosion of soil particles at times of high stormwater flow. Two isolated samples of sediments from the 120 ft long runoff stream were found to contain

240 and 80 mg/kg of PGDN in the top 1 ft. Sediment cyanide concentrations along the runoff stream averaged 6 mg/kg in the top 1 ft. There also has been migration of cyanides by solubilization and transport into the runoff stream; observed cyanide concentrations in the runoff stream water ranged from 0.3 to 1.2 mg/L (PGDN, which is not miscible with water, would not migrate by that mechanism).

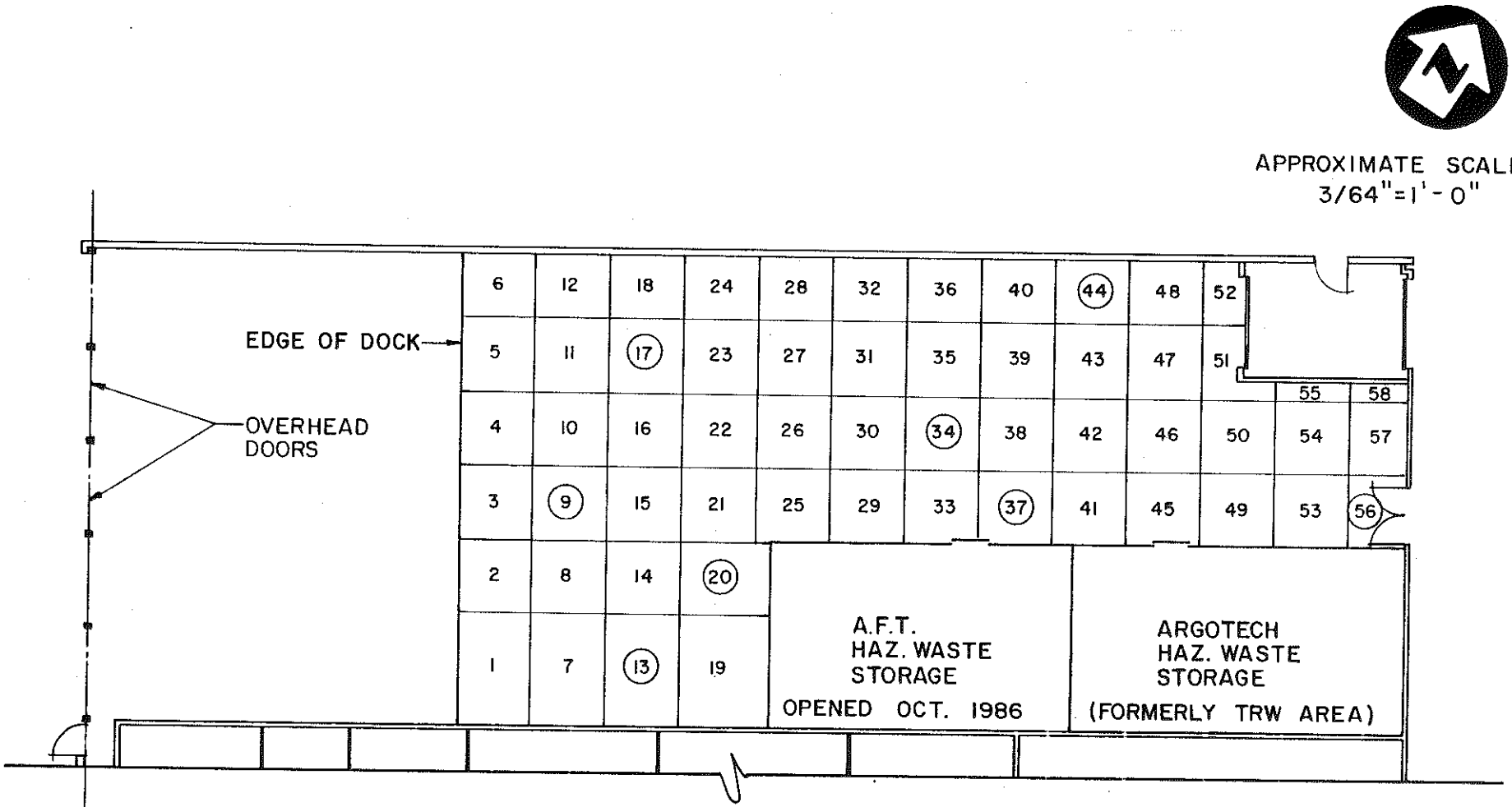
- A narrow belt of soil containing cyanide at concentrations 0.5 to 2 mg/kg in the top 1 ft was found about 100 ft to the south and southeast of the former discharge area.

Additional soil sampling and laboratory analysis for cyanides was undertaken in conjunction with the preparation of this Closure Plan, to define the extent of soils containing cyanides and to determine characteristics of the soil in the vicinity of Building 49, for purposes of treatment and disposal. The results are summarized in Figure 5.4 and Table 5.2 (See Attachment 1 for details).

The soil at the former discharge pipe is considered hazardous because of the presence of PGDN and cyanides. However, the RCRA characteristics tests for ignitability, corrosivity, sulfide reactivity and EP Toxicity were negative. Priority pollutant organics and PCBs were not present at detectable concentrations.

Additional characteristics were determined for the recommended treatment of soil excavated from the former discharge area by incineration (to be followed by ultimate disposal of the resultant ash by landfilling). The observed high flash point, low net heating value, high ash content and high solids content in discharge area samples were essentially the same as those of the background area samples.

The belt of detectable cyanides was found to continue on the north and west of Building 49, with concentrations of 0.5 to 2 mg/kg in the surface soils at distances up to 300 ft from the building. However, the belt does not appear to extend into wooded land further to the east.



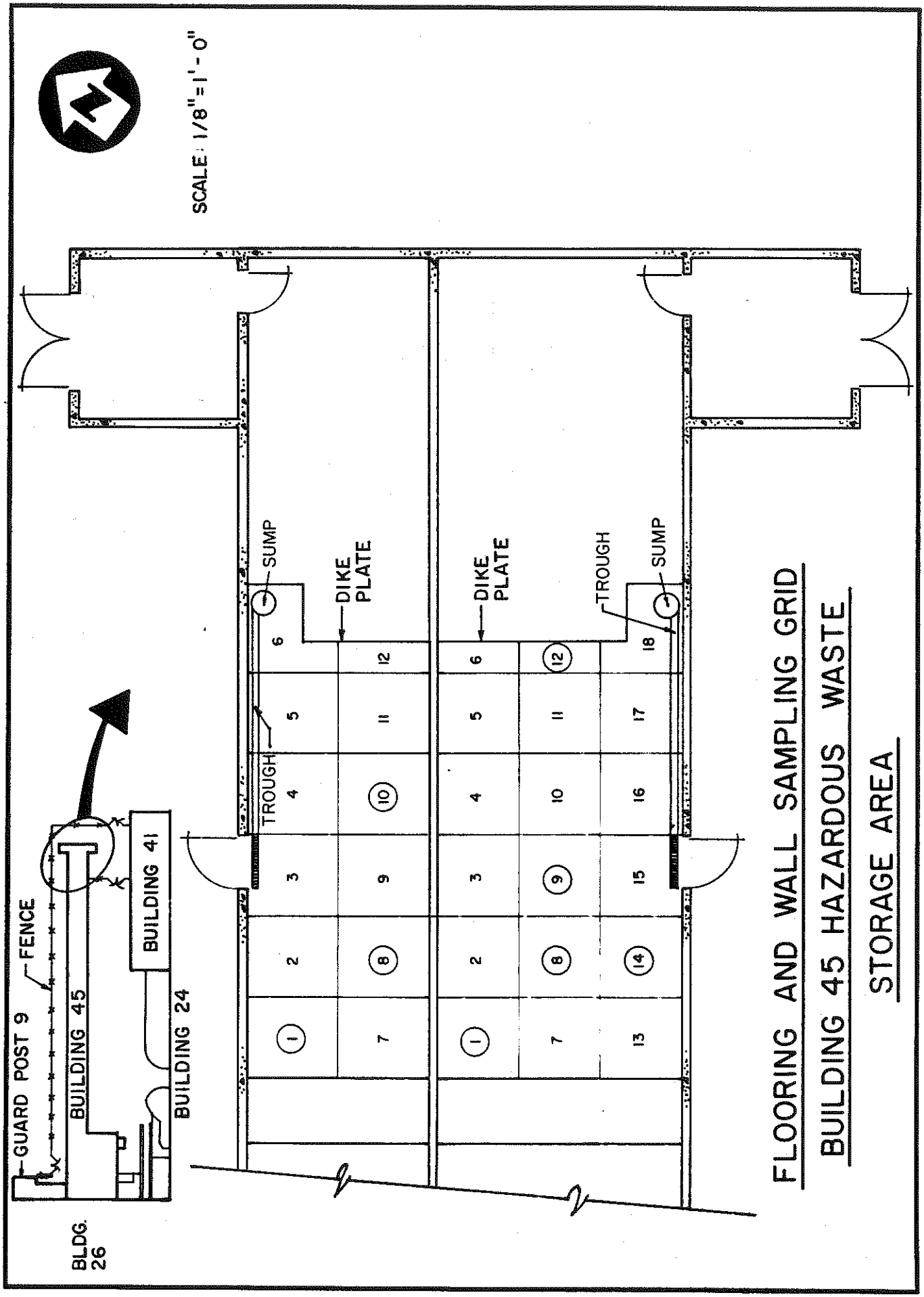
FLOORING SAMPLE GRID

DOCK 2-B HAZARDOUS WASTE

STORAGE AREA

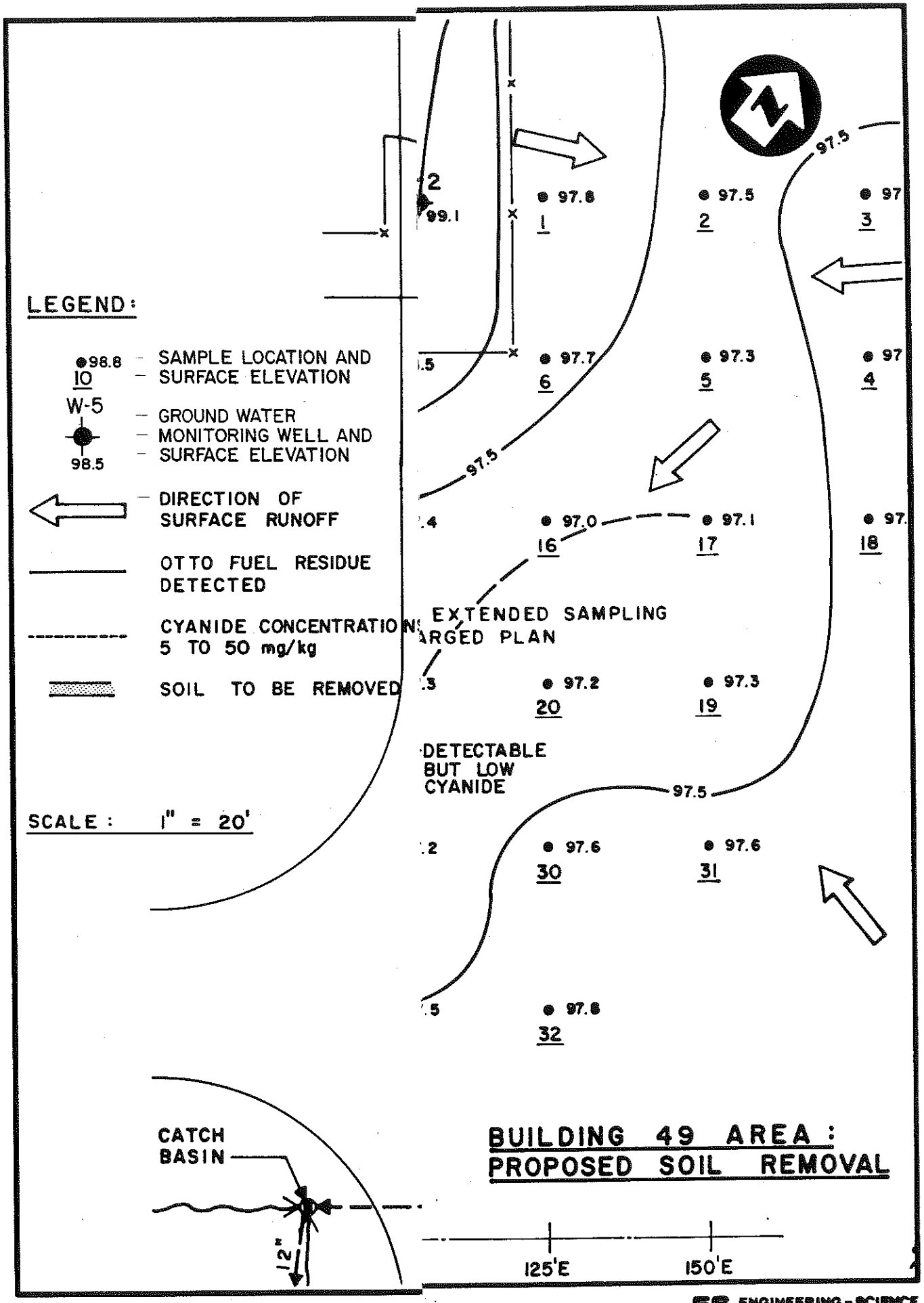
BUILDING 26 BAYS AA-1, AA-2 AND AA-3

FIGURE 5.1



FLOORING AND WALL SAMPLING GRID
BUILDING 45 HAZARDOUS WASTE
STORAGE AREA

FIGURE 5.3



BUILDING 49 AREA: PROPOSED SOIL REMOVAL

ES ENGINEERING-SCIENCE

OVER-SIZED DOCUMENT TARGET

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and filmed in multiple frames.

To enable the user to see this over-sized document

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TABLE 5.1

ANALYTICAL CHARACTERIZATION OF DOCK 2-B AND BUILDING 45 FLOORING

Laboratory-Composited Samples

Parameters	Method	Units	Concentrations Bldg. 45	Concentrations Dock 2-B	Regulatory Limit
Volatile Organic Compounds	8240				
Priority Pollutants		mg/kg	ND	ND	--
Semi-Volatile Organics	8270				
Polynuclear Aromatics		mg/kg	ND	8250#	--
Acid Extractables		mg/kg	ND	ND	--
Other Regulated Semi-Volatiles		mg/kg	ND	ND	--
Pesticides/Herbicides	TCLP	mg/kg	ND	ND	--
PCBs	8080	mg/kg	ND	ND	--
Total Cyanides	9010	mg/kg	<0.1	1.04	BDT
Leachate Heavy Metals	TCLP				
Silver		mg/L	BDT	BDT	5.0
Arsenic		mg/L	BDT	0.07	5.0
Barium		mg/L	0.3	0.4	100
Cadmium		mg/L	BDT	0.09	1.0
Chromium		mg/L	13	0.5	5.0
Lead		mg/L	BDT	1.0	5.0
Mercury		mg/L	BDT	BDT	0.2
Nickel		mg/L	BDT	0.16	--
RCRA Characteristics					
Corrosivity	pH	S.U.	11.0	7.4	2-12
Reactivity (sulfide)	Sulfide	mg/kg	<0.1	<0.1	BDT

proposed

NOTE:

BDT = Below Detection Limit
ND = All compounds in this category BDT
-- = No Limit at Present

#Fifteen (15) Regulated Base/Neutral Compounds Detected

TABLE 5.2

ANALYTICAL CHARACTERIZATION OF SOIL SAMPLES NEAR BUILDING 49

Laboratory-Composited Samples (except as noted below)

Parameters	Method	Units	Concentrations Back-ground Area	Dis-charge Area	Regula-tory Limit
Volatile Organic Compounds	8240				
Priority Pollutants		mg/kg	ND	ND	--
Semi-Volatile Organics	8270				
Polynuclear Aromatics		mg/kg	ND	NA	--
Other Regulated Semi-Volatiles		mg/kg	ND	NA	--
Pesticides/Herbicides	TCLP	mg/kg	ND	ND	--
PCBs	8080	mg/kg	ND	ND	--
Total Cyanides*	9010	mg/kg	0.7	17	BDT
PGDN (Torpedo Fuel)*	Gas Chrom.	mg/kg	NA	543	--
Leachate Heavy Metals	TCLP				
Silver		mg/L	BDT	BDT	5.0
Arsenic		mg/L	BDT	BDT	5.0
Barium		mg/L	1.5	1.2	100
Cadmium		mg/L	BDT	BDT	1.0
Chromium		mg/L	0.04	0.05	5.0
Lead		mg/L	0.54	0.16	5.0
Mercury		mg/L	BDT	BDT	0.2
Nickel		mg/L	0.49	BDT	--
RCRA Characteristics					
Ignitability	Flash Pt.	°F	>180	>180	>140
Corrosivity	pH	S.U.	NA	NA	2-12
Reactivity (sulfide)	Sulfide	mg/kg	60	50	BDT
Incineration Characteristics					
% Solids			70%	73%	>30%
% Ash			NA	72%	--
Heating Value		BTU/lb	NA	<1000	--

proposed

NOTE:

BDT = Below Detection Limit
NA = Analysis Not Required
ND = All compounds in this category BDT
* = Averages for 3-4 Samples
-- = No Limit at Present

6. SCHEDULE FOR CLOSURE

Closure of the Hazardous Waste Management Facilities at the TAPCO site will consist of the following:

Health based?

In the Building 49 Area (the Torpedo Test Compound):

- o Site work, as necessary for equipment access,
- o Excavation of contaminated soil from the Spill Area and dredging of the runoff stream, and removal for off-site incineration,
- o Soil sampling to ensure that the soil that remains does not contain detectable PGDN and/or cyanides at concentrations exceeding 5 mg/kg,
- o Removal and decontamination of the 1,000 gallon underground Separator Tank and auxiliary piping, and
- o Backfilling and final grading of the area of soil excavation.

At the former TRW Hazardous Waste Storage Area at Dock 2-B:

- o Removal and off-site incineration of wood flooring blocks, and
- o Cleaning of the underlying concrete and analysis of rinseates to verify that hazardous waste residues have been removed.

At the Building 45 Target House:

- o Cleaning of the concrete flooring and analysis of rinseates to verify that hazardous waste residues have been removed.

If necessary, demolition of concrete flooring at Building 45 and/or Dock 2-B; off-site disposal of the rubble; and soil sampling to verify that no hazardous waste residues remain.

Figure 6.1 shows the schedule in bar-chart form, based on days elapsed after approval of the Closure Plan by the Director of Ohio EPA. The Closure Plan activities can be completed within the required 180 days. In the event that approval occurs in the autumn, it may be necessary to extend closure activities beyond 180 calendar days, due to the onset of winter conditions hampering outside work at Building 49 and access to the other areas undergoing closure.

Figures 6.2, 6.3 and 6.4, respectively, show the layout of closure facilities and activities at Dock 2-B, Building 45 and Building 49. The paragraphs that follow briefly describe the Closure activities. Additional details on closure activities and contingency planning are provided on Air

Emissions Control during closure (Section 7); Personnel Safety and Fire Protection (Section 8); Decontamination Efforts for tanks and piping to be removed during closure (Section 9); Criteria for Soil Contamination (Section 10); Sampling Plan for Soil (Section 11); Description of Removal Efforts (Section 12); and Description of Closure Equipment Cleaning (Section 14).

The activities comprising closure are as follows:

6.1 Notification of Approval of the Closure Plan by the Ohio EPA received by TRW. The schedule allows for delays in delivery of this notice up to a full work week (7 days).

6.2 The Hazardous Waste Management Units at Dock 2-B and Building 49 are vacated by ARGO-TECH. The new facilities for Torpedo Testing at Building 33 are partially in use as of 1 August 1987. It is assumed that construction there will have been completed on or before the notification date above, so that ARGO-TECH will have ceased Torpedo Testing activities and removed all stored torpedo fuel at Building 49 within five weeks (35 calendar days) thereafter. It is also assumed that all hazardous waste stored by ARGO-TECH at Dock 2-B can be removed within the same time limit for off-site treatment and disposal, or transferred to a new area to be provided by TRW.

6.3 Selection of Contractors by TRW and mobilization of equipment is scheduled to take place in the five work weeks (35 calendar days) following Receipt of Approval of the Closure Plan.

6.4 Site Work at Building 49 for equipment access is required before any other closure activities can begin there (See Figure 6.4). The fence on the southeast side of the Torpedo Test complex must be removed. Decontamination facilities will be set up during this time. A gravel or slag roadway, 12 ft wide x about 150 linear ft., will be installed about 10 ft south of the soil to be excavated, for access by the heavy equipment which otherwise would be mired in the swampy soil. This activity can start as soon as possible, weather permitting. Once started, it will take about two work weeks (14 calendar days) to complete, allowing for possible delays due to adverse weather.

6.5 Excavation of Contaminated Soil from the Building 49 Spill Area will require a Gradall or Clamshell. Soil will be excavated from the approximately 625 sq.ft. polygon area shown in Figure 2.5, to a depth of 1 ft below the interface of competent clay. Sections through the polygon area ae shown in Figures 6.5 and 6.6. Assuming that the excavation averages about 4 ft depth, it will amount to about 95 cu.yd. This activity can begin immediately after completion of the roadway, and will take about one work week, weather permitting. As soon as the excavation has been completed, soil sampling can begin (See Subsection 6.14).

6.6 Dredging of the Runoff Stream will also require the Gradall or Clamshell unit. Sediments will be removed from the approximately 120 ft length of the stream, to a depth of 2 ft. A profile section along the stream is shown in Figure 6.7. Assuming a bucket width of 2 ft, the sediments removed would amount to about 18 cu.yd. An additional 1.4 cu.yd. of sediments will be removed from the first culvert (at the south end of the runoff stream) by hand shoveling. The dredging can begin after completion of the excavation of contaminated soil, and will take about one work week, weather permitting. Soil sampling can begin along the runoff stream bed as soon as the sediment dredging activity has been completed (See Subsection 6.14).

6.7 Off-Site Disposal of the Soil and Sediments. The two preceding activities will generate about 130 cu.yd. of soil and sediments, assuming about 10% expansion. This material will be transferred to containers and hauled off-site for disposal by incineration. In the event that an alternative treatment technology becomes available before approval of the Closure Plan, TRW will investigate its feasibility. Truckload quantities will be accumulated at a covered storage area to the north of Building 49. This activity will follow the soil and sediment removal, as quickly as practicable.

6.8 Removal and Decontamination of the 1,000 Gallon Underground Separator Tank and Auxiliary Piping can occur at any time following the excavation of contaminated soil. This activity will require a backhoe to unearth

the underground facilities, which lie at typical depths up to about 4 ft. It can be completed within two work weeks, weather permitting. The decontamination efforts there are discussed further in Section 9.

6.9 Soil Sampling at Building 49 and Subsequent Laboratory Analysis of the Soil Samples will begin upon completion of the excavation, removal or demolition activities above. A maximum of five weeks (35 calendar days) will be required for the laboratory results to be reported. A random grid sampling strategy, will be followed, to ensure that no contaminated soil remains. The proposed sampling grid and other details of the soil sampling are discussed in Section 11.

A Soil Boring rig will be used to take the soil samples at Building 49. The soil samples will be collected in Shelby Tubes representing 1 ft intervals of depth below the surface (after excavation) down to the bedrock shale.

The Shelby Tubes or cores will be capped, marked with identifying numbers and delivered to a certified laboratory for chemical analysis. Chain-of-Custody documentation and other quality control procedures are discussed in Section 11. The analysis will be only for PGDN and Total Cyanide.

Contingent on the soil sampling results, additional soil removal and/or dredging may be required to ensure that all hazardous waste and contaminated soil have had proper disposal. This must wait upon the laboratory analysis results for the soil samples. Any equipment used in this task will have to be decontaminated before it can be allowed to leave the site.

6.10 Backfilling and Final Grading of the Soil Removal Area will use clean borrow material. Soil from the former shrapnel barrier mound to the south of Building 49 will be used for this, if suitable. (The mound includes a considerable amount of construction rubble. Soil in the mound does not contain detectable concentrations of cyanides, based on analysis of a composite sample of surface soil from the mound which was collected during the preparation of this Closure Plan.) This activity can begin after analytical laboratory tests confirm that the remaining soil is free

of PGDN (torpedo fuel) and has acceptable cyanide concentrations (not exceeding 10 mg/kg). It can be completed within one work week, weather permitting. See Section 11.1 and the Risk Assessment (Attachment 2, Appendix C) for details on Soil Sampling and acceptable cyanide levels.

6.11 Removal of Wood Flooring Blocks must precede the other closure activities at the Dock 2-B former TRW Hazardous Waste Storage Area.

6.12 Sampling and Analysis of Concrete Flooring at Dock 2-B and Building 45. The underlying concrete flooring at Dock 2-B will be sampled and analyzed for hazardous waste residues that may have penetrated through the blocks. A composite sample will be taken by scraping the concrete at the randomly selected areas defined by the 5 ft. grid spacing shown in Figure 6.8.

The concrete flooring in the Building 45 Target House will sampled and analyzed, in order to identify the specific local areas which have residues of Chromium. The samples will be taken by scraping the concrete at the randomly selected areas defined by the 5 ft. grid spacing shown in Figure 6.9. This includes the same locations that were sampled previously, which showed a high composite TCLP extraction chromium concentration (Section 5.2). It will also extend the sampling to include the sumps and the pits adjoining the Target House on the east and west.

This activity can start after the wood flooring blocks have been removed. An estimated four weeks (28 calendar days) will be required for the laboratory results to be available.

6.13 Demolition of Concrete Flooring in the Dock 2-B former TRW Hazardous Waste Storage Area and in the Building 45 Target House is a contingent activity, to be carried out at either or both of the locations, only at the specific areas of the concrete flooring identified as containing hazardous waste residues. Level B personnel protection (impervious clothing and supplied air respiration) will be required in Building 45; Level C (air filtration) will suffice at Dock 2-B. A crew of two will work in each area, one operating the hammer and the other assisting with dust control. This activity will take about two weeks (14 calendar days)

for a single crew. The dust control water spray will be collected for off-site disposal.

The soil underlying the concrete removed by demolition will be inspected visually for evidence of hazardous waste penetration through the now removed concrete flooring. If necessary, sampling and analysis and subsequent soil removal will be carried out.

All concrete flooring removed by demolition from both Dock 2-B and Building 49 will be replaced by patching. At Dock 2-B, additional concrete will be applied on top of the existing flooring (patched as necessary). This surface will be sealed by coating with coal-tar epoxy, to provide a suitable flooring service for future Argo-Tech use of the area for 90 day storage of hazardous materials.

6.14 Off-Site Disposal of Rubble from Dock 2-B and Building 45 will generate an estimated 5 tons of wood blocks, assuming a wood block thickness of 1.5 inches. The concrete demolished in the two buildings is estimated to amount to 20 cu.yd., assuming a concrete thickness of 1 ft and 75% expansion. The rubble will be accumulated at each location in separate covered containers. These activities will follow the demolition as quickly as practicable.

The wood blocks from Dock 2-B will be collected in fibre drums for off-site treatment by incineration, and the resultant ash will then be disposed of by landfilling. The concrete rubble resulting from demolition would have to be disposed of at a landfill certified for hazardous wastes.

6.15 Decontamination of Equipment Used in the Closure is scheduled upon completion of the activities above. A portable steam generator or a high pressure water sprayer will be set up near the work areas. Enclosures will be set up to collect the condensate or washwater, for off-site disposal (See Section 14). This will ensure that all particles of hazardous waste and/or contaminated soil adhering to the equipment are

dislodged and disposed of. Decontamination of the equipment should be done as quickly as possible after the last use of each item.

6.16 Certification is the final task. The independent registered Professional Engineer retained by TRW will have been present on-site during all of the activities enumerated above. Upon completion of all required site work and after review of the soil sampling laboratory data, the Engineer shall submit his report which will certify that all closure activities have been carried out in compliance with the Closure Plan. Further details on Certification are in Section 15.

This activity should have been completed within two weeks (14 days) after completion of the Final Closure field activity.

PROJECT SCHEDULE

TRW, Incorporated

TAPCO SITE CLOSURE
CL065.01
Project Mgr:A. L. Resetar

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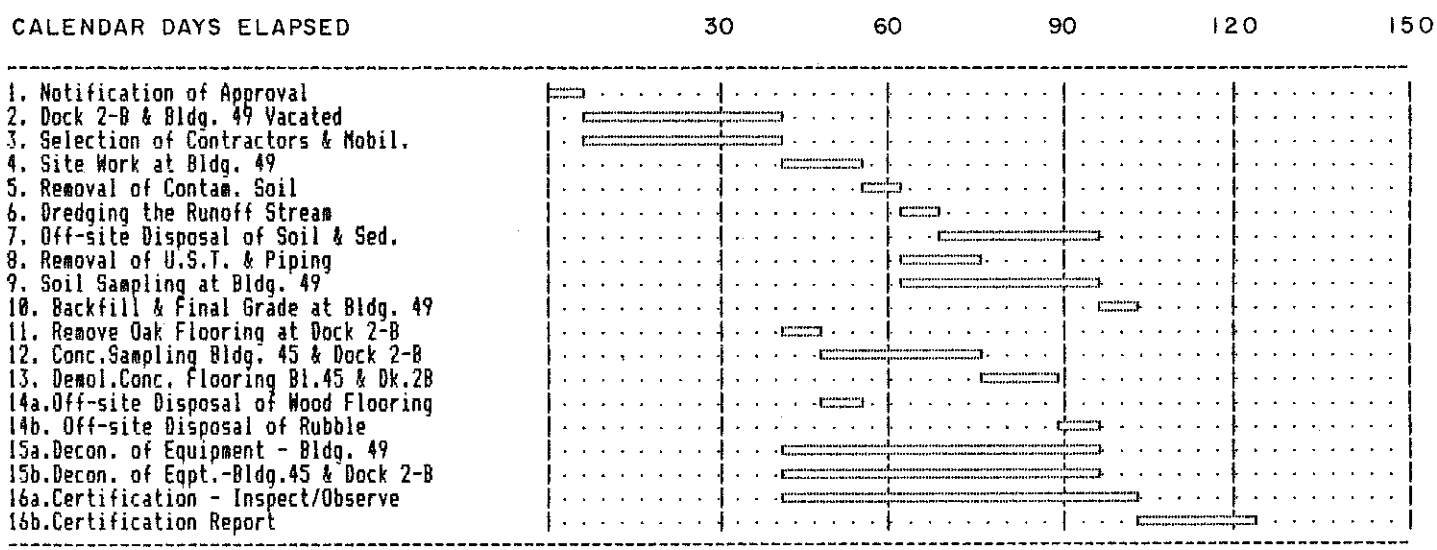

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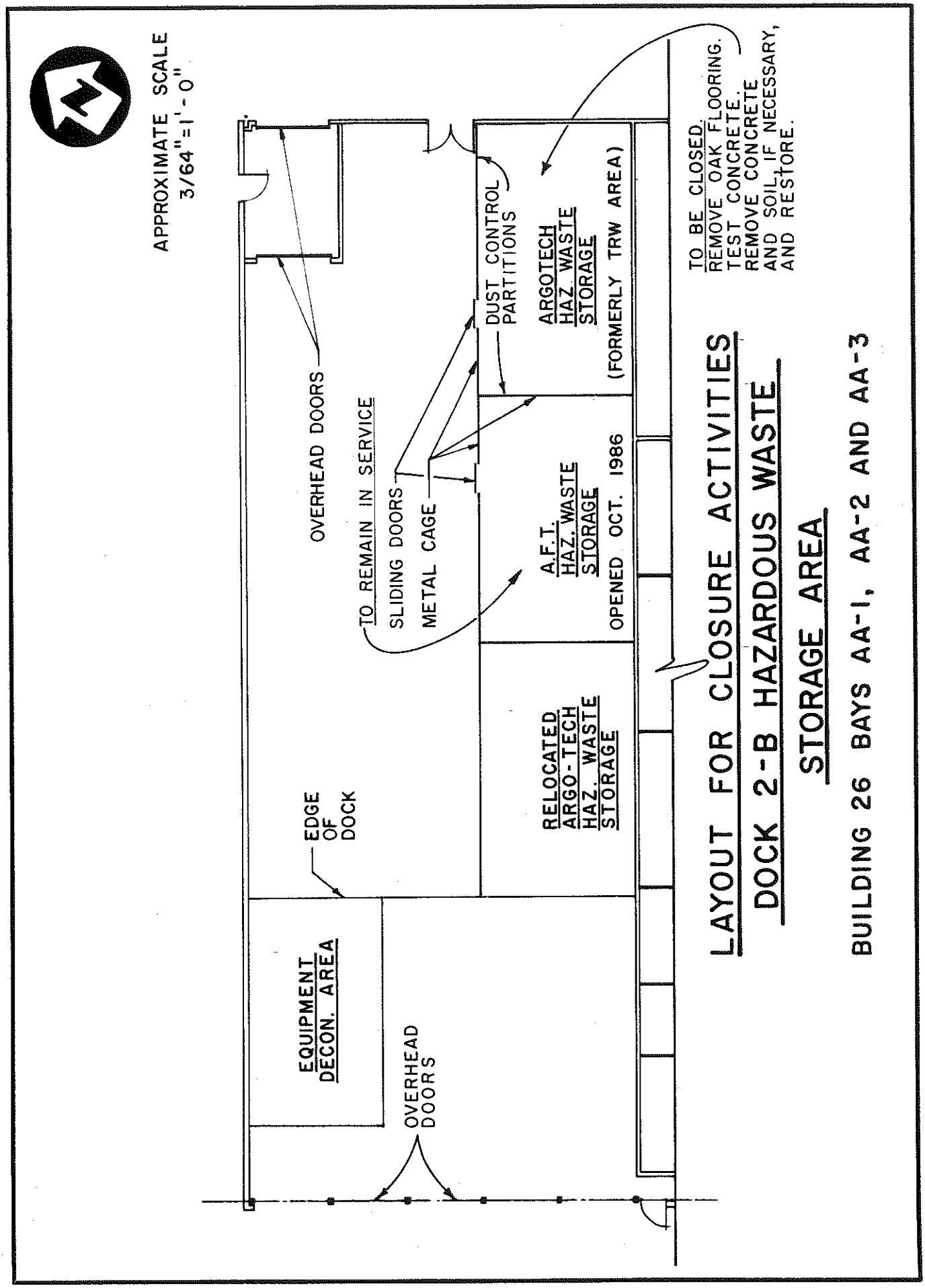
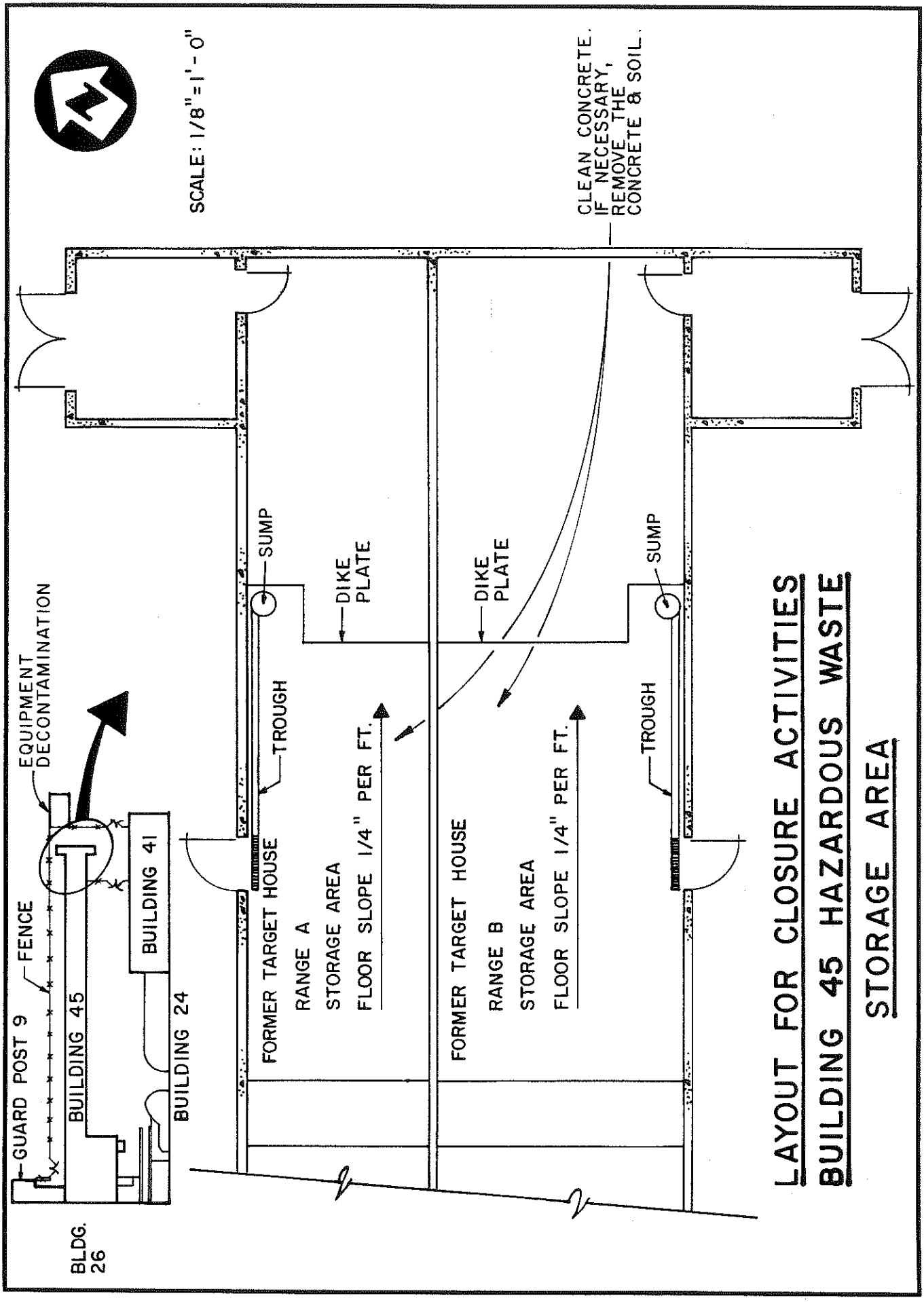
FIGURE 6.1

FIGURE 6.2



ES ENGINEERING—SCIENCE

FIGURE 6.3



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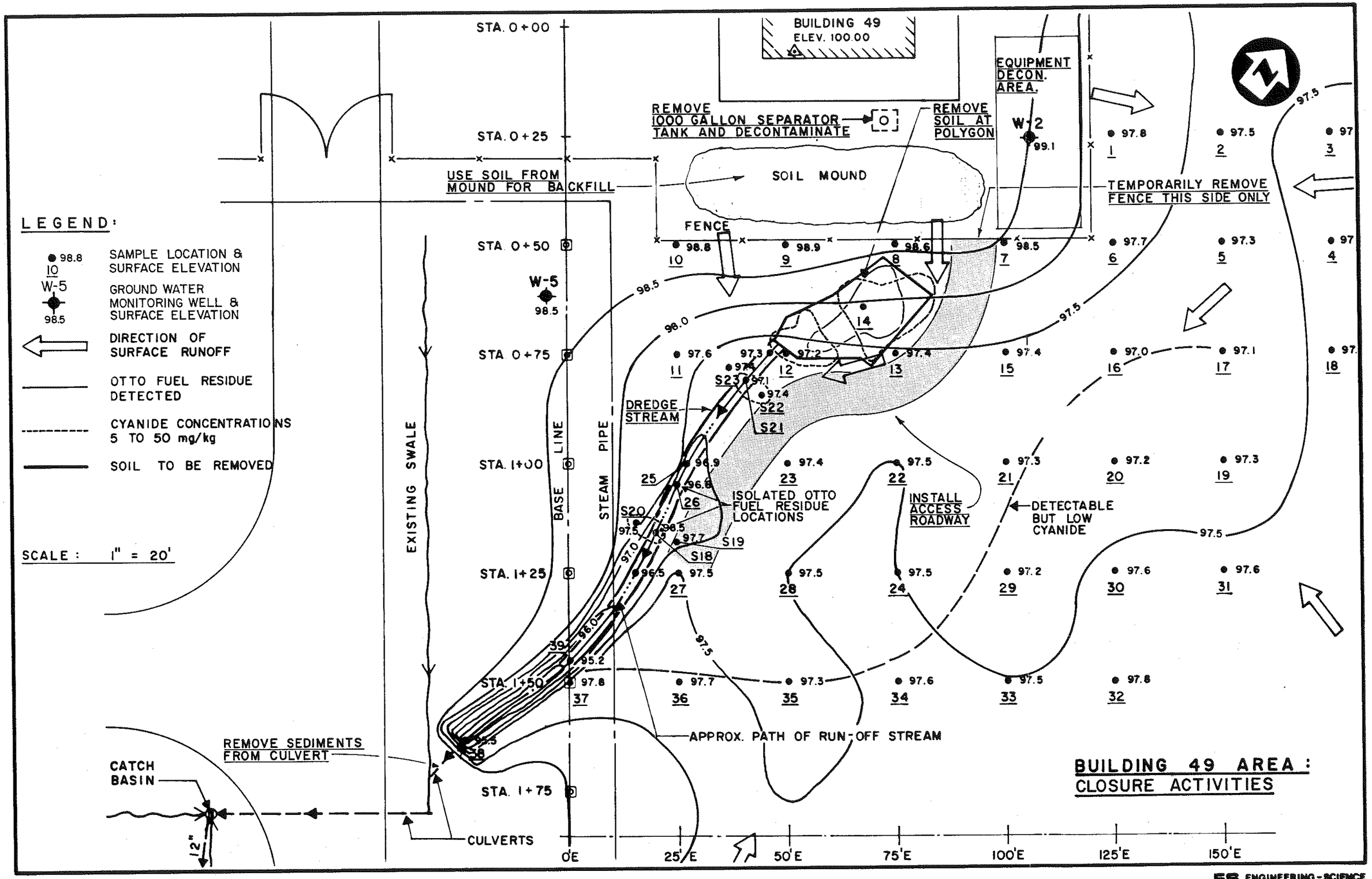

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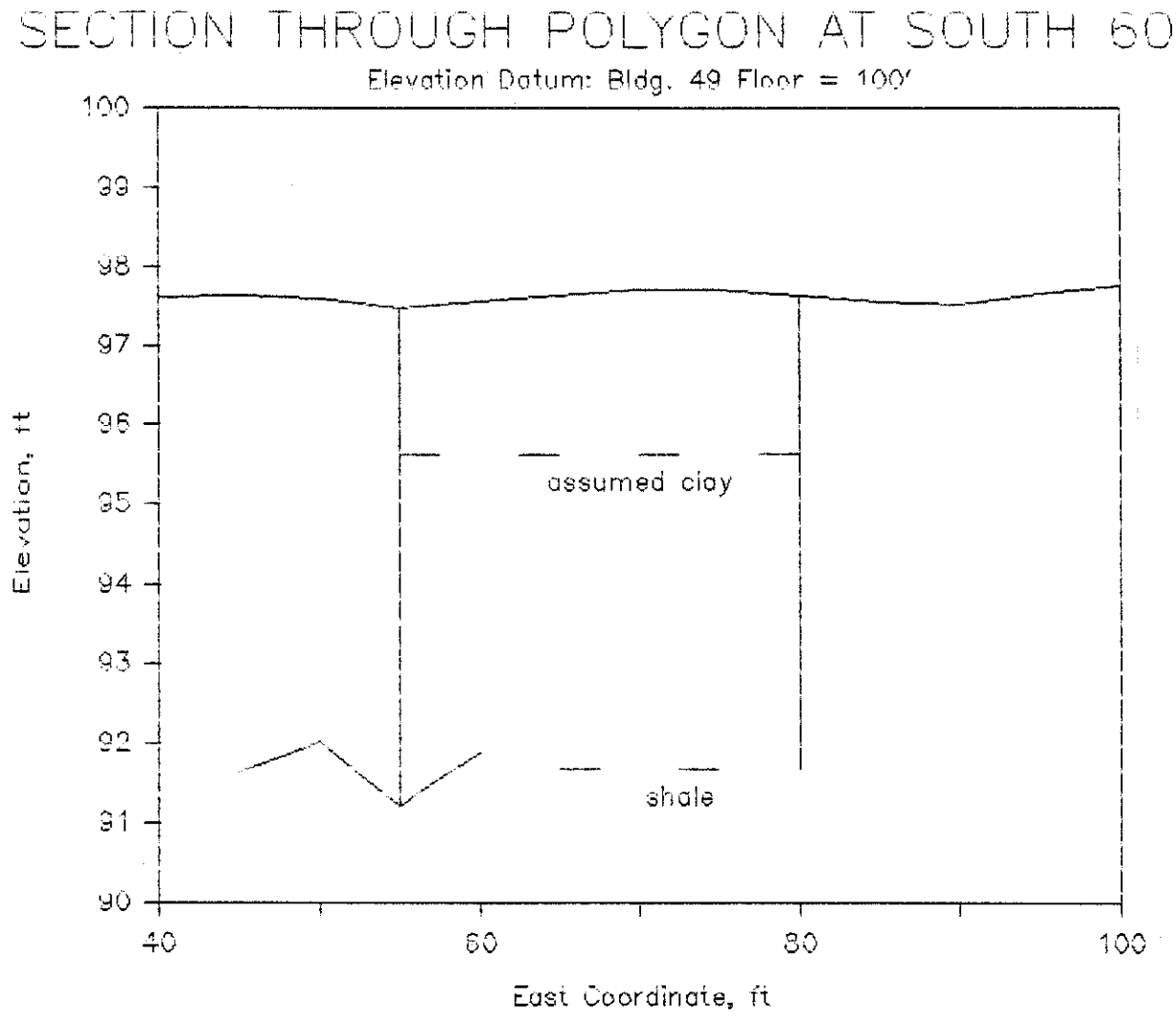
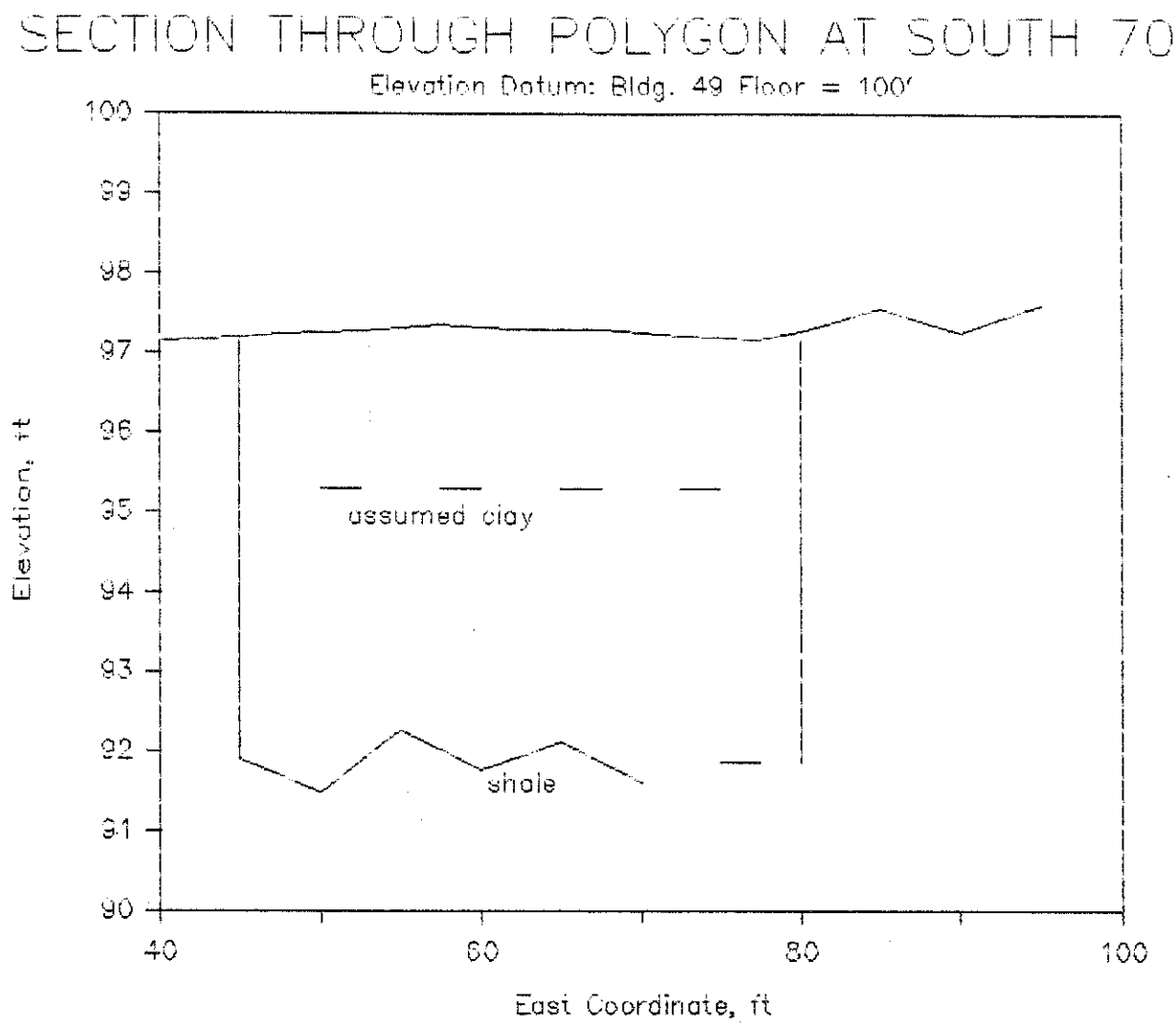

SECTION THROUGH POLYGON AT SOUTH 60
Elevation Datum: Bldg. 49 Floor = 100'
100
99
98
97
96
95
94
93
92
91
90
Elevation, ft
assumed clay
shale
40
60
80
100
East Coordinate, ft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Elevation Datum: Bldg. 49 Floor = 100'
Elevation, ft
100
99
98
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96
95
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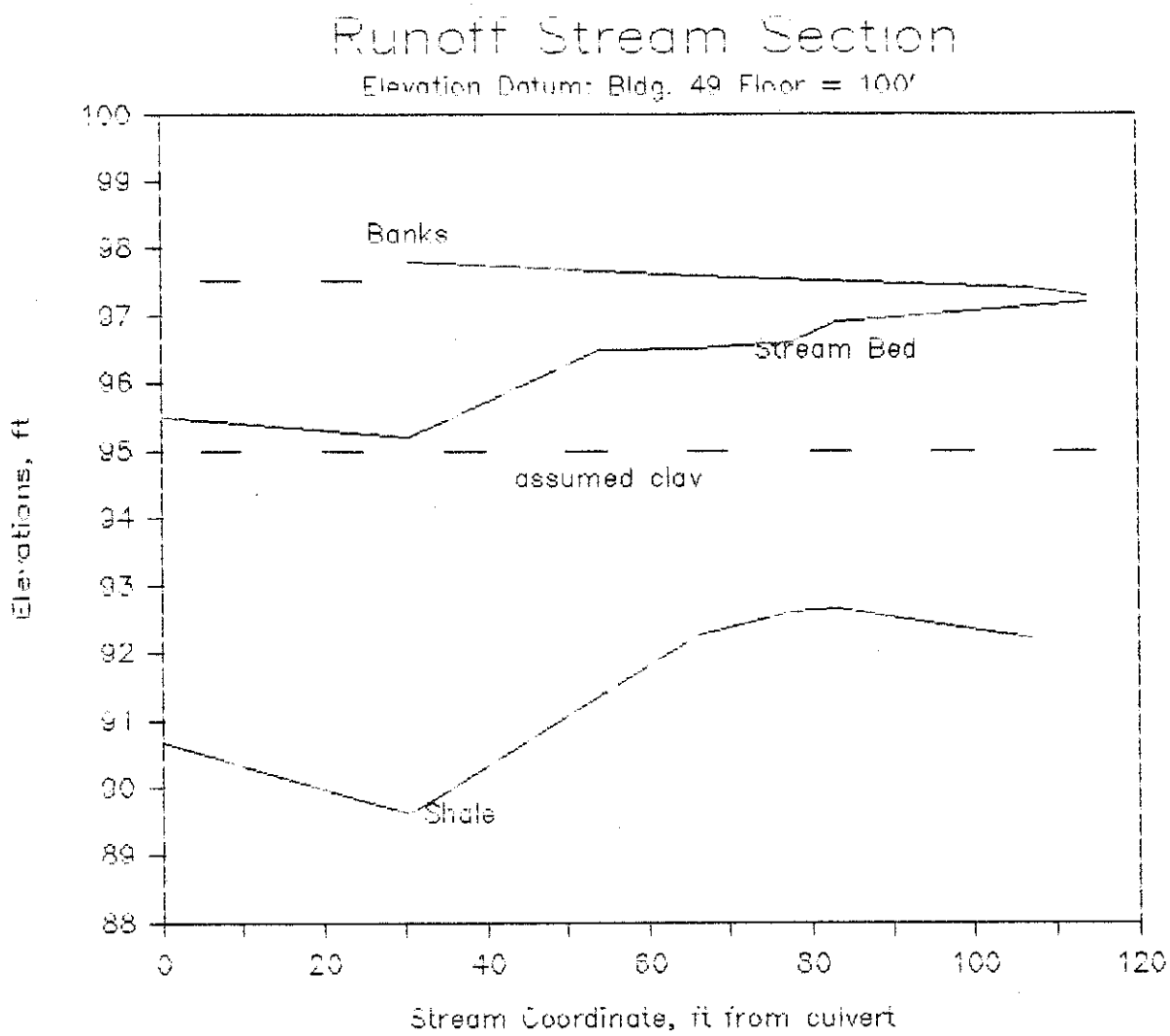
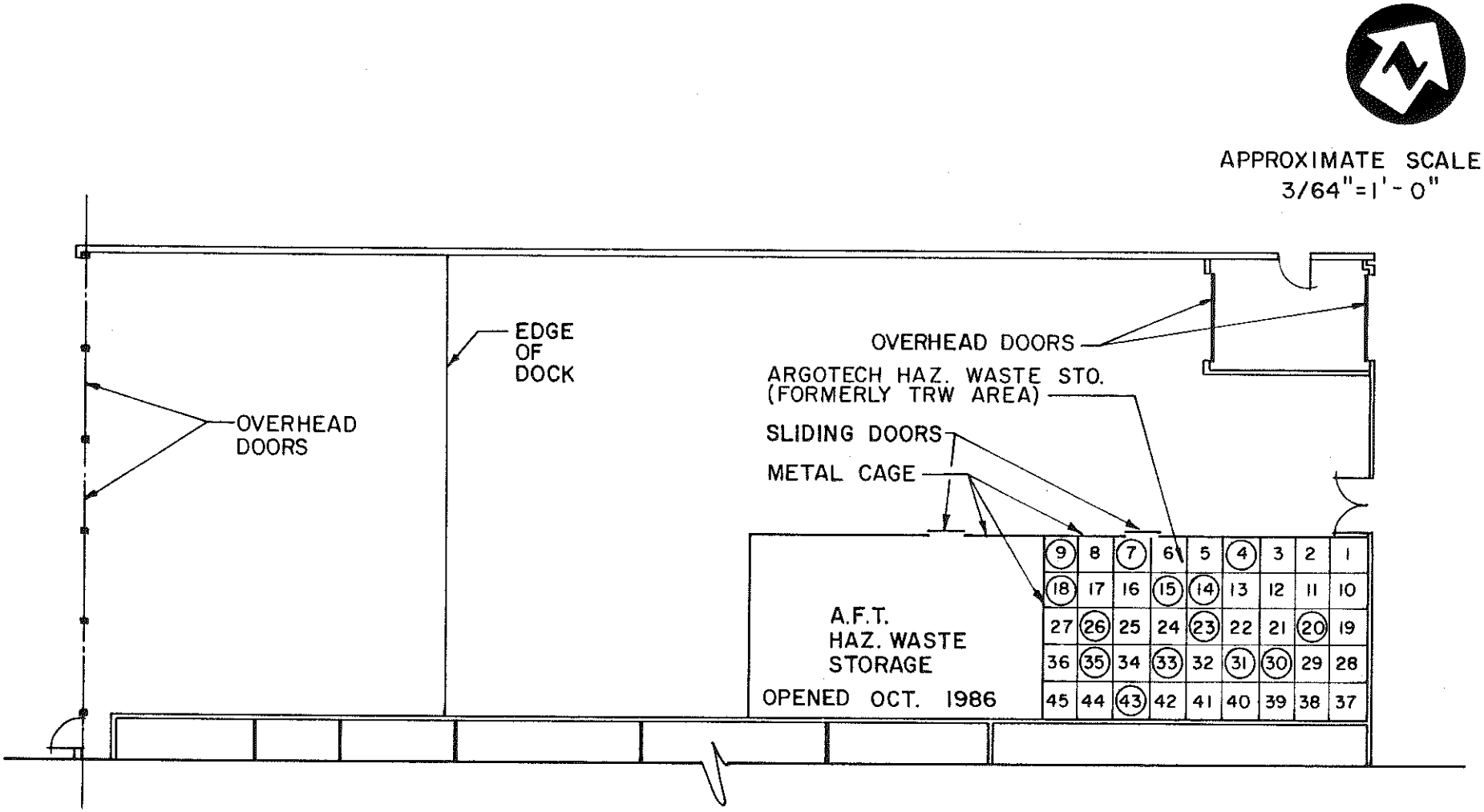
93
92
91
90
assumed clay
shale
40
60
80
100
East Coordinate, ft


Runoff Stream Section
Elevation Datum: Bldg. 49 Floor = 100'
Banks
Stream Bed
assumed clay
Shale
Elevations, ft
100
99
98
97
96
95
94
93
92
91
90
89
88
0
20
40
60
80
100
120
Stream Coordinate, ft from culvert



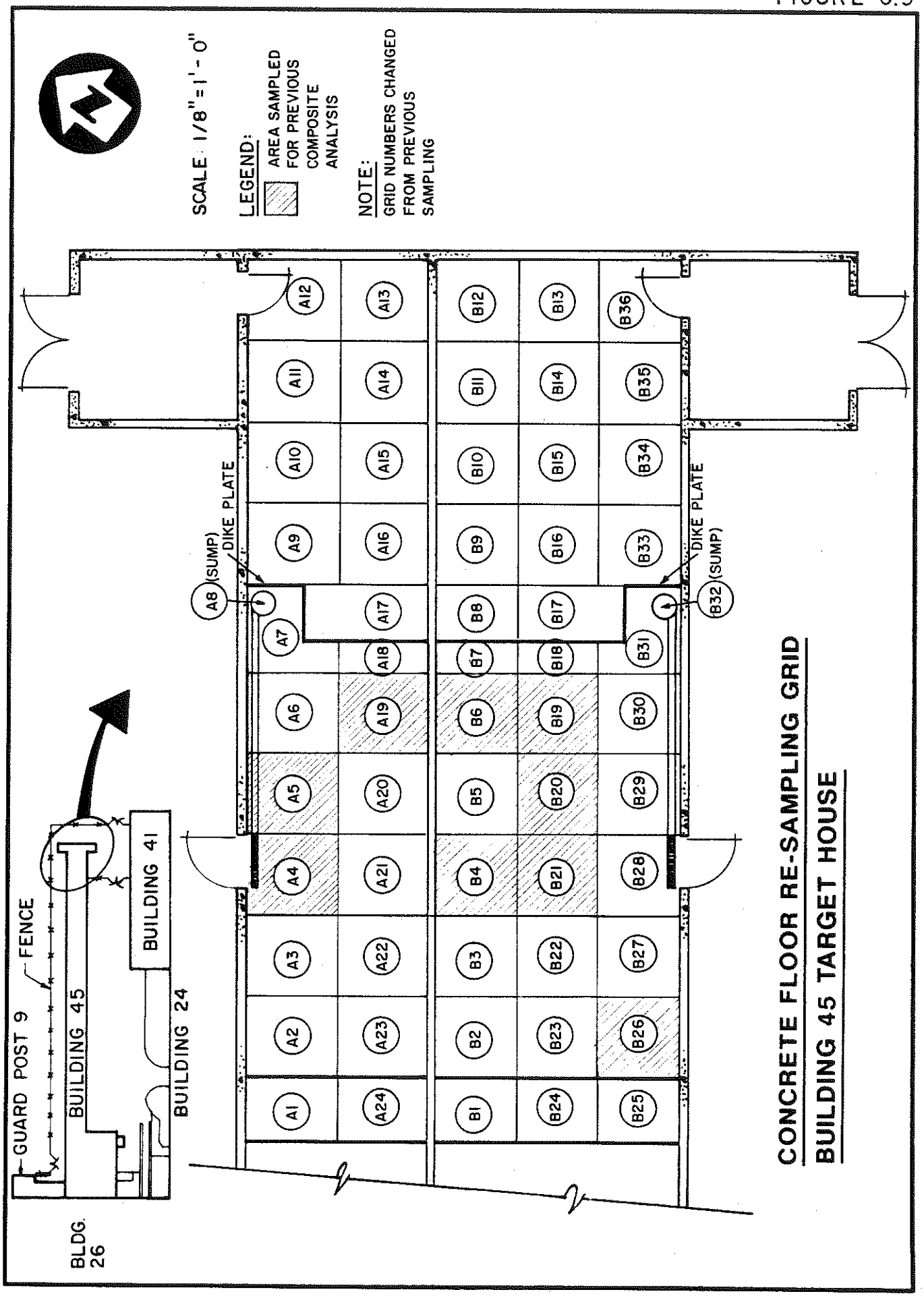
SAMPLING GRID FOR DOCK 2-B CONCRETE SUB-FLOOR

FORMER TRW HAZARDOUS WASTE STORAGE AREA

BUILDING 26, BAYS AA-1, AA-2 and AA-3

FIGURE 6.8

FIGURE 6.9



ES ENGINEERING—SCIENCE

7. AIR EMISSIONS

Engineering controls and precautionary operational practices will be used during closure of the Hazardous Waste Managements Units at the TAPCO site to minimize air emissions of hazardous contaminants.

The soil to be excavated from the torpedo fuel discharge area at Building 49 is swampy. Fugitive dust emissions from that area, which might contain PGDN and/or cyanides, will be controlled by keeping the soil moist. A risk assessment in the Building 49 Study Report (Attachment 2) established that volatilization of PGDN and/or cyanides would not result in harmful concentrations for either humans or animal populations that might be exposed.

Demolition of concrete flooring from Dock 2-B and/or the Building 45 Target House are contingent activities, to be undertaken only if efforts to remove hazardous waste residues are not successful. In that event, temporary barriers will be set up, and water will be sprayed on during air-hammering and/or saw cutting, to absorb any dust that might be generated.

8. PERSONNEL SAFETY AND FIRE PROTECTION

Protective clothing and/or respiratory protection will be required for the following closure activities:

- Removal of soil and sediments from the Torpedo Fuel Discharge Area near Building 49 and loading into containers could release PGDN and cyanide particles. Equipment operators working in the cabs would require only Level C protection, i.e., air filters. Workers on foot would have to remain upwind from the soil being removed, and use Level B protection, if necessary, i.e., disposable impermeable clothing and supplied air respiration. See Figure 6.4 for layout of closure activities near Building 49.

- Cleaning the concrete below the existing wood block floor in Building 45 (after removal of the blocks) will require gloves and impermeable clothing.

- If required, air-hammering and/or saw cutting of the concrete at Dock 2-B could release miscellaneous particles. (These activities would not be required, if cleaning the concrete removes any hazardous residues.) In the absence of any identified toxic constituent present at detectable concentrations, Level C protection would be required, i.e., air filters. See Figure 6.2 for layout of closure activities at Dock 2-B.

- If required, air-hammering and/or saw cutting of the concrete flooring in Building 45 could relase toxic hexavalent chromium particles. (These activities would not be required, if cleaning the flooring removes the absorbed chromium.) Level B protection would be required, i.e., disposable impermeable clothing and supplied air respiration. See Figure 6.3 for layout of closure activities at Building 45.

The danger of fire is not imminent. Of all the hazardous waste materials to be handled during closure, only the wood block flooring removed from Dock 2-B would be ignitable under normal conditions. However, in the event of fire at Dock 2-B, other chemicals stored there may be spread or may release toxic materials due to overheating. Containers of such chemicals should be cooled by spraying water over them.

In the event of any plant-wide emergency situation, particularly a fire in the contiguous buildings, closure activity at either Dock 2-B or Building 45 will be halted immediately upon notification by ARGO-TECH's Emergency Coordinator. Similarly, in the event of an emergency situation affecting Building 49, particularly a brush fire, closure activity there will be halted. In either instance, closure equipment will be secured, if possible, and all personnel will leave the area.

9. DECONTAMINATION EFFORTS

The 1,000 gallon underground separator tank formerly used to treat discharges of wastewater from torpedo testing operations, the vitreous clay auxiliary piping connecting this tank to Building 49 and to the discharge area, and the three underground holding tanks for torpedo testing wastewater will be unearthed and removed. These items will be taken to Building 48, the former laundry facility for the torpedo test complex, to be washed with a detergent solution (Wisk) and rinsed with city water. The detergent is routinely used for cleaning residues of torpedo fuel during torpedo test operations. This washing and rinsing will be repeated as necessary until the intensely reddish torpedo fuel color is no longer visible. The wash water and rinseate will be collected and disposed of off-site. See Figure 6.4 for layout of closure activities near Building 49.

as — ?

Decontamination of equipment used in the Closure activities is discussed in Section 14.

PGDN
≠ miscible
≥ 11,0
(p. 7 Bldg 49 RA)

10. CRITERIA FOR SOIL CONTAMINATION

As indicated in the Schedule for Closure (Section 6), soil sampling will be carried out to ensure that any soil contaminated by hazardous waste generation and 90-day storage activities prior to closure will be removed for appropriate treatment and disposal. The procedures for soil sampling are discussed in Section 11.

It is vital to establish what constitutes a "clean" soil. The hazardous wastes managed at the TAPCO site are known to contain PGDN (torpedo fuel), cyanides and toxic heavy metals. PGDN and Cyanides are not naturally occurring, hence a detectable concentration would indicate contamination. The metals are naturally occurring elements in the area and are anticipated to be present, to some extent, in all soil samples. Detectable below EP-toxic concentrations of Barium, Chromium, Lead and Nickel were leached from soil samples taken near Building 49 (See Table 5.2).

The criterion for cyanide concentration will be 0.25 mg/kg, the detection limit, for soils at Building 45 or at Dock 2-B. However, for soils near Building 49, the criterion will be 10 mg/kg, which was established in a Risk Assessment as not constituting a threat to public health or the environment, specifically for the vicinity of Building 49 (See Attachment 2, Appendix C and D).

The criterion for PGDN concentrations will be its detection limit, i.e., 25 mg/kg.

It is proposed that criteria for metals shall be established based on concentration levels measured on four (4) or more soil samples to be taken at various unaffected locations within the TAPCO site, as follows:

Student's t values

Parameter	Criterion
Cadmium (Cd)	$\bar{x}_{Cd} + 2.35\ s_{Cd}$ (maximum 2.9 ug/kg)
Chromium (Cr)	$\bar{x}_{Cr} + 2.35\ s_{Cr}$ (maximum 23 ug/kg)
Lead (Pb)	$\bar{x}_{Pb} + 2.35\ s_{Pb}$ (maximum 39 ug/kg)
Nickel (Ni)	$\bar{x}_{Ni} + 2.35\ s_{Ni}$

In the above tabulation, x and s, respectively, stand for the mean and standard deviation of the background values for the subscripted metal. This, in

effect, establishes the standard at a concentration statistically greater than background level at about the 5% level of significance, using Student's t-test and assuming three (3) degrees of freedom. (With a larger data base, the level of significance would be lower than 5%.) In the event that the background concentration of a metal exceeds its maximum value as noted above, that maximum value will apply as criterion. The maximum values noted here represent the upper limits of the range for Ohio farm soils.*

* REFERENCE: Logan, T.J. and R.H. Miller, 1983, Background Levels of Heavy Metals in Ohio Farm Soils, Research Circular 275, Ohio State University, Ohio Agricultural Research and Development Center, Wooster, OH)

11. SAMPLING PLAN FOR SOIL AND ANALYTICAL METHODS

11.1 Building 49 Area

11.1.1 Analysis Parameters and Test Methods. The analysis parameters for the samples of soil and runoff stream sediments and the laboratory methods are as follows:

Parameter	Method No.
Cyanide (Total)	9010 (SW-846)
PGDN	Chromatographic

These are the parameters used in the previous Building 49 Study (See Attachment 2). RCRA characterization of additional soil samples undertaken to develop this Closure Plan (See Section 5.3) did not any reveal any other hazardous waste characteristics.

11.1.2 "Clean" Level for Soil. The Risk Assessment (See Appendix C and D of Attachment 2) presents the rationale for establishing what shall be taken to constitute a "clean" level for soil at Building 49. The target concentration levels and the detection limits are as follows:

Parameter	Criterion	Detection Limit
Cyanide (Total)	10 mg/kg	0.5 mg/kg
PGDN	Not Detected	25 mg/kg

11.1.3 Location of Samples. Figures 11.1 and 11.2 show the locations proposed for soil sampling in the Building 49 Area, to verify that the excavation of soils (for off-site disposal by incineration) has successfully removed residues of the indicator parameters above, to within their respective target concentration levels. As in the previous samplings of soil near Building 49, cells within a grid of numbered 5 ft x 5 ft squares were selected randomly. The Closure activity will sample approximately one cell in four, as follows:

- The 625 sq.ft. irregular polygon area for soil removal at the former torpedo test wastewater discharge area: 7 cells/29 (Figure 11.1).
- The 120 ft long runoff stream channel: 6 cells/24 (Figure 11.2).

11.1.4 Sampling Methods and Equipment. A Soil Boring rig will be used to take the soil samples near Building 49. The samples will be collected in Shelby Tubes representing 1 ft intervals of depth below the surface. The tubes will be capped, marked with identifying numbers and delivered to a certified laboratory for chemical analysis.

11.2 Plan for Soil Sampling at Dock 2-B and Building 45, If Required

Concrete flooring will be demolished in Building 45 at the specific locations found to contain chromium residues (See Section 6.12). It may also be necessary to demolish the concrete sub-flooring at Dock 2-B, at any specific locations found to contain hazardous waste residues. The surface soils immediately beneath the affected concrete will be inspected and, if necessary, sampled to ensure that no hazardous waste residues remain.

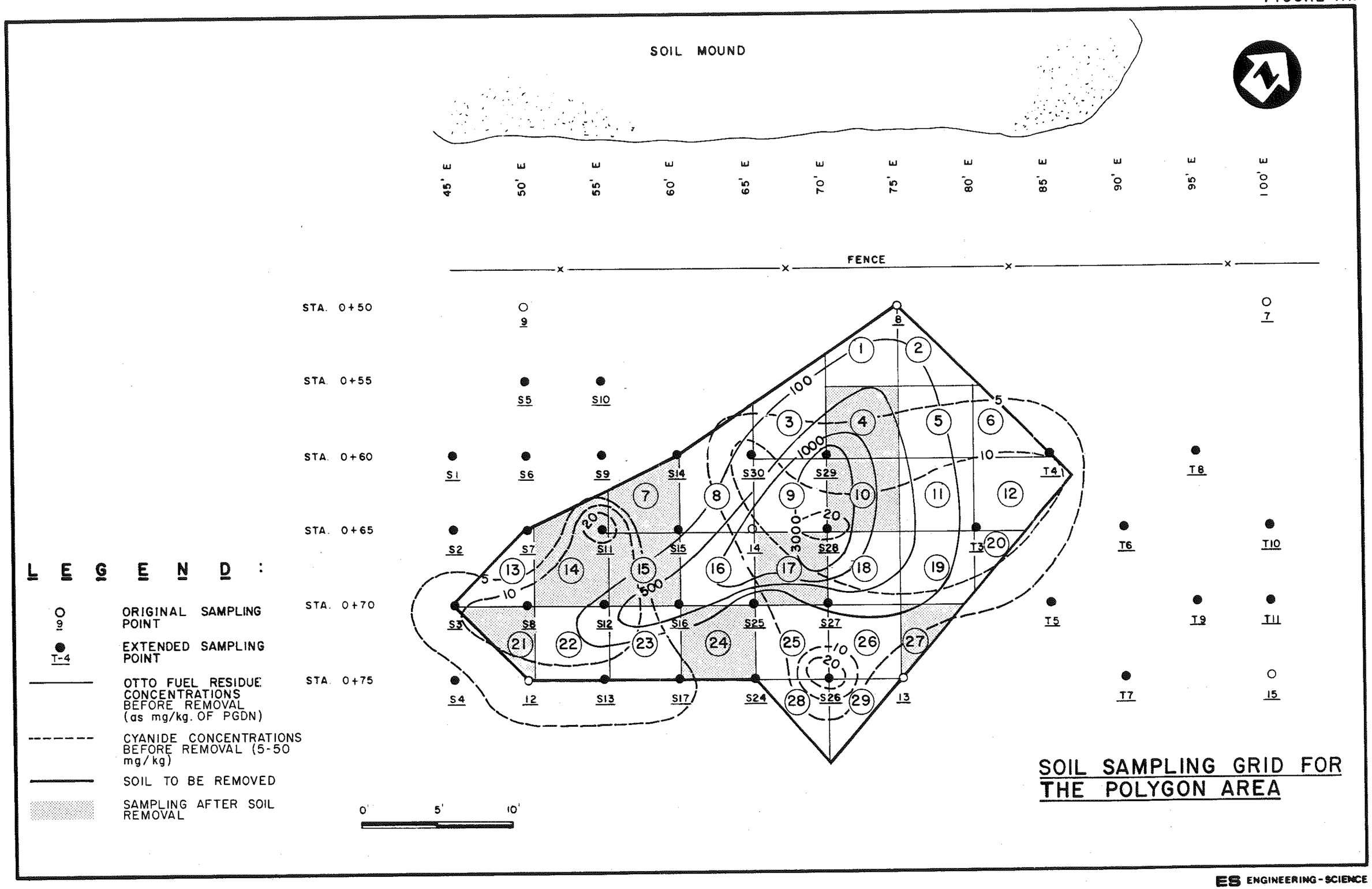
This contingent soil sampling will be limited to the specific parameters which were identified in the analysis of the concrete samples. These soil core samples, if any, will be taken by manually driving 2 inch pipes using a sledge hammer. The test methods for analyzing the parameters will be those provided in U.S. EPA Manual SW-846. Section 10, Criteria for Soil Contamination, presents the rationale for establishing what shall be taken to constitute a "clean" level for soil at the site.

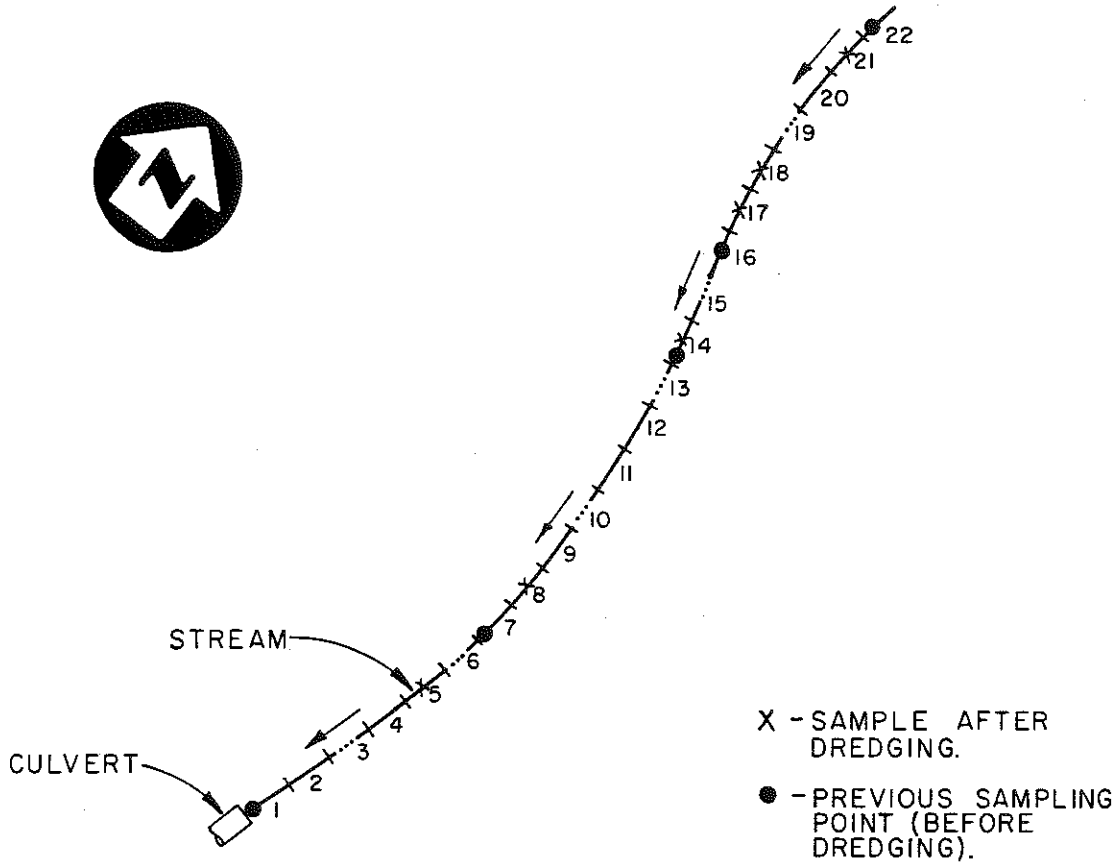
11.3 Background Samples

Additional soil sampling will be undertaken by TRW, not later than the beginning of closure activities, to provide a data base of four (4) or more soil samples taken at unaffected locations within the TAPCO site.

11.4 Quality Assurance/Quality Control Plan

The soil and sediment sampling plan will include 10% blind duplicates and field blanks, which will be submitted for laboratory analysis along with the regular samples. All sample numbers will be assigned using a sequential code to ensure that the identity of duplicates and blanks will be concealed from the analysts. Permanent numbered gummed labels and Chain-of-Custody Forms will be provided.


SOIL MOUND
45' E
50' E
55' E
60' E
65' E
70' E
75' E
80' E
85' E
90' E
95' E
100' E
FENCE
STA. 0+50
STA. 0+55
STA. 0+60
STA. 0+65
STA. 0+70
STA. 0+75
9
7
8
S5
S10
S1
S6
S9
S14
S30
S29
T4
T8
S2
S7
S11
S15
14
S28
T3
T6
T10
S3
S8
S12
S16
S25
S27
T5
T9
T11
S4
12
S13
S17
S24
S26
13
T7
15
100
5
1000
10
20
500
LEGEND:
ORIGINAL SAMPLING POINT
EXTENDED SAMPLING POINT
OTTO FUEL RESIDUE CONCENTRATIONS BEFORE REMOVAL (as mg/kg. OF PGDN)
CYANIDE CONCENTRATIONS BEFORE REMOVAL (5-50 mg/kg)
SOIL TO BE REMOVED
SAMPLING AFTER SOIL REMOVAL
0'
5'
10'
SOIL SAMPLING GRID FOR THE POLYGON AREA



PLAN
1" = 20'

SOIL SAMPLING GRID FOR RUNOFF STREAM
(NEAR BUILDING 49)

12. DESCRIPTION OF REMOVAL EFFORTS

The Closure of the Hazardous Waste Management Unit at Building 49 will excavate soil from the site of discharges of wastewater from torpedo test firings containing cyanides and torpedo fuel residues, for off-site disposal. The Closure of the former TRW Hazardous Waste Storage Area at Dock 2-B will remove wood flooring which was found to contain detectable concentrations of cyanides and priority pollutant organics. The closure of the Units at Building 45 will demolish concrete that contains residues of chromium. If necessary, concrete sub-flooring at Dock 2-B which may be found to contain hazardous waste residues will be demolished. The concrete rubble will be removed for off-site disposal.

The soil and the concrete rubble are solid materials. Laborers wil be at hand during all removal and transfer operations to recover any spilled material. The transfer routes will be covered with polyethylene sheet to ensure against loss of spilled material.

Additional details of the Closure Plan which are presented in this Section ensure proper disposal of all such material.

12.1 Removal of Soil and Sediments at Building 49

All soil excavated at the Building 49 area will be immediately loaded into containers, which will be transferred to a collection area at the north end of the pavement in the former Torpedo Testing compound. The containers will be hauled for off-site incineration and disposal, as soon as possible; hence, the maximum number of containers on-site will be about a single hauling load, at most, 20 tons. See Figure 6.4 for layout of facilities near Building 49.

All earthmoving equipment used in these operations will be decontaminated before being allowed to leave the compound area.

12.2 Removal of Oak Flooring at Dock 2-B

Wood flooring blocks will be removed from the former TRW Hazardous Waste Storage Area at Dock 2-B. These will be collected immediately in fibre drum containers, which will be stored at the new or temporary ARGO-TECH Hazardous Waste Storage Area at the Dock, in a separate area, until all of the existing

flooring in the area to be closed has been removed. Figure 6.2 shows the layout of facilities for closure activities at Dock 2-B.

12.3 Removal of Concrete and Soil at Building 45 and/or Dock 2-B, If Required

Rubble from demolition of the concrete at the former TRW Hazardous Waste Storage areas will be transferred to a roll-off container at the site. At Building 45, the container will be located outside the fence to the east of the former Target House. At Dock 2-B, the container will be located inside the building, at the edge of the dock, on street level. See Figures 6.2 and 6.3 for the layout of facilities for closure activities at these units.

The containers will be covered when not in use and will have dust control partitions. The containers will be hauled for off-site disposal at a landfill certified for heavy metals, as soon as possible. Hence, the maximum inventory of concrete rubble or soil on-site will be the roll-off container capacity, about 16 cu.yd.

In the event that hazardous waste residues are detected in the underlying soil after demolition of the concrete, all soil excavated from these areas will be collected, stored on-site and disposed of by off-site landfilling following the procedure outlined above for concrete rubble.

13. SPECIFIC CONSIDERATIONS

This section is reserved for details which are specific for Treatment or Disposal facilities. Although TRW's original application included possible treatment, the Hazardous Waste Management Units to be closed have only been storage facilities. Hence, no specific considerations are applicable.

14. DESCRIPTION OF EQUIPMENT CLEANING

All equipment used in the Closure activities will be either steam-cleaned or cleaned with a high pressure water spray before being allowed to leave the site. Temporary enclosures, approximately 25 ft x 50 ft, will be set up, using boards and polyethylene sheet. Condensate or spent spray water will be collected in a holding tank to trap any particles of soil or rubble dislodged from the equipment being cleaned. The holding tank will be cleaned, as necessary, and any solid residue removed from it will be transferred to containers for appropriate off-site disposal as hazardous waste.

The Decontamination Area for closure activities at both Building 45 and Dock 2-B will be in the Dock, near the edge, at building floor level (Figures 6.2 and 6.3). The location for the Decontamination Area for closure activities at Building 49 will be to the east of the building, near the southeast corner of the fence (Figure 6.4).

15. CERTIFICATION

TRW Incorporated will retain an independent registered Professional Engineer as an outside consultant, specifically to be present on-site at the former TAPCO site during all of the tasks comprising the Closure Plan and to verify that the activities were conducted in accordance with the Closure Plan which was accepted by the Ohio EPA and the U.S. Environmental Protection Agency.

The Engineer's report will be submitted to the Ohio EPA and the U.S. Environmental Protection Agency by TRW Incorporated.

16. STATUS OF THE FACILITY AFTER CLOSURE

The Closure of Hazardous Waste Management Units at Dock 2-B, Building 45 and Building 49 will be a complete closure. None of the units will be subject to requirements for Post-Closure inspection and maintenance or to requirements for ground water protection.

APPENDIX 1

RCRA INTERIM STATUS PERMIT FOR THE TAPCO FACILITY

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
REGION V
111 West Jackson Blvd.
CHICAGO, ILLINOIS 60604

REPLY TO ATTENTION OF:
RCRA ACTIVITIES

MAY 14 1982

Andrew Resetar, Design Engieer
TRW Incorporated
23555 Euclid Avenue
Cleveland, Ohio 44117

RE: Interim Status Acknowledgement USEPA ID No. OHD 004 179 453
FACILITY NAME: TRW INC

Dear Mr. Resetar:

This is to acknowledge that the U.S. Environmental Protection Agency (USEPA) has completed processing your Part A Hazardous Waste Permit Application. It is the opinion of this office that the information submitted is complete and that you, as an owner or operator of a hazardous waste management facility, have met the requirements of Section 3005(e) of the Resource Conservation and Recovery Act (RCRA) for Interim Status. However, should USEPA obtain information which indicates that your application was incomplete or inaccurate, you may be requested to provide further documentation of your claim for Interim Status. Our opinion will be reevaluated on the basis of this information.

As an owner or operator of a hazardous waste management facility, you are required to comply with the interim status standards as prescribed in 40 CFR Parts 122 and 265, or with State rules and regulations in those States which have been authorized under Section 3006 of RCRA. In addition, you are reminded that operating under interim status does not relieve you from the need to comply with all applicable State and local requirements.

The printout enclosed with this letter identifies the limit(s) of the process design capacities your facility may use during the interim status period. This information was obtained from your Part A Permit application. If you wish to handle new wastes, to change processes, to increase the design capacity of existing processes, or to change ownership or operational control of the facility, you may do so only as provided in 40 CFR Sections 122.22 and 122.23.

As stated in the first paragraph of this letter, you have met the requirements of 40 CFR Part 122.23; your facility may operate under interim status until such time as a permit is issued or denied. This will be preceded by a request from this office or the State (if authorized) for Part B of your application. Please contact Arthur Kawatachi of my staff at (312) 886-7449, if you have any questions concerning this letter or the enclosure.

Sincerely yours,

Karl J. Klepitsch, Jr., Chief
Waste Management Branch

Enclosure

cc: G. E. Schrader

TRW INC OHD 004 179 453

FACILITY OPERATOR

TRW INC

FACILITY OWNER

TRW INC

FACILITY LOCATION

23555 EUCLID AVE
CLEVELAND OH 44117

PROCESS CODE	DESIGN CAPACITY	UNIT OF MEASURE
S02	55800.00000	G
S01	27500.00000	G
T01	1210000.00000	U
T03	54.00000	E

---------- KEY ----------

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE
STORAGE:		
CONTAINER	S01	G or L
TANK	S02	G or L
WASTE PILE	S03	Y or C
SURFACE IMPOUNDMENT	S04	G or L
DISPOSAL:		
INJECTION WELL	D79	G,L,U, or V
LANDFILL	D80	A or F
LAND APPLICATION	D81	B or Q
OCEAN DISPOSAL	D82	U or V
SURFACE IMPOUNDMENT	D83	G or L
TREATMENT:		
TANK	T01	U or V
SURFACE IMPOUNDMENT	T02	U or V
INCINERATOR	T03	D,W,E, or H
OTHER	T04	U,V,J,R,N, or S

UNIT OF MEASURE	CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS/HOUR	W
GALLONS/HOUR	E
LITERS/HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q
POUNDS/HOUR	J
KILOGRAMS/HOUR	R
TONS PER DAY	N
METRIC TONS/DAY	S

FORM 1 GENERAL

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

GENERAL INFORMATION

Consolidated Permits Program

(Read the "General Instructions" before starting.)

I. EPA I.D. NUMBER: F O H D 0 0 4 1 7 9 4 5 3

LABEL ITEMS

I. EPA I.D. NUMBER

II. FACILITY NAME

III. FACILITY MAILING ADDRESS

IV. FACILITY LOCATION

PLEASE PLACE LABEL IN THIS SPACE

GENERAL INSTRUCTIONS

If a preprinted label has been provided, affix it in the designated space. Review the information carefully; if any of it is incorrect, cross through it and enter the correct data in the appropriate fill-in area below. Also, if any of the preprinted data is absent (*the area to the left of the label space lists the information that should appear*), please provide it in the proper fill-in area(s) below. If the label is complete and correct, you need not complete Items I, III, V, and VI (*except VI-B which must be completed regardless*). Complete all items if no label has been provided. Refer to the instructions for detailed item descriptions and for the legal authorizations under which this data is collected.

II. POLLUTANT CHARACTERISTICS

INSTRUCTIONS: Complete A through J to determine whether you need to submit any permit application forms to the EPA. If you answer "yes" to any questions, you must submit this form and the supplemental form listed in the parenthesis following the question. Mark "X" in the box in the third column if the supplemental form is attached. If you answer "no" to each question, you need not submit any of these forms. You may answer "no" if your activity is excluded from permit requirements; see Section C of the instructions. See also, Section D of the instructions for definitions of bold-faced terms.

SPECIFIC QUESTIONS	MARK "X" YES	MARK "X" NO	MARK "X" FORM ATTACHED
A. Is this facility a publicly owned treatment works which results in a discharge to waters of the U.S.? (FORM 2A)		X	
B. Does or will this facility (*either existing or proposed*) include a concentrated animal feeding operation or aquatic animal production facility which results in a discharge to waters of the U.S.? (FORM 2B)		X	
C. Is this a facility which currently results in discharges to waters of the U.S. other than those described in A or B above? (FORM 2C)	X		
D. Is this a proposed facility (*other than those described in A or B above*) which will result in a discharge to waters of the U.S.? (FORM 2D)		X	
E. Does or will this facility treat, store, or dispose of hazardous wastes? (FORM 3)	X		X
F. Do you or will you inject at this facility industrial or municipal effluent below the lowermost stratum containing, within one quarter mile of the well bore, underground sources of drinking water? (FORM 4)		X	
G. Do you or will you inject at this facility any produced water or other fluids which are brought to the surface in connection with conventional oil or natural gas production, inject fluids used for enhanced recovery of oil or natural gas, or inject fluids for storage of liquid hydrocarbons? (FORM 4)		X	
H. Do you or will you inject at this facility fluids for special processes such as mining of sulfur by the Frasch process, solution mining of minerals, in situ combustion of fossil fuel, or recovery of geothermal energy? (FORM 4)		X	
I. Is this facility a proposed stationary source which is one of the 28 industrial categories listed in the instructions and which will potentially emit 100 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X	
J. Is this facility a proposed stationary source which is NOT one of the 28 industrial categories listed in the instructions and which will potentially emit 250 tons per year of any air pollutant regulated under the Clean Air Act and may affect or be located in an attainment area? (FORM 5)		X	

III. NAME OF FACILITY

1 SKIP T R W I N C

IV. FACILITY CONTACT

A. NAME & TITLE (last, first, & title)	B. PHONE (area code & no.)
2 R E S E T A R A N D R E W D E S I G N E N G I N E E R	2 1 6 6 9 2 5 4 7 5

V. FACILITY MAILING ADDRESS

A. STREET OR P.O. BOX

3 2 3 5 5 5 E U C L I D A V E N U E

B. CITY OR TOWN	C. STATE	D. ZIP CODE
4 C L E V E L A N D	O H	4 4 1 1 7

VI. FACILITY LOCATION

A. STREET, ROUTE NO. OR OTHER SPECIFIC IDENTIFIER

5 2 3 5 5 5 E U C L I D A V E N U E

B. COUNTY NAME

U Y A G O G A

C. CITY OR TOWN	D. STATE	E. ZIP CODE	F. COUNTY CODE (if known)
6 C L E V E L A N D	O H	4 4 1 1 7	

CONTINUE ON REVERSE

A. FIRST	B. SECOND
7 3724 (specify) Aircraft Engine Components (Metal Finishing)	7 (specify)
C. THIRD	**D. FOURTH**
(specify)	7 (specify)

OPERATOR INFORMATION

A. NAME: TRW INC

B. Is the name listed in Item VIII-A also the owner? [X] YES [ ] NO

C. STATUS OF OPERATOR (Enter the appropriate letter into the answer box; if "Other", specify.)
F = FEDERAL, S = STATE, P = PRIVATE, M = PUBLIC (other than federal or state), O = OTHER (specify)
P (specify)

D. PHONE (area code & no.): A 216 692 5475

E. STREET OR P.O. BOX: 23555 EUCLID AVENUE

F. CITY OR TOWN: CLEVELAND

G. STATE: OH

H. ZIP CODE: 44117

IX. INDIAN LAND

Is the facility located on Indian lands? [ ] YES [X] NO

X. EXISTING ENVIRONMENTAL PERMITS

A. NPDES (Discharges to Surface Water)	D. PSD (Air Emissions from Proposed Sources)
N OH0000281	P NA
B. UIC (Underground Injection of Fluids)	**E. OTHER (specify)**
U NA	9 NA (specify) NA
C. RCRA (Hazardous Wastes)	**E. OTHER (specify)**
R NA	9 NA (specify) NA

MAP

Attach to this application a topographic map of the area extending to at least one mile beyond property boundaries. The map must show the outline of the facility, the location of each of its existing and proposed intake and discharge structures, each of its hazardous waste treatment, storage, or disposal facilities, and each well where it injects fluids underground. Include all springs, rivers and other surface water bodies in the map area. See instructions for precise requirements.

XII. NATURE OF BUSINESS (provide a brief description)

Manufacture aircraft engine components.

XIII. CERTIFICATION (see instructions)

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this application and all attachments and that, based on my inquiry of those persons immediately responsible for obtaining the information contained in the application, I believe that the information is true, accurate and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME & OFFICIAL TITLE (type or print)	B. SIGNATURE	C. DATE SIGNED
F. J. Rechin V.P. & Gen. Mgr., TRW Aircraft Comp. Grp		5/7/83

COMMENTS FOR OFFICIAL USE ONLY

FORM 3 RCRA

EPA

U.S. ENVIRONMENTAL PROTECTION AGENCY

HAZARDOUS WASTE PERMIT APPLICATION

Consolidated Permits Program

(This information is required under Section 3005 of RCRA.)

I. EPA I.D. NUMBER: I O H D 0 0 4 1 7 9 4 5 3

FOR OFFICIAL USE ONLY

APPLICATION APPROVED	DATE RECEIVED (yr., mo., & day)	COMMENTS

II. FIRST OR REVISED APPLICATION

Place an "X" in the appropriate box in A or B below *(mark one box only)* to indicate whether this is the first application you are submitting for your facility or revised application. If this is your first application and you already know your facility's EPA I.D. Number, or if this is a revised application, enter your facility's EPA I.D. Number in Item I above.

A. FIRST APPLICATION *(place an "X" below and provide the appropriate date)*

☐ 1. EXISTING FACILITY *(See instructions for definition of "existing" facility. Complete item below.)*

☐ 2. NEW FACILITY *(Complete item below.)*

FOR EXISTING FACILITIES, PROVIDE THE DATE *(yr., mo., & day)* OPERATION BEGAN OR THE DATE CONSTRUCTION COMMENCED *(use the boxes to the left)*

FOR NEW FACILITIES PROVIDE THE DATE *(yr., mo., & day)* OPERATION BEGAN OR IS EXPECTED TO BEGIN

C	YR.	MO.	DAY
8			

B. REVISED APPLICATION *(place an "X" below and complete Item I above)*

☒ 1. FACILITY HAS INTERIM STATUS

☐ 2. FACILITY HAS A RCRA PERMIT

III. PROCESSES – CODES AND DESIGN CAPACITIES

A. PROCESS CODE – Enter the code from the list of process codes below that best describes each process to be used at the facility. Ten lines are provided for entering codes. If more lines are needed, enter the code(s) in the space provided. If a process will be used that is not included in the list of codes below, then describe the process *(including its design capacity)* in the space provided on the form *(Item III-C)*.

B. PROCESS DESIGN CAPACITY – For each code entered in column A enter the capacity of the process.

1. AMOUNT – Enter the amount.
2. UNIT OF MEASURE – For each amount entered in column B(1), enter the code from the list of unit measure codes below that describes the unit of measure used. Only the units of measure that are listed below should be used.

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Storage:		
CONTAINER *(barrel, drum, etc.)*	S01	GALLONS OR LITERS
TANK	S02	GALLONS OR LITERS
WASTE PILE	S03	CUBIC YARDS OR CUBIC METERS
SURFACE IMPOUNDMENT	S04	GALLONS OR LITERS
Disposal:		
INJECTION WELL	D79	GALLONS OR LITERS
LANDFILL	D80	ACRE-FEET *(the volume that would cover one acre to a depth of one foot)* OR HECTARE-METER
LAND APPLICATION	D81	ACRES OR HECTARES
OCEAN DISPOSAL	D82	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	D83	GALLONS OR LITERS

PROCESS	PROCESS CODE	APPROPRIATE UNITS OF MEASURE FOR PROCESS DESIGN CAPACITY
Treatment:		
TANK	T01	GALLONS PER DAY OR LITERS PER DAY
SURFACE IMPOUNDMENT	T02	GALLONS PER DAY OR LITERS PER DAY
INCINERATOR	T03	TONS PER HOUR OR METRIC TONS PER HOUR; GALLONS PER HOUR OR LITERS PER HOUR
OTHER *(Use for physical, chemical, thermal or biological treatment processes not occurring in tanks, surface impoundments or incinerators. Describe the processes in the space provided; Item III-C.)*	T04	GALLONS PER DAY OR LITERS PER DAY

UNIT OF MEASURE	UNIT OF MEASURE CODE
GALLONS	G
LITERS	L
CUBIC YARDS	Y
CUBIC METERS	C
GALLONS PER DAY	U
LITERS PER DAY	V
TONS PER HOUR	D
METRIC TONS PER HOUR	W
GALLONS PER HOUR	E
LITERS PER HOUR	H
ACRE-FEET	A
HECTARE-METER	F
ACRES	B
HECTARES	Q

EXAMPLE FOR COMPLETING ITEM III *(shown in line numbers X-1 and X-2 below)*: A facility has two storage tanks, one tank can hold 200 gallons and the other can hold 400 gallons. The facility also has an incinerator that can burn up to 20 gallons per hour.

C DUP Y/A C I

LINE NUMBER	A. PROCESS CODE (from list above)	B. PROCESS DESIGN CAPACITY 1. AMOUNT (specify)	2. UNIT OF MEASURE (enter code)	FOR OFFICIAL USE ONLY
X-1	S 0 2	600	G	
X-2	T 0 3	20	E	
1	S 0 2	30,000	G	
2	S 0 2	1,000	G	
	S 0 2	2,000	G	
4	S 0 1	4,400	G	
5	S 0 1	23,100	G	
6	S 0 2	30,000	G	
7	T 0 1	3	U	
8				
9				
10				

CONTINUE ON REVERSE

Continued from the front.

III. PROCESSES *(continued)*

C. SPACE FOR ADDITIONAL PROCESS CODES OR FOR DESCRIBING OTHER PROCESSES *(code "T04")*. FOR EACH PROCESS ENTERED HERE INCLUDE DESIGN CAPACITY.

N/A

IV. DESCRIPTION OF HAZARDOUS WASTES

A. **EPA HAZARDOUS WASTE NUMBER** – Enter the four–digit number from 40 CFR, Subpart D for each listed hazardous waste you will handle. If you handle hazardous wastes which are not listed in 40 CFR, Subpart D, enter the four–digit number*(s)* from 40 CFR, Subpart C that describes the characteristics and/or the toxic contaminants of those hazardous wastes.

B. **ESTIMATED ANNUAL QUANTITY** – For each listed waste entered in column A estimate the quantity of that waste that will be handled on an annual basis. For each characteristic or toxic contaminant entered in column A estimate the total annual quantity of all the non–listed waste*(s)* that will be handled which possess that characteristic or contaminant.

C. **UNIT OF MEASURE** – For each quantity entered in column B enter the unit of measure code. Units of measure which must be used and the appropriate codes are:

ENGLISH UNIT OF MEASURE	CODE	METRIC UNIT OF MEASURE	CODE
POUNDS	P	KILOGRAMS	K
TONS	T	METRIC TONS	M

If facility records use any other unit of measure for quantity, the units of measure must be converted into one of the required units of measure taking into account the appropriate density or specific gravity of the waste.

D. **PROCESSES**

1. PROCESS CODES:
   For listed hazardous waste: For each listed hazardous waste entered in column A select the code*(s)* from the list of process codes contained in Item III to indicate how the waste will be stored, treated, and/or disposed of at the facility.
   For non–listed hazardous wastes: For each characteristic or toxic contaminant entered in column A, select the code*(s)* from the list of process codes contained in Item III to indicate all the processes that will be used to store, treat, and/or dispose of all the non–listed hazardous wastes that possess that characteristic or toxic contaminant.
   Note: Four spaces are provided for entering process codes. If more are needed: (1) Enter the first three as described above; (2) Enter "000" in the extreme right box of Item IV-D(1); and (3) Enter in the space provided on page 4, the line number and the additional code*(s)*.

2. PROCESS DESCRIPTION: If a code is not listed for a process that will be used, describe the process in the space provided on the form.

NOTE: HAZARDOUS WASTES DESCRIBED BY MORE THAN ONE EPA HAZARDOUS WASTE NUMBER – Hazardous wastes that can be described by more than one EPA Hazardous Waste Number shall be described on the form as follows:

1. Select one of the EPA Hazardous Waste Numbers and enter it in column A. On the same line complete columns B,C, and D by estimating the total annual quantity of the waste and describing all the processes to be used to treat, store, and/or dispose of the waste.
2. In column A of the next line enter the other EPA Hazardous Waste Number that can be used to describe the waste. In column D(2) on that line enter "included with above" and make no other entries on that line.
3. Repeat step 2 for each other EPA Hazardous Waste Number that can be used to describe the hazardous waste.

EXAMPLE FOR COMPLETING ITEM IV *(shown in line numbers X-1, X-2, X-3, and X-4 below)* – A facility will treat and dispose of an estimated 900 pounds per year of chrome shavings from leather tanning and finishing operation. In addition, the facility will treat and dispose of three non–listed wastes. Two wastes are corrosive only and there will be an estimated 200 pounds per year of each waste. The other waste is corrosive and ignitable and there will be an estimated 100 pounds per year of that waste. Treatment will be in an incinerator and disposal will be in a landfill.

LINE NO.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (if a code is not entered in D(1))
X-1	K054	900	P	T03 D80	
	D002	400	P	T03 D80	
	D001	100	P	T03 D80	
X-4	D002				included with above

NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

Form Approved OMB No 158 S80004

EPA I.D. NUMBER (enter from page 1)	FOR OFFICIAL USE ONLY
W O H D 0 0 4 1 7 9 4 5 3 — C: 1	W — DUP — C: 2 — DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

No.	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)	D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
1	D 0 0 1	410	T	S 0 2	
2	D 0 0 2	500 *	T	S 0 1	* See Attachment "A"
3	D 0 0 3	670	P	S 0 2 T 0 1	
4	D 0 0 8	5	T	S 0 1	
5					
6					
7					
8					
9					
10					
11					
12					
13					
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18					
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21					
22					
23					
24					
25					
26					

EPA Form 3510-3 (6-80)

CONTINUE ON REVERSE

NOTE: Photocopy this page before completing if you have more than 26 wastes to list.

Form Approved OMB No. 158-S80004

EPA I.D. NUMBER (enter from page 1)		FOR OFFICIAL USE ONLY	
W	1	W DUP	2 DUP

IV. DESCRIPTION OF HAZARDOUS WASTES (continued)

	A. EPA HAZARD. WASTE NO. (enter code)	B. ESTIMATED ANNUAL QUANTITY OF WASTE	C. UNIT OF MEASURE (enter code)	D. PROCESSES 1. PROCESS CODES (enter)				D. PROCESSES 2. PROCESS DESCRIPTION (If a code is not entered in D(1))
1	F002	3200	P	S01				
2	F003	2500	P	S01				
3	F005	4700	P	S01				
4	F006	5900	T	S02				
5	F007	See F006	T	S02				
6	U151	10	P	S01				
7	U159	See F005	P	S01				
8	U160	1	P	S01				
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								

EPA Form 3510-3 (6-80)

CONTINUE ON REVERSE

Continued from the front.

IV. DESCRIPTION OF HAZARDOUS WASTES *(continued)*

E. USE THIS SPACE TO LIST ADDITIONAL PROCESS CODES FROM ITEM D(1) ON PAGE 3.

N/A

EPA I.D. NO. *(enter from page 1)*

F O H D 0 0 4 1 7 9 4 5 3 6

V. FACILITY DRAWING

All existing facilities must include in the space provided on page 5 a scale drawing of the facility *(see instructions for more detail)*.

VI. PHOTOGRAPHS

All existing facilities must include photographs *(aerial or ground—level)* that clearly delineate all existing structures; existing storage, treatment and disposal areas; and sites of future storage, treatment or disposal areas *(see instructions for more detail)*.

II. FACILITY GEOGRAPHIC LOCATION

LATITUDE *(degrees, minutes, & seconds)*	LONGITUDE *(degrees, minutes, & seconds)*
41 34 040	081 31 018

VIII. FACILITY OWNER

[X] A. If the facility owner is also the facility operator as listed in Section VIII on Form 1, "General Information", place an "X" in the box to the left and skip to Section IX below.

B. If the facility owner is not the facility operator as listed in Section VIII on Form 1, complete the following items:

1. NAME OF FACILITY'S LEGAL OWNER	2. PHONE NO. *(area code & no.)*
E N/A	

3. STREET OR P.O. BOX	4. CITY OR TOWN	5. ST.	6. ZIP CODE
F	G		

IX. OWNER CERTIFICATION

I certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached documents, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the submitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

A. NAME *(print or type)*	B. SIGNATURE	C. DATE SIGNED
F. J. Rechin V.P. & Gen. Mgr., TRW Aircraft Comp. Grp.		5/9/83

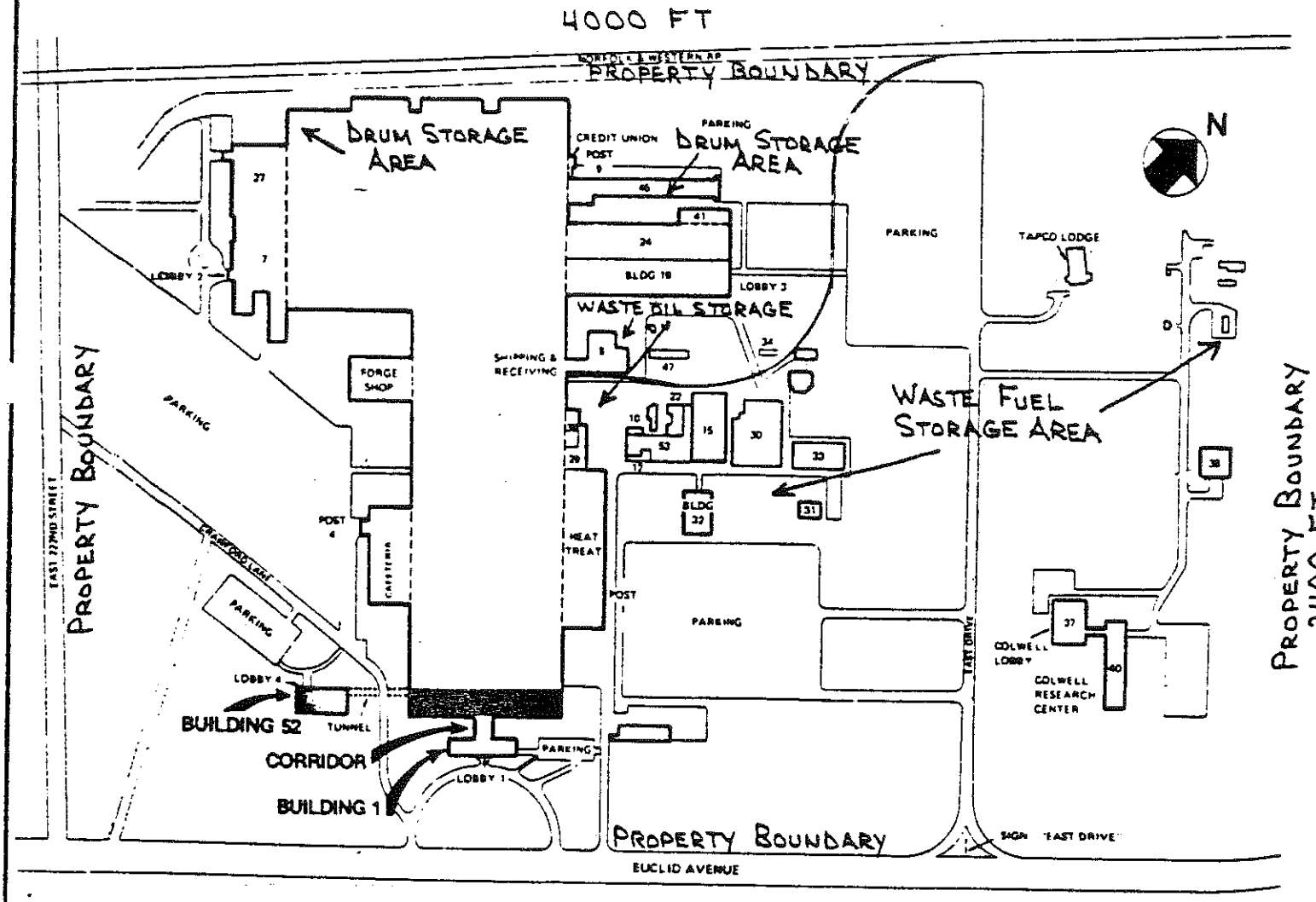
X. OPERATOR CERTIFICATION

certify under penalty of law that I have personally examined and am familiar with the information submitted in this and all attached uments, and that based on my inquiry of those individuals immediately responsible for obtaining the information, I believe that the mitted information is true, accurate, and complete. I am aware that there are significant penalties for submitting false information, cluding the possibility of fine and imprisonment.

A. NAME *(print or type)*	B. SIGNATURE	C. DATE SIGNED
F. J. Rechin V.P. & Gen. Mgr., TRW Aircraft Comp. Grp.		5/9/83

CONTINUE ON PAGE 5

TRW EUCLID PROPERTY



TRW
GENERAL OFFICES

November 14, 1980

ATTACHMENT "A"

Y. J. Kim
EPA Region V
RCRA Activities
P.O. Box 7861
Chicago, Illinois 60680

Please be advised that a solid corrosive material is generated from metal finishing operations at this plant. This statement is intended to notify you that an appropriate EPA Hazardous Waste Number is not included in Part 261. The estimated annual quantity of this waste is 250 tons.

TRW Aircraft Components Group
23555 Euclid Avenue
Cleveland, OH 44117

June 6, 1983

Mr. T. Crepeau
Division of Permits and Manifest Records
P. O. Box 1049
361 East Broad Street
Columbus, Ohio 43215

Dear Mr. Crepeau:

The original Resource Conservation and Recovery Act (RCRA) Part A permit application included information regarding a waste treatment system located at TRW's Euclid, Ohio facility (Items 1 through 10, inclusive, Page 1 of 5). This waste treatment system treats acid, alkali, chromium and cyanide wastes generated by electroplating and metal finishing operations. Due to revisions in RCRA and the fact that the waste treatment system's discharge is regulated by a National Pollutant Discharge Elimination System permit (OH0000281), said information has been removed from the Part A application.

The following revisions were also made to the application:

1) Removed information regarding a 1, 1, 1 - trichloroethane still recovery/recycling system (Section III C, Page 2 of 5).

2) Added D008 hazardous waste (Item 4, Page 3 A of 5).

3) Increased amount of "D002" solid corrosive material (Item 2, Page 3A of 5).

4) Added a hazardous waste storage area (Item 5, Page 1 of 5).

5) Added treatment rate for Otto fuel dewatering tank (Item 7, Page 1 of 5).

6) Removed treatment designation from Item 1, Page 3A of 5 since material is beneficially reused.

The amended application is hereby submitted for your records. Please advise me if you have any questions.

Respectfully,

Andrew L. Resetar

Andrew L. Resetar
Plant Engineering Department

Attachment
cc: RCRA Activities
USEPA
Region V

ALR/i

BUILDING 49 STUDY

ASSESSMENT OF SOIL CONTAMINATION AND POTENTIAL CONTAMINANT MIGRATION

prepared for TRW, Inc.

Lyndhurst, Ohio

Engineering-Science Inc.
19101 Villaview Road
Cleveland, Ohio 44119

BUILDING 49 STUDY
ASSESSMENT OF SOIL CONTAMINATION AND POTENTIAL CONTAMINANT MIGRATION

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BUILDING 49 STUDY
ASSESSMENT OF SOIL CONTAMINATION AND POTENTIAL CONTAMINANT MIGRATION

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1. INTRODUCTION

TRW, Inc. retained Engineering-Science (ES) to determine the extent of previously unsuspected discharges from the Building 49 Torpedo Test facilities. Soil sampling in support of this began in October 1985 and continued through several stages through October of 1986. TRW also authorized a coordinated assessment of potential effects of those discharges on surface water and ground water. This report summarizes the results of those studies and ES' recommendations for remedial action.

1.1 Background and Site Conditions

TRW, Inc. conducted torpedo engine testing in Building 49, in the southeastern portion of its former TAPCO complex in Euclid, Ohio. Waste water resulting from test firing activities has been discharged through a 1,000 gallon underground steel separator tank, which was designed to remove and collect liquid residues of the torpedo fuel. The overflow from this tank discharged through an underground pipeline onto the soil in an undeveloped area about 100 feet southeast from the building. Modifications of the facilities in Building 49 have been installed, and further discharges of the fuel residue have been eliminated. Torpedo testing activities are being transferred to new facilities elsewhere on the TAPCO complex.

The affected area is shown in relation to Building 49 in Figure 1. (See also appended Drawings 1 and 2.) The now-discontinued discharges were released from an underground pipe in a flat undeveloped area to the southeast of Building 49, bounded on its north by the torpedo test area fence and by woods on its other sides. The area is ponded over much of the year and has typical swamp vegetation. Field activities have shown that the poor drainage is attributable to a layer of low permeability clay (10^{-6} to 10^{-8} cm/sec) which was found typically about 3 feet below the surface.

Run-on from the soil mound (explosion barrier for the torpedo testing) flows southeastward across the former discharge zone and drains southward through the runoff stream, as indicated on Drawing 2. Additional run-on from wooded areas to the north and east drains through the area immediately to the southeast of the former discharge zone, and into the same runoff stream.

During the summer months there was additional run-on due to daytime flows of 12 - 15 gpm city water through the Building 49 air conditioning unit, which discharged by pipeline in a wooded area to the northeast of the building. (Analysis of the air conditioner effluent showed no detectable concentrations of cyanides.)

The runoff stream flows southward through a wooded strip and emerges into a cleared area adjoining the roadway. A sorbent boom has been placed across the stream at the edge of the woods. From there, the stream discharges through a corrugated steel culvert (which is half filled with sediments), enters a drainage swale paralleling the roadway,

then crosses under the roadway through a culvert, and discharges directly into a catch basin for the storm sewers. The 30-inch storm sewer serving the eastern part of the property proceeds westward about 300 ft to join other storm drains, and then along a northwesterly alignment to discharge into a culvert at the property line.

1.2 Nature of the Chemicals Discharged

The torpedo fuel, Otto Fuel II, is a liquid mixture consisting of about 76% propylene glycol dinitrate (PGDN), 22.5% di n-butyl sebacate and 1.5% 2-nitro diphenyl amine, which is stable at ambient pressures and temperatures. The fuel is heavier than water (specific gravity = 1.23) and is essentially immiscible with water. It is not volatile. (The vapor pressure is 0.09 mm of mercury at 77 F.)

Physical exposure by absorption through the skin or by ingestion is known to cause severe headaches, but definitive toxicity data are not available. Otto Fuel is considered hazardous, subject to liquid hazard classification Group 1 (combustible, but low fire hazard, with flash point 265 F) and compatibility Group G (not to be stored near other hazardous materials). [1] However, it is not flammable according to U.S Department of Transportation or RCRA (Resource Conservation and Recovery Act) criteria since the flash point exceeds 140 F.

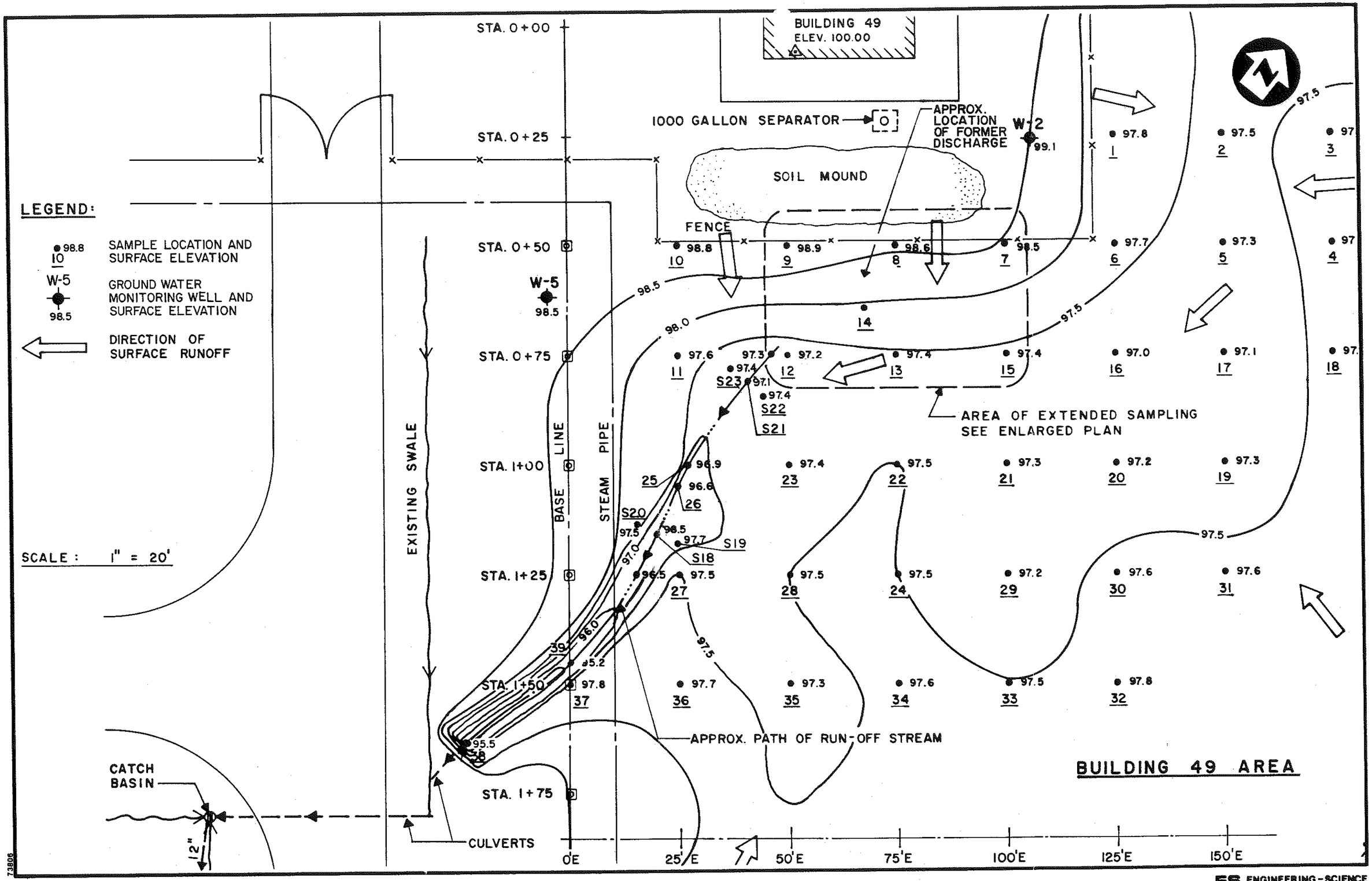
Waste water discharges to the separator were intermittent, mainly in 200 to 300 gallon batches during and shortly after a torpedo test firing. Normally the separator tank removed the liquid fuel residue effectively. It was not previously suspected that turbulence at high flow rates through the tank entrained droplets of fuel residue into the former discharge pipe. This was confirmed during actual test firings in July 1985.

Exhaust gases from torpedo test firings were vented to the atmosphere through 4 inch diameter stacks, about 20 feet above ground level. The exhaust gases typically contained low concentrations of hydrogen cyanide and ammonia resulting from incomplete combustion of Otto Fuel. Any condensate droplets in the exhaust gas would have discharged into drainage piping leading to the separator tank for waste water discharges. Cyanides were present in the discharges from the separator tank as a result of this. Analysis of grab samples taken at the former discharge pipe, authorized by TRW prior to this study, showed concentrations of 3 to 26 mg/L of total cyanide.

1.3 Scope of Studies

The Building 49 study consisted of coordinated soil sampling, surface water monitoring and ground water monitoring activities. The methods of investigation and the principal findings for these phases of the study are reported in Sections 3, 4 and 5, respectively. The methods for chemical analysis of samples from all phases of the study are presented in Section 2. The results are reviewed in Section 6, and recommendations are presented for closure of the discharge area and the Building 49 site.

FIGURE I



ES ENGINEERING-SCIENCE

2. METHODS OF CHEMICAL ANALYSIS

All samples in this study were transported to Wadsworth/Alert Laboratories, Canton, Ohio for analysis. Their reports are appended. Wadsworth has been designated by the U.S. Environmental Protection Agency as a Contract Laboratory Procedures facility for analysis of soil samples. Wadsworth has also been certified by the Ohio Environmental Protection Agency for analysis of water and wastewater.

2.1 Otto Fuel

The analysis for propylene glycol dinitrate (PGDN), the principal ingredient of Otto Fuel II, consisted of an acetone extraction followed by gas-liquid chromatography using a flame ionization detector. Otto Fuel II, nominally containing 76% PGDN, was used as a standard for calibration.

The detection limit for PGDN in a soil sample was 300 mg/kg for the initial sampling. This was improved to 25 mg/kg for the later soil samples and 125 mg/kg in a sample of suspect vegetation. The detection limit for PGDN in sediment samples varied from 60 to 80 ug/L, depending on sample size.

TRW authorized development of this analytical technique by Wadsworth, in conjunction with this study. The only other known analytical method is a wet-chemical technique [1], which has much higher detection limits.

2.2 Cyanide

The cyanide analysis used the "total" cyanide technique (EPA Method 9010: acidification, volatilization and alkaline absorption), which is the standard for soil, sediment and solid waste samples. [2] The detection limit was 0.25 mg/kg of cyanide for soil samples and 0.005 mg/L for water samples. This method is quantitative for all forms of cyanide except the essentially non-toxic complexes of iron and cyanide.

2.3 Sample Preservation and Preparation

Soil core samples were taken in carbon steel pipes, sealed at the site, and transported to the laboratory by Engineering-Science. Chain-of-custody documentation was provided, although not formally required for the study.

Upon arrival at the laboratory, selected cores were cut to provide samples representing desired depth intervals. The soil core samples that were not analyzed initially were retained at the laboratory and stored in a cold room for possible later analysis, pending the results for other related samples.

"Clean" Soil criteria
(p. 11-1)
CN 10 mg/kg
PGDN ND @ 25 mg/kg

3. DIRECTED SOIL SAMPLING PROGRAM

Soil in and near the former discharge area was sampled on four occasions between October 1985 and October 1986. The sample locations and analytical data are summarized in Table 1 and Figures 2 through 4. (Also see appended Drawings 3 through 5.) The principal findings are as follows:

- @ An irregularly shaped area surrounding the former discharge pipe has Otto Fuel residue present at the surface (in the top 1 ft) at concentrations of 150 to 4,900 mg/kg of PGDN and Total Cyanide at concentrations of 5 to 50 mg/kg.

- @ PGDN was found at only one location below the top 1 ft, i.e., at the former discharge pipe outlet. Here, 80 mg/kg of PGDN was found in a composite sample from a 2 ft depth to the bottom of the core.

- @ At specific isolated locations in the runoff stream, 30 to 70 feet from the former discharge pipe, soil in the top 1 ft was found containing 89 to 240 mg/kg of PGDN and/or 5 to 20 mg/kg of Total Cyanide. (See Figure 4 and appended Drawing 3.)

- @ Cyanide was also found in the top 1 ft of soil at detectable but low concentrations, typically about 1 mg/kg, along a narrow belt of adjoining sampling stations, located to the south and east of Building 49 at distances of 75 to 175 ft. Cyanide also was detected at concentrations of about 1 mg/kg, in the top 1 ft or 2 ft of the soil, at isolated locations to the west and northwest of Building 49.

- @ Cyanide was detected below the top 1 ft of soil at or near the same sample locations (that had detectable cyanides in the top 1 ft), generally at lower concentrations than at the surface. However, three isolated sample locations along the belt of stations to the south and east of Building 49 had their highest cyanide concentrations (of 1.4 to 4 mg/kg) at the bottom.

It is believed that the Otto Fuel residue droplets settled rapidly after being released in the area near the former discharge pipe outlet and were absorbed by surface soil particles. Occasionally, isolated particles of soil were eroded, which mobilized small quantities of PGDN. However, Cyanides in the torpedo test waste water discharges, being soluble, spread over a larger area. Cyanides would be mobilized either by erosion or by leaching.

Cyanides in the belt to the south and east of Building 49 are attributed to deposition by downwash of exhaust gases vented during the torpedo testing.

A narrative of the soil sampling methods and the tentative findings at each stage follows.

3.1 October 1985 Soil Sampling

The initial sampling had as its objectives to confirm that discharges of torpedo fuel residue and cyanides had occurred, and to indicate whether either or both of these chemicals had spread away from the former discharge pipe. This sampling utilized hand augers and was limited to the top three feet. Most of the sample locations were ponded over at the time.

At the former discharge pipe, PGDN concentrations of 800 to 1300 mg/kg were found, along with Total Cyanide at 3 to 11 mg/kg. Both chemicals were present in the samples representing the top 1 ft, the second 1 ft, and the third 1 ft. This apparent vertical migration may have been due to movement of material from the surface into the lower samples, which could not have been prevented under the field conditions.

Cyanide was found at a location near the runoff stream, at concentrations of 11 mg/kg in the top 1 ft and at 1 to 2 mg/kg in the next 2 ft below that. Cyanide also was detected at 0.9 mg/kg in the top 1 ft at a location to the southeast of the former discharge pipe.

Samples also were collected at this time at two suspected spill locations at the northeast corner of the torpedo test complex. PGDN was not detected in either of these samples. However, cyanide was present at concentrations of 4 to 6 mg/kg.

3.2 May and August 1986 Soil Samplings

TRW authorized additional soil sampling and a survey of the area, in order to define both the vertical and the lateral extent of soil contamination. In order to ensure personnel safety, (See Appendix A, ES Health and Safety Report for this project) the sampling used a rig which could be operated some distance away from the former discharge area, on dry ground. The rig locations are noted on appended Drawing 1.

The sampling rig was a modified sheet piling driver, attached to a crane. Sample cores were obtained by driving a steam cleaned 10 foot length of 3 inch carbon steel pipe to refusal (typically 4 to 7 feet), withdrawing the pipe and sealing the ends. This effectively eliminated cross contamination (between samples representing different depths). The core hole was refilled with powdered bentonite.

During the week of 31 March - 4 April 1986, 39 locations southeast of Building 49 were sampled, most of them within the ponded area, on the 25 ft center grid shown on Figure 1 and the appended drawings. Four of these samples (25, 26, 38 and 39) were from points in the runoff stream.

Concentrations of 1600 mg/kg PGDN and 5.7 mg/kg CN were found at the surface near the former discharge pipe (Sample 14), confirming the previous results. However, neither chemical was detected in the bottom 1 ft of that sample core. PGDN was also found at a concentration of 89 mg/kg in the top 1 ft of sediments, at a pool in the runoff stream (Sample 26). Cyanide was detected at these points and at several other locations, either at the surface or at the bottom of the core.

During the 4 - 7 August 1986 period, 29 additional points (S-1 through S-29) were sampled, most of these being on a 5 ft center grid superimposed on the coarser grid in the vicinity of the former discharge pipe. (See Figure 2 and the inset on appended Drawings 2 through 7.) Two points in the runoff stream and four locations on the adjoining banks (S-18 through S-23) were included in this sampling. Selected cores were analyzed sequentially, starting with the top 1 ft section and in some cases continuing with the next lower 1 ft section and a composite of the remaining material below 2 ft.

PGDN and Cyanide were found in the top 1 ft at several sample locations near the former discharge pipe. PGDN concentrations there ranged from 150 to 3900 mg/kg, and Cyanide ranged from 5 to 50 mg/kg. PGDN was detected below the top 1 ft in only one of the sample cores (S-29),at the same location that had the highest surface PGDN concentration. Cyanide was detected below the top 1 ft at the locations near the former discharge pipe, at concentrations of about 1 mg/kg.

3.3 October 1986 Soil Sampling

Another nine soil core samples (T-3 through T-11) were collected on 16 October 1986, at locations on an extension of the 5 ft center grid eastward from the former discharge pipe. (See Figure 2 and the inset on appended Drawings 2 through 7.) These additional soil cores were collected by a modified Shelby Tube method, using 3 ft lengths of 2 inch black iron pipe threaded on one end. The pipe was driven into the ground with a sledge to a depth of 2-3 feet and manually withdrawn. The pipe ends were closed with plastic immediately after collection of the sample. The pipe was cleaned with detergent solution and pressurized water spray before sample collection.

Samples were analyzed from the four points closest to the August samples, about 20 ft to the east of the former discharge. PGDN was not detected in any of these cores. The cyanide concentrations were 5 to 15 mg/kg in the top 1 ft of soil, but less than 1 mg/kg for depths of 1 ft-2 ft.

3.4 September 1986 Well Installation

Five wells were installed during the week of 5 to 8 September 1986, for the ground water monitoring activities discussed in Section 5. The wells were located 25 to 75 feet beyond the area of soil sampling of the former discharge area (see appended Drawing 1). During the well installation, the augers were cleaned between holes to eliminate cross-contamination. Undisturbed Shelby-tube samples of the unconsolidated sediments (W-1 through W-5) were obtained at shallow intervals. Generally, one tube was obtained for the 1 ft -3 ft interval and another tube for the 3 ft - 5 ft interval.

All of the Shelby tube samples were analyzed for Total Cyanide. It was found at the three northerly well locations, at concentrations of 1 to 2 mg/kg, at the 1 ft - 3 ft level. It was not detected below that depth. Sediment samples from Wells W-2 and W-3 were also analyzed for PGDN, based on the field observation that the silty clays just above bedrock appeared to be stained dark gray to black; the PGDN

concentrations were below the detection limit of 25 mg/kg in both of those samples.

3.5 Spreading of PGDN and Cyanides from the Former Discharge Area

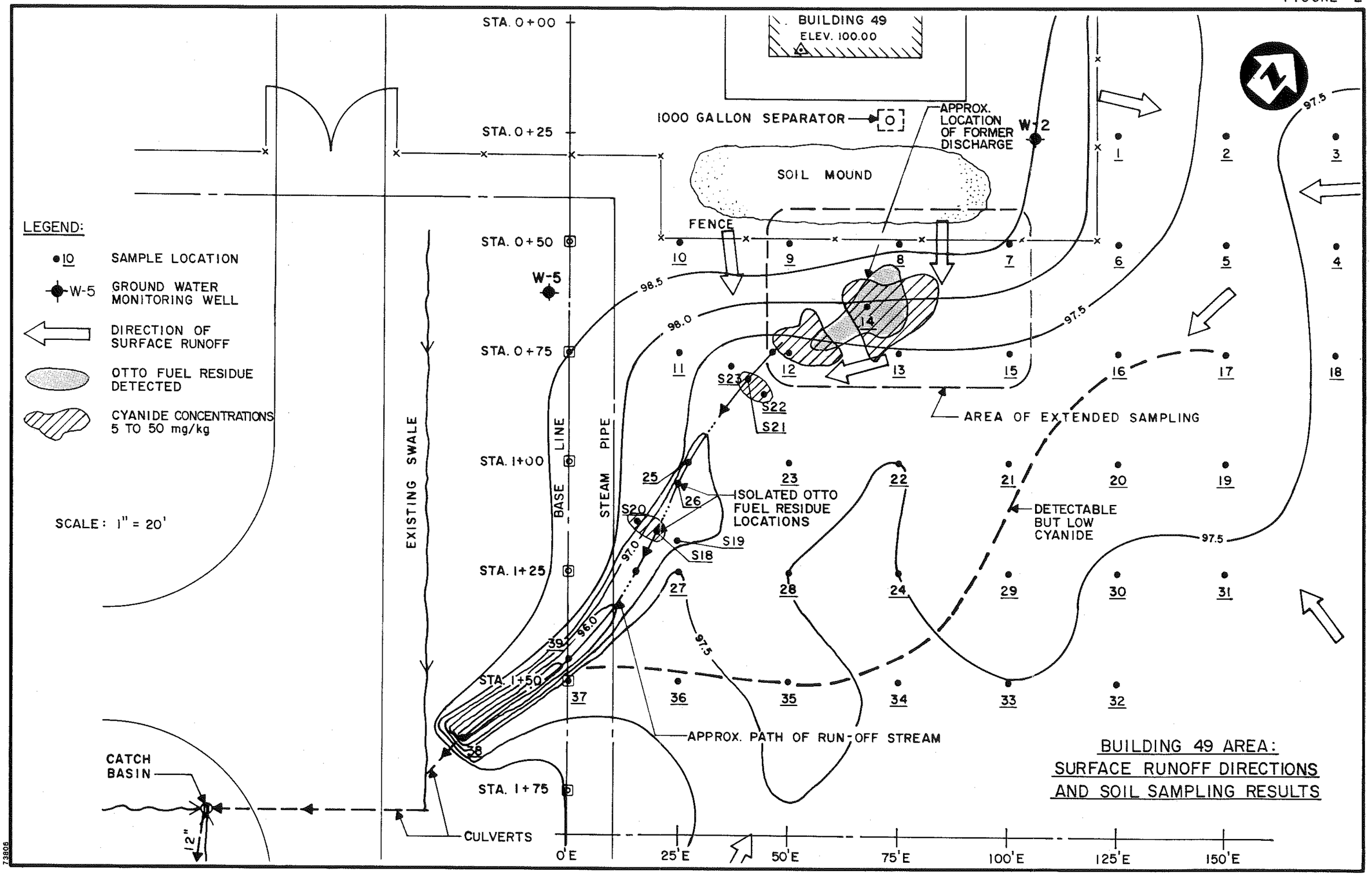
Figures 2 and 3 indicate the results of the soil sampling. The highest concentrations of Otto Fuel residue and cyanides are in an irregularly shaped area surrounding the former discharge pipe. Somewhat lower concentrations were found in the runoff stream, at specific isolated locations 30 to 70 feet away from there.

Detectable PGDN concentrations (solid lines in Figure 3) cover a portion of the area of highest concentrations, approximately on the path for drainage between the former discharge pipe and the runoff stream. It is believed that Otto Fuel residue droplets settled rapidly after discharge and were absorbed by surface soil particles. This essentially immobilized the water-immiscible fuel components, except for occasional isolated instances of erosion. Runoff from the soil mound to the northwest flowing directly over the discharge area could dislodge soil particles containing PGDN, carrying and depositing them into the runoff stream.

Detectable cyanide concentrations (dashed lines) near the former discharge pipe cover a larger area than PGDN. Soluble cyanides are spread over a larger area, having been mobilized either by erosion or by leaching. Cyanides also are subject to volatilization, chemical destruction and microbiological degradation, which may account for the presence of two zones of cyanide concentrations exceeding 5 to 10 mg/kg, one zone at the former discharge area and another zone further northeast.

Cyanide was also found at detectable but low concentrations, typically about 1 mg/kg, along a narrow belt of adjoining sampling stations, 75 to 175 ft. to the south and east of Building 49, and at isolated locations to the west and northwest of Building 49. This is attributed to deposition of atmospheric cyanides by downwash of exhaust gas vented during the torpedo test firings. The cyanides at these locations would be subject to mobilization by leaching and to the degradation mechanisms noted above.

Subsurface cyanide concentrations generally decreased with depth below the surface and were found only at or adjoining locations with detectable surface cyanide concentrations. However, three isolated sample locations along the belt to the south and east of Building 49 had their highest cyanide concentrations (of 1.4 to 4 mg/kg) at the bottom of the soil core.


BUILDING 49
ELEV. 100.00
1000 GALLON SEPARATOR
APPROX. LOCATION OF FORMER DISCHARGE
W-2
SOIL MOUND
FENCE
STA. 0+00
STA. 0+25
STA. 0+50
STA. 0+75
STA. 1+00
STA. 1+25
STA. 1+50
STA. 1+75
W-5
LEGEND:
SAMPLE LOCATION
GROUND WATER MONITORING WELL
DIRECTION OF SURFACE RUNOFF
OTTO FUEL RESIDUE DETECTED
CYANIDE CONCENTRATIONS 5 TO 50 mg/kg
SCALE: 1" = 20'
EXISTING SWALE
BASE LINE
STEAM PIPE
AREA OF EXTENDED SAMPLING
ISOLATED OTTO FUEL RESIDUE LOCATIONS
DETECTABLE BUT LOW CYANIDE
APPROX. PATH OF RUN-OFF STREAM
CATCH BASIN
12"
CULVERTS
98.5
98.0
97.5
97.0
96.0
0'E
25'E
50'E
75'E
100'E
125'E
150'E
BUILDING 49 AREA:
SURFACE RUNOFF DIRECTIONS
AND SOIL SAMPLING RESULTS

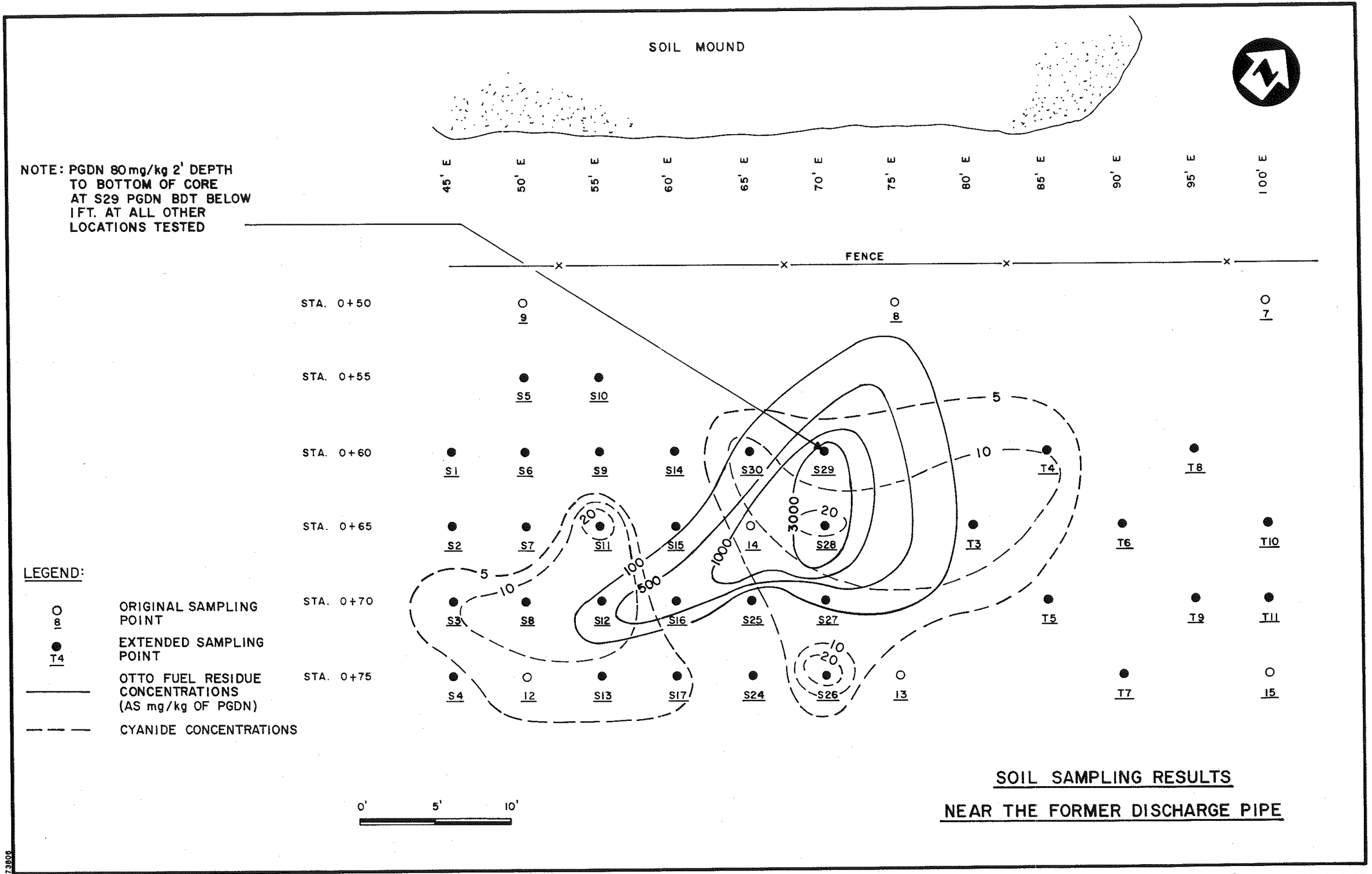
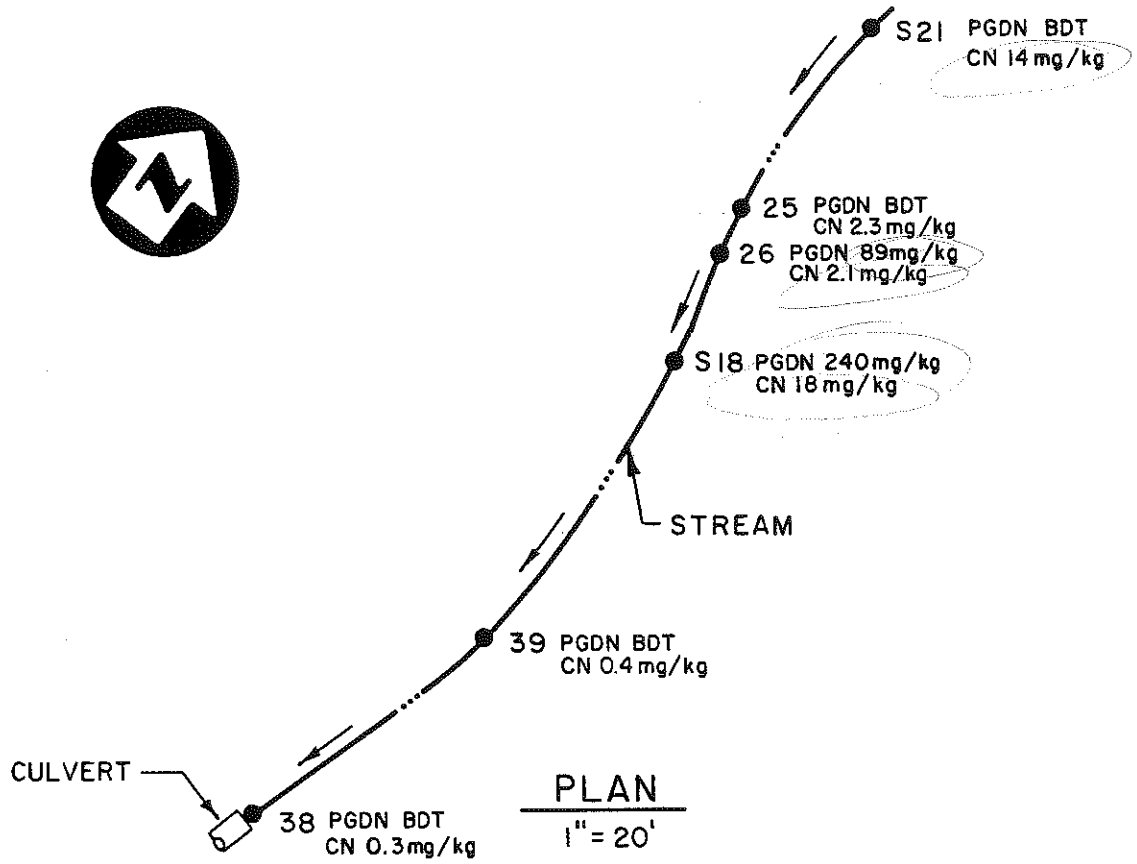
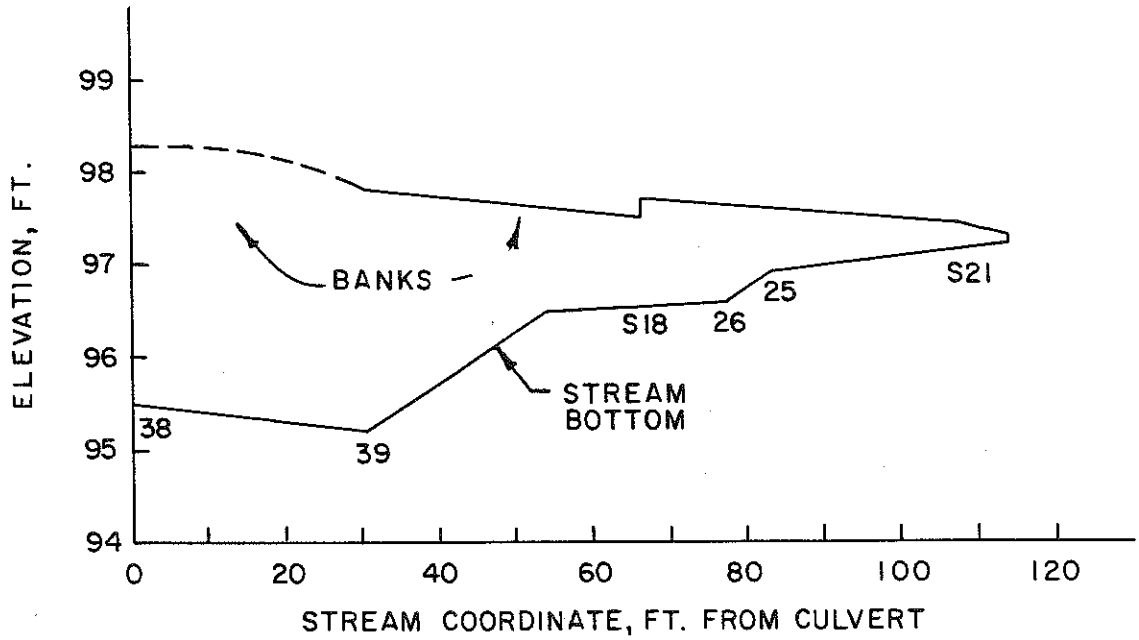

SOIL MOUND
NOTE: PGDN 80 mg/kg 2' DEPTH TO BOTTOM OF CORE AT S29 PGDN BDT BELOW 1 FT. AT ALL OTHER LOCATIONS TESTED
45' E
50' E
55' E
60' E
65' E
70' E
75' E
80' E
85' E
90' E
95' E
100' E
FENCE
STA. 0+50
STA. 0+55
STA. 0+60
STA. 0+65
STA. 0+70
STA. 0+75
9
8
7
S5
S10
S1
S6
S9
S14
S30
S29
T4
T8
S2
S7
S11
S15
14
S28
T3
T6
T10
S3
S8
S12
S16
S25
S27
T5
T9
T11
S4
12
S13
S17
S24
S26
13
T7
15
5
10
20
100
500
1000
3000
LEGEND:
ORIGINAL SAMPLING POINT
EXTENDED SAMPLING POINT
OTTO FUEL RESIDUE CONCENTRATIONS (AS mg/kg OF PGDN)
CYANIDE CONCENTRATIONS
0'
5'
10'
SOIL SAMPLING RESULTS
NEAR THE FORMER DISCHARGE PIPE

FIGURE. 4



PLAN

1" = 20'



PROFILE

BUILDING 49 SOIL SAMPLING

RUNOFF STREAM PROFILE AND PLAN

ES ENGINEERING—SCIENCE

Table 1

Summary of Building 49 Soil Sampling

Sample No.	Analytical Results (mg/kg) Top 1 ft CN	Top 1 ft PGDN	Bottom 1 ft CN	Bottom 1 ft PGDN	Locations (ft) Surface Elev.	Coordinates North	Coordinates East	Core Length (ft) as Driven	Compac -ted
1	BDT	BDT	BDT	BDT	97.8	25	125	5.7	4.8
2	BDT	BDT	BDT	BDT	97.5	25	150	5.3	4.4
3	BDT	BDT	BDT	BDT	97.6	25	175	4.9	5.0
4	BDT	BDT	BDT	BDT	97.7	50	175	4.5	3.8
5	BDT	BDT	BDT	BDT	97.3	50	150	4.7	4.1
6	BDT	BDT	BDT	BDT	97.7	50	125	5.3	5.2
7	BDT	BDT	BDT	BDT	98.5	50	100	6.3	4.7
8	BDT	BDT	BDT	BDT	98.6	50	75	5.9	4.0
9	BDT	BDT	BDT	BDT	98.9	50	50	6.4	4.8
10	1.2	BDT	BDT	BDT	98.8	50	25	5.7	3.8
11	0.8	BDT	BDT	BDT	97.6	75	25	4.9	4.5
12	7.4	BDT	BDT	BDT	97.2	75	50	5.3	4.6
13	0.9	BDT	BDT	BDT	97.4	75	75	4.9	3.9
14	5.7	1600	BDT	BDT	97.4	65	65	5.3	4.9
15	BDT	BDT	BDT	BDT	97.4	75	100	5.0	4.4
16	0.3	BDT	0.5	BDT	97.0	75	125	5.3	5.0
17	0.7	BDT	BDT	BDT	97.1	75	150	5.6	4.4
18	BDT	BDT	BDT	BDT	97.6	75	175	5.1	4.3
19	BDT	BDT	BDT	BDT	97.3	100	150	4.5	3.9
20	BDT	BDT	1.4	BDT	97.2	100	125	4.8	4.0
21	0.3	BDT	0.3	BDT	97.3	100	100	4.6	4.0
22	BDT	BDT	BDT	BDT	97.5	100	75	4.7	4.2
23	BDT	BDT	BDT	BDT	97.4	100	50	4.3	4.1
24	BDT	BDT	BDT	BDT	97.5	125	75	4.4	3.7
* 25	2.3	BDT	BDT	BDT	97.7	100	25	4.3	3.9
* 26	2.1	89	0.5	BDT	96.6	105	25	4.0	4.0
27	BDT	BDT	BDT	BDT	97.5	125	25	4.5	3.7
28	BDT	BDT	BDT	BDT	97.5	125	50	4.7	3.7
29	0.3	BDT	BDT	BDT	97.2	125	100	4.4	3.5
30	BDT	BDT	BDT	BDT	97.6	125	125	4.6	3.6
31	BDT	BDT	1.0	BDT	97.6	125	150	4.8	3.5
32	BDT	BDT	BDT	BDT	97.8	150	125	4.6	3.5
33	BDT	BDT	BDT	BDT	97.5	150	100	5.0	4.0
34	0.3	BDT	2.8	BDT	97.6	150	75	5.8	4.0
35	0.4	BDT	0.3	BDT	97.3	150	50	4.6	4.0
36	BDT	BDT	BDT	BDT	97.7	150	25	4.7	3.6
37	0.7	BDT	0.3	BDT	97.8	150	0	7.3	7.7
* 38	0.3	BDT	BDT	BDT	95.5	163	-25	4.8	4.6
* 39	0.4	BDT	3.9	BDT	95.2	145	0	5.6	4.8

* = stream sampling point -- = not analyzed
BDT = below detection limits: 0.25 mg/kg Total CN and 25 mg/kg PGDN
Datum for elevations 100.0 ft = floor level in Building 49

Table 1 (continued)

Summary of Building 49 Soil Sampling

Sample No.	Analytical Results (mg/kg) Top 1 ft CN	Top 1 ft PGDN	1 ft-2 ft CN	1 ft-2 ft PGDN	Below 2 ft CN	Below 2 ft PGDN	Locations (ft) Surface Elev.	Coordinates North	Coordinates East	Core Length (ft) as Driven	Core Length (ft) Compac-ted
S-1	--	--	--	--	--	--	97.6	60	45	6.0	4.8
S-2	4.3	--	--	--	--	--	97.4	65	45	5.8	5.3
S-3	9.5	BDT	4.3	--	--	--	97.2	70	45	5.2	4.8
S-4	0.95	BDT	1.4	--	--	--	97.2	75	45	5.3	4.8
S-5	--	--	--	--	--	--	98.1	55	50	6.2	4.3
S-6	--	--	--	--	--	--	97.6	60	50	5.6	4.8
S-7	1.4	BDT	--	--	--	--	97.3	65	50	5.5	4.8
S-8	13	BDT	1.5	BDT	--	--	97.2	70	50	5.8	4.8
S-9	1.5	BDT	--	--	--	--	97.5	60	55	6.2	5.0
S-10	--	--	--	--	--	--	98.1	55	55	7.7	7.7
S-11	26	BDT	--	--	--	--	97.3	65	55	5.7	4.7
S-12	15	480	1.2	BDT	--	--	97.3	70	55	5.0	4.4
S-13	6.3	BDT	1.5	BDT	--	--	97.3	75	55	5.2	4.8
S-14	1.5	BDT	0.74	BDT	--	--	97.6	60	60	5.7	4.0
S-15	0.9	BDT	0.61	BDT	--	--	97.3	65	60	5.6	5.0
S-16	2.0	800	0.58	BDT	--	--	97.3	70	60	5.6	4.6
S-17	6.0	BDT	--	--	--	--	97.4	75	60	5.1	4.1
* S-18	18	240	1.0	BDT	--	--	96.5	116	20	4.2	4.2
S-19	--	--	--	--	--	--	97.7	118	24	n/a	n/a
S-20	6.1	BDT	BDT	BDT	--	--	97.5	114	16	5.8	6.5
* S-21	14	BDT	2.1	--	--	--	97.1	81	42	4.9	4.0
S-22	4.7	BDT	1.4	--	--	--	97.4	84	45	5.2	4.9
S-23	1.1	BDT	0.81	--	--	--	97.4	78	38	4.4	4.1
S-24	1.1	BDT	--	--	--	--	97.1	75	65	5.0	4.4
S-25	3.8	BDT	0.52	BDT	--	--	97.3	70	65	5.2	4.2
S-26	40	BDT	--	--	--	--	97.4	75	70	5.2	4.8
S-27	7.2	150	--	BDT	--	--	97.3	70	70	5.7	5.2
S-28	54	3600	1.4	BDT	1.5	BDT	97.5	65	70	5.6	4.8
S-29	5.5	4900	0.77	BDT	BDT	80	97.7	60	70	6.2	5.9
S-30	11	150	0.73	BDT	--	--	97.6	60	65	6.0	5.4
T-3	14	BDT	0.66	BDT	--	--	97.5	65	80	>2.0	
T-4	9.1	BDT	BDT	BDT	--	--	97.6	60	85	>1.5	
T-5	4.7	BDT	0.54	BDT	--	--	97.3	70	85	>2.0	
T-6	--	BDT	--	BDT	--	--	97.5	65	90	>2.0	
T-7	1.2	BDT	0.93	BDT	--	--	97.5	75	90	>2.0	
T-8	--	BDT	--	BDT	--	--	97.7	60	95	>1.5	
T-9	--	BDT	--	BDT	--	--	97.2	70	95	>2.0	
T-10	--	BDT	--	BDT	--	--	97.6	65	100	>2.0	
T-11	--	BDT	--	BDT	--	--	97.6	70	100	>2.0	
W-1	--	--	BDT	--	BDT	--	97.7	198	123	4.5	
W-2	--	--	2.0	BDT	BDT	BDT	99.1	25	106	5.5	
W-3	--	--	--	--	2.0	BDT	98.9	-63	-5	6.0	
W-4	--	--	BDT	--	BDT	--	98.3	212	19	5.5	
W-5	--	--	1.2	BDT	BDT	BDT	98.5	63	-5	6.5	

* = stream sampling point -- = not analyzed n/a = core not recovered
BDT = below detection limits: 0.25 mg/kg Total CN and 25 mg/kg PGDN
Datum for elevations 100.0 ft = floor level in Building 49

4. SURFACE WATER STUDY

In August 1986 TRW authorized a study to assess potential migration of PGDN and Cyanide from the original affected area near Building 49 through surface water and ground water. This section deals with the assessment for surface water movement.

Table 2 summarizes the surface water monitoring and associated chemical analysis data. The principal findings with respect to surface water are as follows:

- @ Isolated and occasional soil particles containing Otto Fuel residue (mainly PGDN) have migrated out of the immediately affected area through the runoff stream and have entered the storm sewer system.

- @ The runoff stream also contains detectable but low concentrations of Cyanide, typically not exceeding 1 mg/L.

Details follow on the studies that led to these findings.

4.1 Surface Water Runoff Monitoring

The runoff stream flow exiting from the swampy area south of Building 49 was monitored twice during September 1986, first during a low flow period after extended dry weather on 16 September, and a second time on 24 September, several hours after a moderate rain. The flow at the first culvert was measured with a portable weir on both occasions, and multiple grab samples were collected and field composited for Total Cyanide analysis. (The PGDN concentrations would have been below the detection limit of 25 mg/kg, since it is not miscible with water.)

The dry weather monitoring showed total flow of the runoff stream less than 3 gallons/day, but with a Total Cyanide concentration of 1.2 mg/L. After a moderate rainfall, the runoff stream flow was measured at about 1760 gal/day, with a Total Cyanide concentration of 0.24 mg/L.

The Building 49 air conditioning discharge flow was also monitored on the same dates. At the entry to the pipeline that discharges the air conditioning effluent into the wooded area to the east of the building, the observed flows ranged from 12 to 15 gal/min (17,000 to 21,000 gal/day). Grab samples from this stream did not contain Cyanides at detectable concentrations.

4.2 Otto Fuel Residue Migration in the Runoff Stream

The Surface Water Study provided additional evidence confirming that the occasional erosion of isolated soil particles containing Otto Fuel residue had carried them through the runoff stream.

TRW maintenance crews cleaned the runoff stream channel during the late fall of 1985. Leaves and debris removed from the stream in that operation were placed in the wooded area immediately to the west of

Sample Location 11, between the former discharge area and the roadway. (See Figure 1). A sample of this material was found to contain 1100 mg/kg of PGDN. Such organic materials would be expected to absorb and retain PGDN effectively.

Sediment samples were collected on 15 August 1986, from the inverts of all accessible manholes in the storm sewer system downstream from the catch basin where the runoff stream enters. Manhole #3, some 300 ft westward from the catch basin which receives the swamp runoff, was the only one of the sampling locations which had a sump bottom. Its sample contained 760 ug/L of PGDN, which is interpreted as the net result of 300 mg/L of soil particles containing 2500 mg/kg PGDN. None of the other storm sewer sediment samples contained PGDN.

Additional sediment samples (T-1 and T-2) were collected on 16 October 1986 from the upstream and downstream ends of the first culvert for the runoff stream, just to the west of the point where the stream emerges from the wooded area. The culvert is about half filled with sediment. Neither of these sediment samples had a detectable concentration of PGDN.

PGDN had been detected in only two of the samples of sediments and organic debris from the runoff stream. (See Section 3.) It is believed that erosion gradually displaces particles containing PGDN further and further from the former discharge area. Cyanides would be present in the erosion-displaced particles, but at very low concentrations. Accordingly, the samples of sediments and organic debris from the culvert and the storm sewers were not tested for cyanides.

Table 2

Summary of Surface Water and Sediment Monitoring Data

Location	Date	Concentrations PGDN	Total CN	Flow
Surface Water Runoff Stream				
at Culvert	16 Sept	--	1.2 mg/L	3 gal/day
	24 Sept	--	Ø.3 mg/L	176Ø gal/day
Air Cond Effluent	16 Sept	--	BDT	12 gal/min
	24 Sept	--	BDT	15 gal/min
Runoff Stream Debris		11ØØ mg/kg	--	
Runoff Stream Sediments (inside culvert)				
T-1 (upstream)	16 Oct	BDT	--	
T-2 (dnstream)	16 Oct	BDT	--	
Storm Sewers				
Catch Basin	15 Aug	BDT	--	
Manhole #1	15 Aug	BDT	--	
Manhole #2	15 Aug	BDT	--	
Manhole #3	15 Aug	76Ø ug/L	--	
Manhole #4	15 Aug	BDT	--	
Manhole #5	15 Aug	BDT	--	
Manhole #6	15 Aug	BDT	--	
Manhole #7	15 Aug	BDT	--	

Note: -- = not analyzed
BDT = below detection limits:
Total CN Ø.ØØ5 mg/L in surface water stream
PGDN 25 mg/kg in runoff stream debris and sediments
PGDN 6Ø-8Ø ug/L in storm sewer sediments

5. GROUND WATER STUDY

In August 1986 TRW authorized a study to assess potential migration of PGDN and Cyanide from the original affected area near Building 49 through surface water and ground water. This section deals with the assessment for ground water.

The principal findings of the ground water study are as follows:

- @ The lateral ground water flow below and adjacent to the former discharge area is generally from north to south
- @ Cyanide was not observed in any wells at detectable concentrations. Therefore, off-site migration via shallow ground water movement is not occurring.

Details follow on the methods for the ground water study and what led to these findings.

5.1 Installation of Ground Water Monitoring Wells

Five (5) shallow ground water monitoring wells were installed along the boundaries of the swampy area south of Building 49. The wells were located 25 to 75 feet beyond the area of soil sampling of the former discharge area (see appended Drawing 6), with the major objective to determine whether cyanides are migrating out of this area via the ground water. (Otto Fuel residue was not of concern for ground water, owing to its immiscibility with water.) The monitoring wells were required to sample the shallow ground water for cyanides and to identify the approximate directions of lateral flow.

The wells were installed on 5 and 8 September 1986 by Lake Drilling Co. under the direction of Engineering-Science. During the well installation, the drilling augers were cleaned between holes to eliminate cross-contamination, and undisturbed 24-inch length Shelby-tube samples of the unconsolidated sediments were obtained almost continuously down to the bedrock surface. (The Shelby-tube samples were discussed in Section 3.4.) The wells were completed to a depth 14 ft below the surface, and screens were installed in the bottom 10 ft. Stainless steel well casing and screen were used to ensure representative ground water samples and to ensure well integrity over extended time. After completion, the wells were developed by bailing and surging to remove fine-grained sediments. The well logs are included as Appendix B.

5.2 Sampling Ground Water

The ground water monitoring wells were sampled twice, first on 17 September and again on 9 October 1986. Each time, the wells were bailed of three to five volumes of water with a clean teflon bailer. In all cases, the wells recovered to static levels within a few hours. The samples were placed on ice immediately and delivered to the laboratory.

Cyanide was not detected in any of the five well samples on either sampling date. The detection limit was 0.005 mg/L, about one percent of the concentrations observed in the runoff stream.

5.3 Ground Water Flow Direction

The geology at the TAPCO complex in Euclid is typical of areas on the south shore of Lake Erie. Lacustrine silts and clays overlie weathered and fractured gray and brownish shales of Devonian age. At this location, the depth to bedrock varies from 3 to 5 ft.

Table 3 summarizes the observed water levels at the five ground water monitoring wells on two separate occasions during late September and early October 1986. On both of these observations, the water level was between 2.7 and 4.0 feet below grade, above the weathered bedrock interface. This thin weathered zone is the first saturated zone below the site.

Each time, the ground water flow was observed to be from North to South, the same direction as the surface runoff stream from the former discharge area. See Appended Drawing 6. Shallow groundwater flow would ordinarily be expected to follow a south-to-north gradient toward Lake Erie, following the regional surface topography. Where a surface runoff channel has cut into the topography, the ground water flow pattern may be slightly altered. In this area, the very shallow ground water may be induced to flow into this channel, thereby interrupting the overall south to north flow. Because shallow ground water is so close to the surface, it is likely that surface water and ground water are hydraulically connected.

Table 3

Monitoring Well Data

Well Number	W-1	W-2	W-3	W-4	W-5
date installed	Ø5-Sep	Ø5-Sep	Ø8-Sep	Ø8-Sep	Ø8-Sep
Coordinates (ft)					
North	198	25	-63	212	63
East	123	1Ø6	-5	19	-5
Elevations (ft)					
Cover	99.3	1ØØ.5	1ØØ.4	99.7	99.9
Surface	97.7	99.1	98.9	98.3	98.5
Top of Clay	96.7	96.6-98.1	96.9	92.8-98.3	96.5-97.5
Top of Screen	93.7	95.1	94.9	94.3	94.5
Shale Interface	93.2	93.6	92.9	92.8	91.9
24-Sep-86 Well Level Monitoring (ft)					
Depth to Water *	5.1	5.2	4.1	5.6	5.5
Ground Water Level	94.2	95.3	96.3	94.1	94.4
Ø9-Oct-86 Well Level Monitoring (ft)					
Depth to Water *	4.8	4.7	4.2	5.3	5.2
Ground Water Level	94.5	95.8	96.2	94.4	94.7
Cyanide Concentrations in Monitoring Samples (mg/L)					
17-Sep-86	BDT	BDT	BDT	BDT	BDT
Ø9-Oct-86	BDT	BDT	BDT	BDT	BDT

Note: BDT = below detection limit (Ø.ØØ5 mg/L Total Cyanide)
Datum for elevations 1ØØ.Ø ft = floor level in Building 49

* Depth indicated is in feet below the top of the cover

6. RECOMMENDATIONS FOR CLOSURE PLAN

An assessment of risks to human health and the environment was carried out for the chemical discharges from Building 49, using very conservative established procedures to identify any potential risk to Public Health. [3] The Risk Assessment is included in this report as Appendix C. The methodology provides a basis for ranking of the alternatives for remedial action for the former discharges of Otto Fuel residue and cyanides near Building 49, by systematic evaluation of the possible threats to public health and the environment. This involves an understanding of the nature of the chemicals, the potential pathways for exposure of human and animal populations in the event of any future release from the site, the degrees to which such releases (if any) could violate applicable standards and criteria, and a measure of the potential threats to public health and the environment that might result from such releases.

The principal findings in this Risk Assessment are as follows:

- The no-action alternative is not recommended. Soil containing Otto Fuel residue, although not a significant hazard to public health, does pose an ongoing ingestion and dermal contact danger for animal populations that may enter the area. It would continue to be subject to mobilization by particle erosion, eventually discharging through the storm sewer system (into Lake Erie). Cyanides would continue to leach into the runoff stream in detectable but low concentrations, posing an additional threat for animal populations. Eventually, chemical degradation, volatilization, bacterial action or plant uptake would mitigate any hazards due to cyanides.

- The minimal action required would be to remove the areas of highest Otto Fuel residue and cyanide concentrations at the former discharge pipe and in the runoff stream, with due precautions to avoid mobilization during removal.

- Ultimate disposal of the soil removed from the areas of highest concentrations should be by incineration.

- No further removal of soil from the area would be required. Although cyanides would be present, at concentrations less than 10 mg/kg, there would be no remaining significant threats to public health or the environment. The alternative of additional soil removal and disposal at a conventional landfill (not certified for hazardous materials containing cyanides) would not achieve significantly improved reduction of hazards.

Details on the Risk Assessment are found in Appendix C. These issues, and the implications for Closure of the Building 49 area, are addressed in the sections that follow.

6.1 Closure of the Spill Area

Surface soil in the irregular approximately 625 sq ft area noted on Figure 5 and the runoff stream channel will have to be excavated for off-site disposal. This will remove all areas with detectable PGDN concentrations and/or Total Cyanide exceeding 10 mg/kg. It is recommended that the removal should include the organic swampy soils and the upper 1 ft. of clay. Assuming a total depth of 4 ft. removed from the area near the former discharge pipe and 2 ft. x 2 ft. dredging of the 120 ft. long runoff stream, the soil removal would amount to about 100 cubic yards. The sediments in the first culvert and the sediments from all manholes in the storm sewer system will also have to be removed. The contaminated leaves and organic debris, previously removed from the runoff stream channel and dumped in the wooded area, should be collected and added to the soil and sediments.

A Gradall or a hydraulic clamshell would be required for the soil removal and stream dredging. Personnel protection would be necessary at Level B (disposable outer garments and respiration equipment). However, mechanical methods, i.e., working upwind or use of fans would minimize the need for supplied air. (See Appendix C.)

Site work will be required, to provide access to the removal area for earthmoving equipment. A 12 ft. wide temporary roadway using 9" to 12" coarse stone and construction filter fabric is recommended. This should follow a southward alignment on the east side of Building 49, through the existing fence, and westward to the removal area. (See Appended Drawing 7.)

Additional site work should also be considered, to change the drainage to the runoff stream. A new drainage channel is proposed, which would follow a semicircular arc from the low point in the ponding area, southwestward to join the existing runoff stream near the culvert. (See Appended Drawing 7.) This would decrease leaching of cyanides into the runoff by preventing the ponding that now provides extended contact time. It will also reduce flow through the runoff stream, thereby reducing erosion of any sediment particles containing cyanides.

6.2 Concentration Limits for Residues in the Soil

The recommended action, to excavate soil near the former discharge pipe and to dredge the bed of the runoff stream, will remove all Otto Fuel residues detected in the soil sampling. See Figures 5 and 6. This conforms to the recommendation for off-site disposal of soil containing Otto Fuel from spills, in the U.S. Navy manual for Otto Fuel [1]. The Risk Assessment (Appendix C) identified toxic hazards to the environment associated with the Otto Fuel Residues.

This action would also remove the soil with the highest cyanide concentrations, which occurred in essentially the same areas. After the removal, Cyanides will be present at concentrations not exceeding 10 mg/kg anywhere in the area. The Risk Assessment indicates that the remaining soil, being free of PGDN and containing low concentrations of

cyanides, should not be considered harmful. Natural soils under aerobic conditions are known to be tolerant of (and capable of assimilating) cyanides at concentrations exceeding 2 mg/kg. [4]

Recent actions by state agencies with respect to cyanides in mineral processing residues have required removal to levels up to 10 mg/kg, based on rationale for the cyanide concentrations that would leach into surface water. (See Appendix D.) For example, the California Regional Water Quality Control Board, Colorado River Basin, Region 7 increased the limit on total cyanide found in abandoned leach piles from 1.0 mg/kg to 10 mg/kg, after a review of fish toxicity studies and the environmental chemistry of cyanides. Their rationale was that only the cyanide ion content has to be considered. A cyanide level of 0.02 mg/L was acceptable in the receiving stream, and after multiplying by their customary factor of 100 to account for dilution, a level of 2.0 mg/L was obtained for the leachate. Then, the acceptable limit for a solid residue is 10 mg/kg based on leaching 1 part solid: 5 parts liquid. [5]

The runoff stream from the former discharge area south of Building 49 was observed to contain from 0.3 to 1.2 mg/L of Total Cyanide. Leaching of cyanides into this stream is predicted to decrease by about 70% after the recommended removal of all soil and sediments containing detectable PGDN and Total Cyanides exceeding 10 mg/kg. Even discounting any further dilution, the predicted 0.1 to 0.36 mg/L concentrations in the runoff stream would be comparable to discharges of cyanides from the TAPCO Plant's industrial wastewater treatment system (via the same outfall as the storm sewer system), subject to Ohio EPA authorization to discharge under the NPDES system, Ohio EPA Permit 3IC00035*BD, effective 23 August 1984 through 20 August 1989. The cyanide concentration limits for the treated industrial effluents are 0.32 mg/L monthly average, 0.86 mg/L maximum day.

6.3 Ultimate Disposal of Soil

The U.S. Navy manual for Otto Fuel [1] recommends off-site disposal for soil containing Otto Fuel from spills. Concentrated liquid residues of Otto Fuel are presently disposed of by incineration. (As supplied, Otto Fuel is considered by the Navy and by Navy contractors as subject to RCRA regulations as a reactive hazardous material.) Rotary-kiln incinerators would have to be used, since liquid hazardous waste incinerator installations generally can only handle limited quantities of drummed soil. The costs for disposal by incineration will be high, since there may be problems with ash disposal and/or material handling (size reduction, moisture content, etc.) depending on site-specific requirements of the installation to be used.

The manual does describe a method for chemical reduction of liquid Otto Fuel residues, using acetone solvent and sodium sulfide. [1] This does not appear to be feasible for on-site application, since it would require rigorous working area isolation facilities to ensure personnel safety and to prevent emission of toxic hydrogen sulfide fumes.

Depending on the quantity of soil involved, on-site chemical destruction of cyanide may be economically feasible in comparison to landfill disposal. The technology for alkaline hypochlorination of excavated soil using earth moving equipment was estimated by its developers (Haztech) to cost in the range of $50 to $150/cu yd, for soil quantities of 250 to 500 cu yd. This method has been used at two sites which had experienced spillage of concentrated cyanides, to treat soils containing 100 mg/kg or more of cyanides. It is claimed to be capable of reducing cyanides to concentrations below present detection limits, at somewhat higher costs. Preventing emission of toxic chlorine fumes during the soil treatment is a major drawback for this technology.

An optional alternative for site work could also be considered, to inter the remaining cyanides insitu, by regrading to provide an impermeable cap over the areas containing detectable cyanides and diverting all surface runoff and groundwater that would otherwise contact the buried soil. However, this would involve a commitment to long-term monitoring of groundwater quality.

6.4 Closure of Building 49 and the Adjoining Area

The entire Torpedo Test area should undergo closure at the same at the same time as the spill area. Additional activities that should be included in the closure are discussed in the paragraphs that follow.

Leakage of torpedo test wastewater may have occurred from the underground tanks and piping. In order to locate such leakage sites, if any, the 1000 gallon underground separator tank for wastewater discharges from Building 49 must be removed, and the former discharge piping should be unearthed along its entire length (estimated to be about 60 ft). Similarly, the new underground holding tanks for torpedo test wastewater, which were installed on the west side of Building 49, and the piping from the separator tank to the new holding tanks must also be removed.

Soil sampling and analysis for PGDN should be carried out at the tank sites and along the piping, at the pipe joints and any other suspect locations. In addition, the soil at two areas of possible spillage of Otto Fuel or torpedo testing wastewater should also be sampled and analyzed for PGDN. Spills may have occurred at the Otto Fuel storage area on the east side of Building 49 and/or on the concrete pad on the south side of the building.

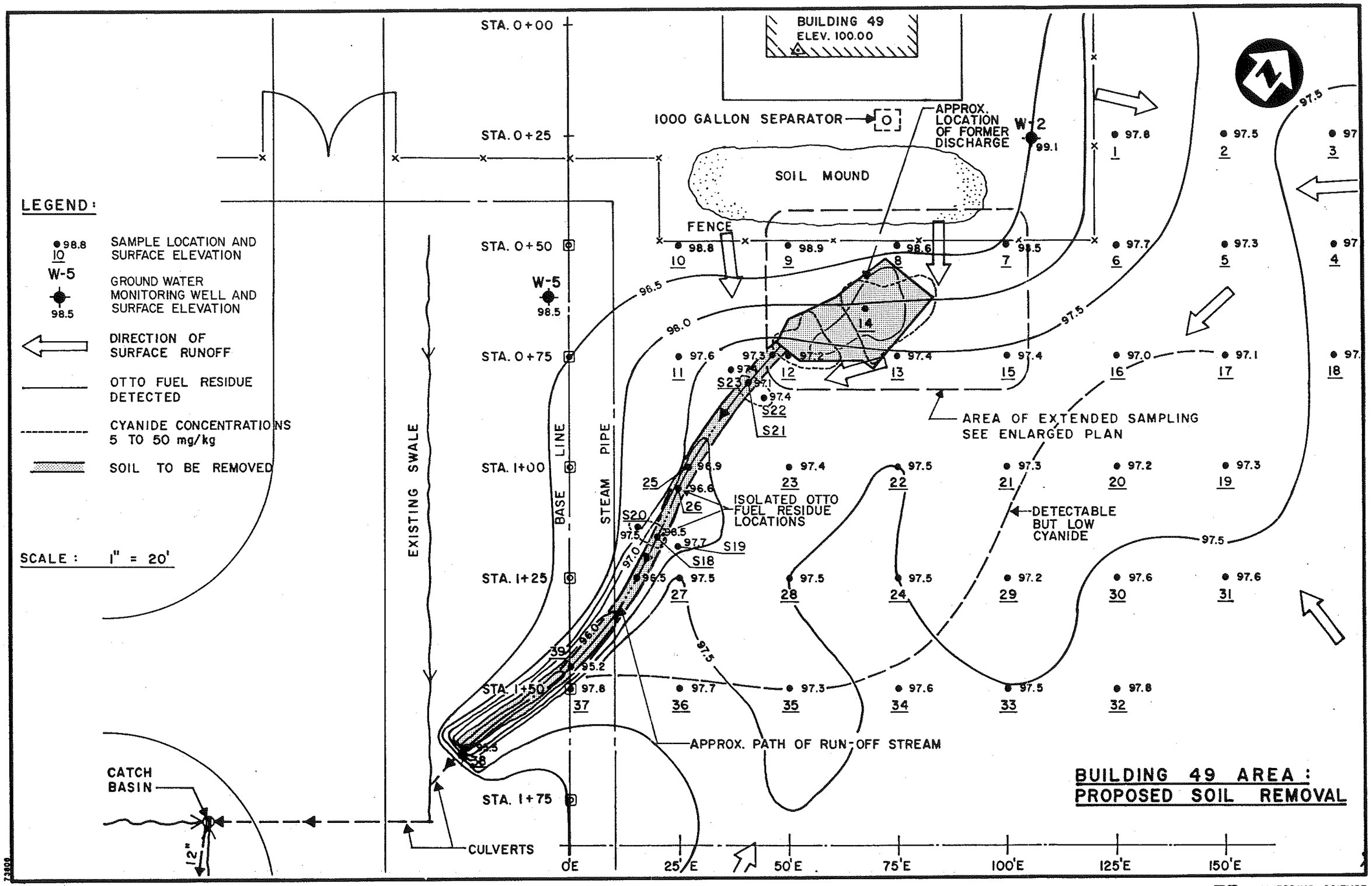
The tanks and pipe should be cleaned on site by rinsing with methanol, and the spent rinses should be collected and disposed of by incineration. Samples of the last spent rinses should be analyzed for PGDN to verify that no Otto Fuel residues remain. The tanks may then be salvaged for reuse, if possible, or disposed of as non-hazardous solid waste.

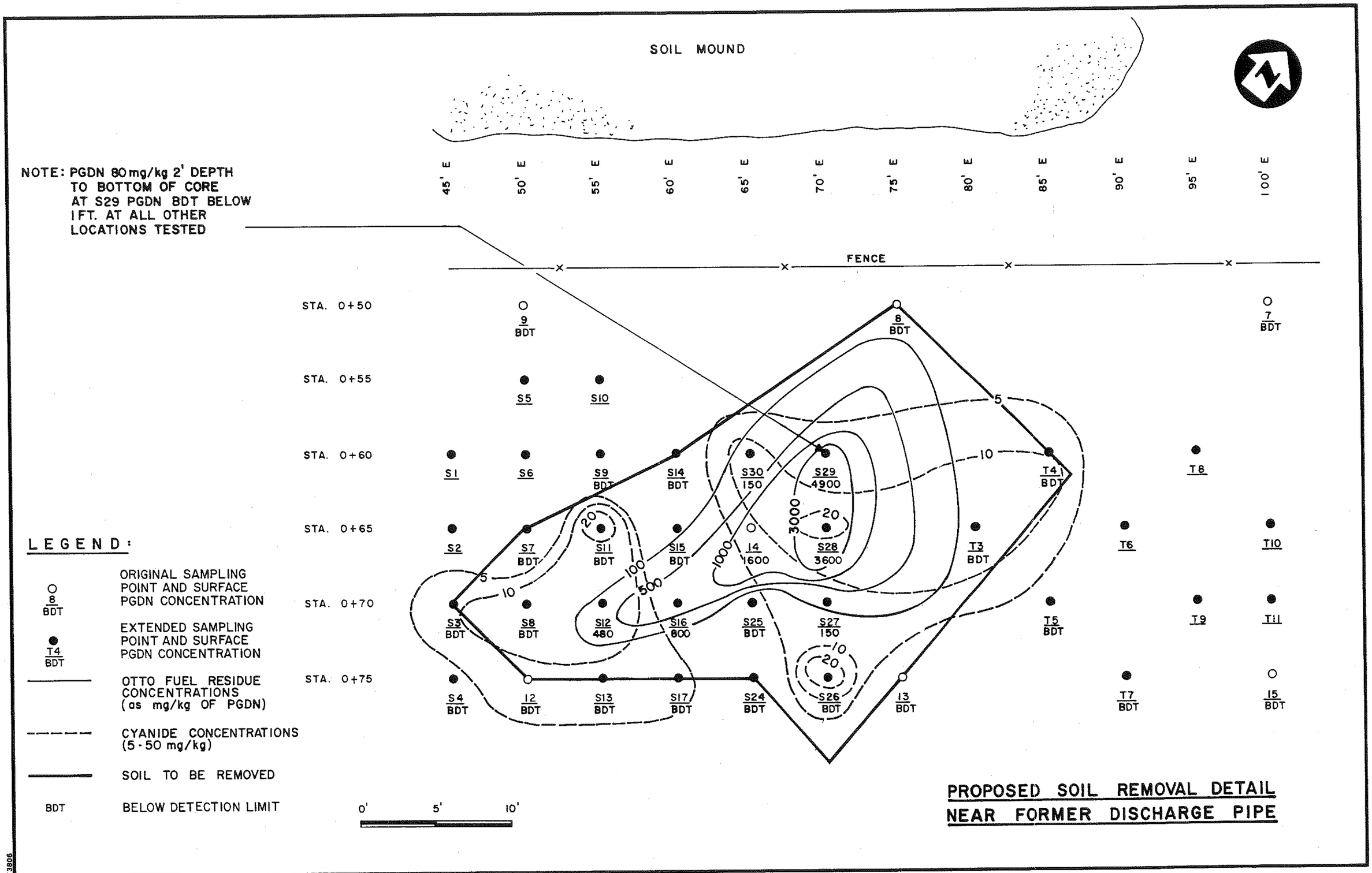
Limited additional soil sampling should be carried out within the torpedo test compound, to ensure that no hazardous concentrations of cyanides remain after closure. The top 2 ft of soil are of concern, based on the detectable-but-low concentrations found at the monitoring

well sites within the compound and the November 1985 hand-auger sampling at the northeast corner.

In the event that Building 49 or any of the auxiliary buildings are to be demolished in the foreseeable future, it would be prudent to test at this time for asbestos insulation. Similarly, transformers in the torpedo testing compound should be checked for PCBs .

The soil mound between Building 49 and the former discharge area should be sampled and analyzed for cyanides. If found to be free of cyanides, this soil can be used for backfilling after removal of soil containing residues of PGDN and cyanides.


BUILDING 49
ELEV. 100.00
1000 GALLON SEPARATOR
APPROX. LOCATION OF FORMER DISCHARGE
W-2
99.1
SOIL MOUND
FENCE
STA. 0+00
STA. 0+25
STA. 0+50
STA. 0+75
STA. 1+00
STA. 1+25
STA. 1+50
STA. 1+75
W-5
98.5
EXISTING SWALE
BASE LINE
STEAM PIPE
LEGEND:
SAMPLE LOCATION AND SURFACE ELEVATION
GROUND WATER MONITORING WELL AND SURFACE ELEVATION
DIRECTION OF SURFACE RUNOFF
OTTO FUEL RESIDUE DETECTED
CYANIDE CONCENTRATIONS 5 TO 50 mg/kg
SOIL TO BE REMOVED
SCALE: 1" = 20'
AREA OF EXTENDED SAMPLING SEE ENLARGED PLAN
ISOLATED OTTO FUEL RESIDUE LOCATIONS
DETECTABLE BUT LOW CYANIDE
APPROX. PATH OF RUN-OFF STREAM
CATCH BASIN
12"
CULVERTS
0'E
25'E
50'E
75'E
100'E
125'E
150'E
BUILDING 49 AREA: PROPOSED SOIL REMOVAL


SOIL MOUND
NOTE: PGDN 80 mg/kg 2' DEPTH TO BOTTOM OF CORE AT S29 PGDN BDT BELOW 1 FT. AT ALL OTHER LOCATIONS TESTED
45' E
50' E
55' E
60' E
65' E
70' E
75' E
80' E
85' E
90' E
95' E
100' E
FENCE
STA. 0+50
STA. 0+55
STA. 0+60
STA. 0+65
STA. 0+70
STA. 0+75
9 BDT
8 BDT
7 BDT
S5
S10
S1
S6
S9 BDT
S14 BDT
S30 150
S29 4900
T4 BDT
T8
S2
S7 BDT
S11 BDT
S15 BDT
14 1600
S28 3600
T3 BDT
T6
T10
S3 BDT
S8 BDT
S12 480
S16 800
S25 BDT
S27 150
T5 BDT
T9
T11
S4 BDT
12 BDT
S13 BDT
S17 BDT
S24 BDT
S26 BDT
13 BDT
T7 BDT
15 BDT
5
10
20
100
500
1000
3000
LEGEND:
8 BDT — ORIGINAL SAMPLING POINT AND SURFACE PGDN CONCENTRATION
T4 BDT — EXTENDED SAMPLING POINT AND SURFACE PGDN CONCENTRATION
OTTO FUEL RESIDUE CONCENTRATIONS (as mg/kg OF PGDN)
CYANIDE CONCENTRATIONS (5-50 mg/kg)
SOIL TO BE REMOVED
BDT — BELOW DETECTION LIMIT
0' 5' 10'
PROPOSED SOIL REMOVAL DETAIL
NEAR FORMER DISCHARGE PIPE

73806

REFERENCES

1. Technical Manual: OTTO Fuel II Safety, Storage and Handling, 6th Revision, NAVSEA OP 3368 (U.S. Navy Sea Systems Command, 1 October, 1976.)

2. Test Methods for Evaluating Solid Wastes: Physical and Chemical Methods, SW-846, Second Edition (Revised), U.S. Environmental Protection Agency, Office of Solid Wastes, 1984

3. "Superfund Public Health Evaluation Manual", OSWER Directive 9285.4-1, Office of Emergency and Remedial Response, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington, D.C., October 1986

4. Fuller, W.H., "Cyanides in the Environment, with Particular Attention to the Soil", keynote review paper presented at Conference on Cyanide and the Environment, Tucson AZ, December 1984, pp. 19-45.

5. Engineering-Science, Inc., Report to U.S. Environmental Protection Agency, Water Management Division, State Programs Branch, Denver CO, 1986. "Heap Leach Technology and Potential Effects in the Black Hills", Appendix B, "Cyanide Chemistry", pp. 283-340. (See Table B-11, "Western State Regulations or Guidelines for Neutralization of Spent Heap Leach Piles", pp. 326-327.)

6. Sax, N. I. "Dangerous Properties of Industrial Materials", 5th Ed., van Nostrand-Reinhold, New York City, 1979; pp. 728 and 862

7. "Occupational Diseases, A Guide to their Recognition" U.S. Dept. of Health, Education and Welfare, Public Health Service, Center For Disease Control, National Institute of Occupational Safety and Health, Revised Edition, 1977, pp. 232 and 283

APPENDIX A.

HEALTH AND SAFETY PLAN

ES ENGINEERING-SCIENCE

57 EXECUTIVE PARK SOUTH, N.E., SUITE 590 • ATLANTA, GEORGIA 30329 • 404/325-0770

66207/864J50

April 7, 1986

Chris Raddel
Engineering-Science, Inc.
19101 Villaview Road
Suite 301
Cleveland, Ohio 44119

Dear Chris:

Please find enclosed the Safety Guidelines for the TRW site investigation. If you have any comments concerning any of the protocols feel free to contact me.

Sincerely,

ENGINEERING-SCIENCE

Edward Grunwald

Edward Grunwald
Corporate Health and Safety
Manager

EG/bb

Enclosure

Respiratory Protection

The personal levels of respiratory protection prescribed for the field work to be performed at TRW building 49 is level D with a contingency to use level C. This level is based upon the potential exposure to OTTO. OTTO is a monopropellant made up of 1,2-propylene glycol Dinitrate, Di-N-butyl Sebacate, and 2-Nitrodiphenylamine. OTTO has a very low vapor pressure, therefore, the inhalation of toxic gases, fumes, or vapors is unlikely to be encountered. The inhalation of toxic particulates (dusts, soils, etc.) can be a problem when soil conditions are dry. If the inhalation of airborn particulates is a problem, (as may be the case during drilling activities) field personnel should "water down" the area of concern. OTTO does not have an established Threshold Limit Value (TLV) or Permissible Exposure Limit (PEL). The major component of OTTO, 1,2-Propylene Glycol Dinitrate, has a TLV of 0.02 ppm. Because of the low TLV of 1,2-Propylene Glycol Dinitrate ambient air monitoring of organic vapors will be required at each sampling point and drilling location. This information will be used to aid the site manager in determining the level of protection for the various activities.

The following criteria should be used to select the appropriate respiratory protection:

Organic Vapor Concentration (in Breathing Zone)	Protection Level
0 PPM	Level D
0.02-5 PPM	Level C

Level C respiratory protection should not be used for protection with poor warning properties or in an atmosphere containing less than 19.5 percent oxygen (ANSI Z88.2-1980). Information is not available to determine if OTTO had good warning properties (i.e., low odor threshold

when compared to its TLV). For this reason the upper limit for level C respirator protection is set at 5 ppm, at this concentration cartridge breakthrough is unlikely to occur. Level C respiratory protection will consist of a full face air mask with organic vapor cartridges. Individuals who use air purifying respirators must wear a respirator which has successfully been fitted to their faces. An improperly fitted respirator delivers little respiratory protection. Additionally, a five minute escape air pack must be available when Level C operations commence.

Level B respiratory protection Self-Contained Breathing Apparatus (SCBA) will be worn when the following conditions occur:

- When organic vapor concentration (in the breathing zone) exceeds 5 PPM
- When evidence exists of immediate (less than five minutes) breakthrough time for the cartridge air-purifying respirator.
- Where there is reason to suspect that the cartridge sorbent has a high heat of reaction (hot to the touch) with one of the substances at the site.
- Where there is reason to suspect that a substance sorbed onto the surface of a cartridge is shock sensitive.

Dermal Protection

OTTO can be absorbed through the skin; OTTO is also an eye irritant. Personnel can avoid skin and eye contact by wearing the protective clothing specified below.

For level D Operations:

- Tyvek or Saranex suits (over coveralls)
- Neoprene boots
- Polyethylene gloves
- Goggles

For Level C Operations

- Full-face air purifying respirator equipped with organic vapor cartridges
- Neoprene outer gloves
- Polyethylene inner gloves
- Tyvek or Saranex suits (over coveralls)
- Steel-toed Neoprene boots

Health and Safety Training

Every potential respirator wearer shall receive fitting instructions including demonstrations and practice in how the respirator should be worn, how to adjust it, and how to determine if it fits properly.

Air Monitoring

Monitoring for organic vapors will be conducted using an HNu with an 11.7 ev lamp. Reading of organic vapor concentration above background will initiate Level C respiratory protection.

Health and Safety Equipment

Each field team shall have the following items readily available:

- Copy of site Health and Safety Plan including a list of emergency contacts
- First aid kit
- Eye wash bottle
- Duct tape
- Paper towels
- Plastic garbage bags
- HNu with 11.7 ev lamp
- Long-handle brushes
- Tyvek
- Gloves
- Full-face air purifying respirator
- Safety boots
- Decon solution
- Organic vapor cartridges

SITE SPECIFIC DECONTAMINATION PROCEDURES

Work at the TRW site will be of moderate duration and exposure to hazardous materials should be minimal if proper precautions are followed. Simple and expedient decontamination procedures, appropriate to the site and work conditions, will be followed.

Based upon the site information, it may be necessary to establish one or more zones of exclusion. Should this occur, a decontamination pad will be established at the entrance/exit point to each exclusion zone. Workers entering this area must be equipped in the level of protection previously established. The decontamination procedures must be followed by all personnel as they leave the zone of exclusion.

Level C decontamination at the TRW site will consist of the following:

Station 1: Segregated Equipment Drop

Deposit equipment used on the site (tools, sampling devices and containers, monitoring instruments, clipboards, etc.) on plastic drop cloths or in different containers with plastic liners. Each will be contaminated to a different degree. Segregation at the drop reduces the probability of cross-contamination.

Equipment necessary is:

1. Containers of various sizes
2. Plastic liners
3. Plastic drop cloths

Station 2: Suit/Safety Boot and Outer-Glove Wash

Thoroughly wash tyvex or saranex suit, safety boots and outer-gloves. Scrub with long-handle, soft-bristle scrub brush and copious amount of decon solution (Wisk®/water solution). Repeat as many times as necessary (determined by visual inspection).

Equipment necessary is:

1. Container (30 gal)
2. Decon solution: Wisk®/water solution
3. Long-handle, soft-bristle scrub brushes

Station 3: Suit/Safety Boot and Outer-Glove Rinse

Rinse off decon solution (Wisk®/water solution) using copious amount of water. Repeat as many times as necessary.

Equipment necessary is:

1. Container (30 gal)
2. Spray unit
3. Water
4. Long-handle, soft-bristle scrub brushes

Station 4: Canister or Mask Change

If worker leaves Exclusion Zone to change canister (or mask), this is the last step in the decontamination procedures. Worker's canister is exchanged, new outer gloves and tyvec donned, and joints taped. Worker returns to duty.

Equipment necessary is:

1. Canister (or mask)
2. Tape
3. Boot covers
4. Gloves

Station 5: Outer Glove Removal

Remove outer gloves and deposit in individually marked plastic bags.

Equipment necessary is:

1. Container (30 gal)
2. Plastic liners
3. Bench or stool

Station 6: Tyvex or Saranex Suit Removal

With assistance of helper, remove tyvex or saranex suit. Deposit in container with plastic liner.

Equipment necessary is:

1. Container (30 gal)
2. Stool
3. Plastic liner

Station 7: Inner-Glove Wash

Wash inner-gloves with Wisk®/water solution that will not harm skin. Repeat as many times as necessary.

Equipment necessary is:

1. container
2. water
3. wash basin
4. brushes

Station 8: Inner-Glove Rinse

Rinse inner-gloves with water. Repeat as many times as necessary.

Equipment necessary is:

1. Water
2. Basin
3. Small table

Station 9: Safety Boot Removal

Remove safety boots and deposit in individually marked plastic bags.

Equipment necessary is:

1. Container
2. Plastic liners
3. Bench or stool

Station 10: Respirator Removal

Remove facepiece. Avoid touching face with gloves. Wash respirator in clean, sanitized solution (e.g., anticeptic mouthwash) and deposit facepiece in plastic bag. Store in clean area.

Equipment necessary is:

1. Plastic bags

Station 11: Inner-Glove Removal

Remove inner-gloves and deposit in container with plastic liner.

Equipment necessary is:

1. Container
2. Plastic liners

Station 12: Field Wash

Wash hands and face.

Equipment necessary is:

1. Water
2. Soap
3. Tables
4. Wash basins or buckets

Equipment Decontamination

The drill rigs and downhole equipment will be steam cleaned prior to drilling the first boring. Downhole equipment will be decontaminatied after the completion of each boring in the following manner:

- Downhole equipment (aguer bits, drill rods, etc.) will be steam clened to remove gross contamination;
- The equipment will then be washed in a detergent (Wisk®) solution and brushed.
- The equipment will then be rinsed with tap water, followed by acetone and distilled water.
- The downhole equipment will then be air dried in a clean section of the decontamination area.

Drill rigs will be steam cleaned upon the completion of the final boring. A drilling sequence heirarachy (from less likely to more likely contaminated boring locations) will be imposed to reduce the potential of cross contamination.

Hazard Evaluation

The compound of concern at the TRW site is OTTO. Although this chemical has a low vapor pressure air monitoring for organics should be conducted (particularly during drilling activities) to determine the need to upgrade the level of respiratory protection. Since OTTO is a propellant care should be taken to use non-sparking tools whenever possible. Smoking will be prohibited at the site. An explosimeter may

be a useful tool for monitoring combustible atmospheres when the chemical of concern is volatile but in the case of OTTO which is a non volatile, viscous substance the benefit gained by using an explosimeter is questionable.

The toxic effects from the inhalation of OTTO include: headaches, nasal congestion, and a drop in blood pressure. OTTO is also an eye irritant. The proper selection of protective clothing is important. Polyethylene and Neoprene clothing (gloves and boots) provide the greatest degree of protection. Butyl rubber and natural rubber tends to degrade quicker when exposed to the components of OTTO. Neoprene gloves and boots are recommened as a substitute for natural rubber garments.

APPENDIX B.

WELL LOGS

DRILLING CONTRACTOR:
Driller: LAKE DRILLING
Inspector: K.M. Palombo

ENGINEERING-SCIENCE DRILLING RECORD

PROJECT NAME TRW BUILDING 49 STUDY
PROJECT NO. CL021

BORING NO. W-1
Sheet 1 of 1
Location

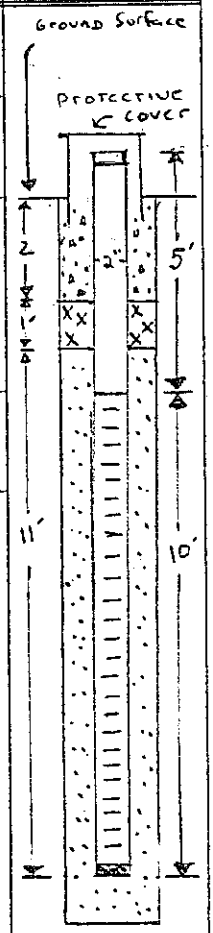
GROUND WATER OBSERVATIONS
AT ___ FT. AFTER ___ HOURS
AT ___ FT. AFTER ___ HOURS

Weather Sunny 70°'s
Remarks Screen Size .010 Stainless Steel

Surface Elev.
Date Start 9-5-86
Date Finish 9-5-86

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
	1-3.5	U				1	light Brown Silt
	3.5-4.5	U				4.5	grayish Brown clay
						7.5	Brownish gray weathered shale
						12	Fractured gray shale
							Hard gray shale.

WELL CONSTRUCTION DETAILS



coarse sand
Bentonite
cement

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

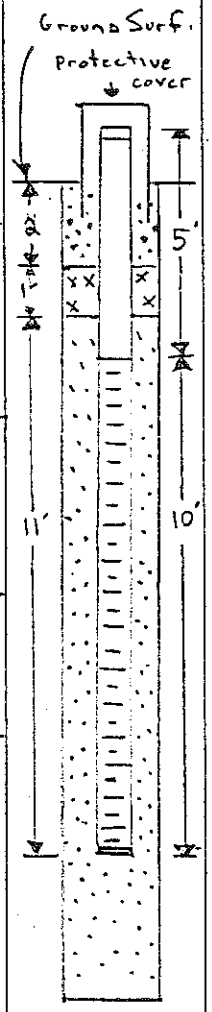
PAY QUANTITIES	
FOOTAGE IN EARTH	5
FOOTAGE IN ROCK	10
NO. OF SAMPLES	2
CORE BARREL	0

DRILLING CONTRACTOR:	ENGINEERING-SCIENCE DRILLING RECORD	BORING NO. W-2
Driller: LAKE DRILLING		Sheet 1 of 1
Inspector: K.M. Palombo		Location
	PROJECT NAME TRW Building 49 Study	
	PROJECT NO. CL021	

GROUND WATER OBSERVATIONS	Weather Sunny 70's	Surface Elev.
AT ___ FT. AFTER ___ HOURS	Remarks Screen Size .010 STAINLESS STEEL	Date Start 9-5-86
		Date Finish 9-5-86
AT ___ FT. AFTER ___ HOURS		

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
						1	Brown Sandy Topsoil
	1-3'	U				2.5	Light Brown Silty Clay
	3-5'	U				3.5	Dark gray to Black clay (Appears Stained)
						5.5	Brown weathered clay with shale fragments
						11	Weathered, fractured Gray Shale.
							Harder gray Shale.

WELL CONSTRUCTION DETAILS



COARSE SA

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

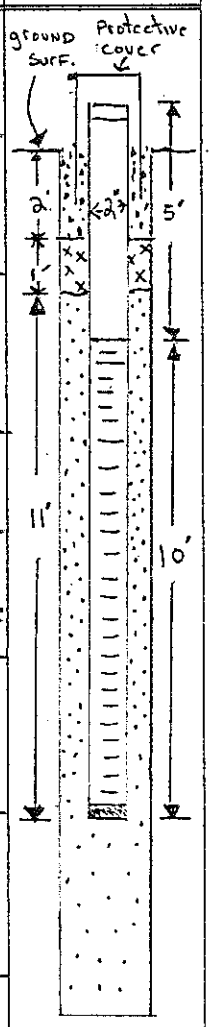
PAY QUANTITIES	
FOOTAGE IN EARTH	5.5
FOOTAGE IN ROCK	11.5
NO. OF SAMPLES	2
CORE BARREL	0

DRILLING CONTRACTOR:	ENGINEERING-SCIENCE DRILLING RECORD	BORING NO. W-3
Driller: LAKE DRILLING		Sheet 1 of 1
Inspector: K.M. Palombo		Location
	PROJECT NAME TRW Building 49	
	PROJECT NO. CL021	

GROUND WATER OBSERVATIONS		
AT ___ FT. AFTER ___ HOURS	Weather Ptly Cloudy - Cool 60's	Surface Elev.
	Remarks Screen Size .010	Date Start 9-8-86
	Stainless Steel	Date Finish 9-8-86
AT ___ FT. AFTER ___ HOURS		

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
							Top soil - Light Brown Silt w/minor Fine Sand
						1	
							Gravel, old asphalt, wood (Fill)
						2	
							Dark Gray Clay (appears stained, hydrocarbon odor)
	3.0-5.0'	U				3.5	
							Medium Brown Silty Clay
						6.0	
							Brown Weathered Shale
						6.5	
							Gray, weathered, (Broken) Shale
						16	
							Gray Shale, harder, less weathered
						18	
							Coarse Sand
							Bentonite
							Cement

WELL CONSTRUCTION DETAILS



D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

PAY QUANTITIES	
FOOTAGE IN EARTH	6.0
FOOTAGE IN ROCK	12.0
NO. OF SAMPLES	2
CORE BARREL	0

DRILLING CONTRACTOR:
Driller: LAKE DRILLING
Inspector: K.M. Palombo

ENGINEERING-SCIENCE DRILLING RECORD

PROJECT NAME TRW BUILDING 49 STUDY
PROJECT NO. CL021

BORING NO. W-4
Sheet 1 of 1
Location

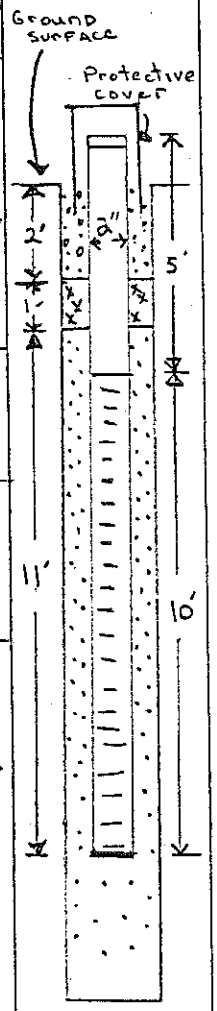
GROUND WATER OBSERVATIONS
AT ___ FT. AFTER ___ HOURS
AT ___ FT. AFTER ___ HOURS

Weather PTLY CLOUDY, COOL 60'S
Remarks SCREEN SIZE .010 STAINLESS STEEL

Surface Elev.
Date Start 9-8-86
Date Finish 9-8-86

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
	1-3.5	U				1	Brown Silty clay
	3.5-5	U				2.5	Reddish Brown Silty clay (Moist)
						5.5	Brown Silty clay (Dry)
						7	Light Brown weathered shale
						12	gray shale – some fractures
						17	Brownish gray shale weathered, iron stains

WELL CONSTRUCTION DETAILS



COARSE SAND
BENTONITE
CEMENT

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

PAY QUANTITIES	
FOOTAGE IN EARTH	5.5
FOOTAGE IN ROCK	11.5
NO. OF SAMPLES	2
CORE BARREL	

DRILLING CONTRACTOR:
iller: LAKE DRILLING
spector: K.M. Palombo

ENGINEERING-SCIENCE DRILLING RECORD

PROJECT NAME TRW BUILDING 49 STUDY
PROJECT NO. CL021

BORING NO. W-5
Sheet 1 of 1
Location 10' W. of OVERHEAD STEAM LINES

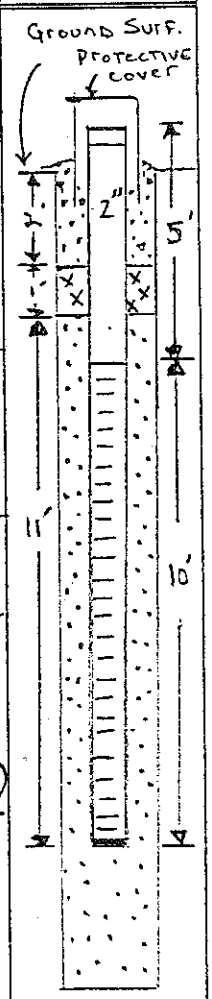
GROUND WATER OBSERVATIONS
AT ___ FT. AFTER ___ HOURS
AT ___ FT. AFTER ___ HOURS

Weather PTLY CLDY 60'S
Remarks Screen Size .010 STAINLESS STEEL SCREEN AND RISER

Surface Elev.
Date Start 9-8-86
Date Finish 9-8-86

DEPTH BELOW SURFACE	SAMPLE DEPTHS	TYPE OF SAMPLE	STANDARD PENETRATION TEST 0–6	6–12	12–18	STRATA CHANGE	REMARKS FIELD IDENTIFICATION OF MATERIAL (Incl. Color, Loss of Wash Water, Seams in Rock, etc.)
	1-3'	U					Top Soil / Brown Silty Cly
						2	Dark gray clay - No odors
	3.5-5	U				3	Brownish-Gray Clay MOIST AT TOP DRY AT BOTTOM
						6	Brown Firm clay to weathered shale
						7	Gray Shale
						11	Brownish Gray Shale (weathered, Fractured, iron stains)
						12	Gray Shale w/ Some Brown Streaks
						17	

WELL CONSTRUCTION DETAILS



coarse sand
Bentonite
Cement

D = DRY W = WASHED C = CORED P = PIT A = AUGER CUTTINGS
U = UNDISTURBED SS = SPLIT SPOON

PAY QUANTITIES	
FOOTAGE IN EARTH	6
FOOTAGE IN ROCK	11
NO. OF SAMPLES	2
CORE BARREL	0

APPENDIX C.

RISK ASSESSMENT

APPENDIX C

RISK ASSESSMENT

An assessment of risks to human health and the environment was carried out, for the area near Building 49 affected by the discharges of Otto Fuel residue and cyanides. The assessment covered both existing conditions and alternatives for remedial action. The discussion that follows describes the Risk Assessment procedure in general terms and then applies that methodology to the case at hand.

1. Baseline Risk Assessment Procedure

The methodology for assessment of risks to human health and the environment is based on very conservative established procedures to identify and evaluate possible threats to public health and the environment. This involves an understanding of the nature of the chemicals, the potential pathways for exposure of human and animal populations in the event of any release from the site, the degrees to which such releases could violate applicable standards and criteria, and a measure of the potential threats to public health and the environment that might result from such releases. The risk assessment consists of five steps, as follows:

Step 1: Selection of Indicator Chemicals - Often, many chemicals are involved; it may be necessary to choose a tractable number of chemical species from among those present, for quantitative estimates. The indicator species should be chosen on the basis of higher mobility, greater toxicity, more persistence in the environment and/or higher concentrations. A screening procedure is available for use with complicated mixtures [3].

Step 2: Estimation of Exposure Point Concentrations consists of identifying possible pathways for exposure of human and animal populations to indicator chemical releases from the site, identifying the potential exposure points, and estimating the chemical releases and their subsequent environmental fate and transport via air, ground water, surface water and soils. Separate accountings must be made for pathways leading to oral intake, to direct dermal intake, or to intake by ingestion, since each intake mechanism has a separate toxicological data base.

The exposure pathways are reviewed to identify which of them may be "complete" pathways for exposure by human and animal populations. An exposure pathway is comprised of a source and mechanism of chemical release; an environmental transport medium; a human or animal exposure point and a feasible exposure route to the exposure point. If any one portion of the exposure pathway is missing, then exposure by that route is not possible.

The projected exposure levels may then be compared to Applicable or Relevant and Appropriate Requirements (ARARs), which include

allowance for the intake mechanisms and the toxicological limits. If possible, determinations should be made for both acute and chronic (long term) exposure. In the event that ARAR values are available for all indicator chemicals, it is not necessary to proceed with the remaining steps of the Risk Assessment Procedure.

Step 3 - Estimation of Chemical Intake attempts to quantify the actual human or animal exposure, in order to assess possible adverse health effects. The exposure is expressed in terms of intake, i.e., the amount of a substance taken into the body per unit body weight. Each of the media should be considered separately, due to their differing assumptions and variable data quality.

The intakes for each chemical are combined separately for the oral and inhalation routes. Toxicological data generally keep these routes separate. For long term (chronic) exposure, the oral (or the inhalation) intake rates are combined by summation. However for the short term (subchronic) exposure, where peak intakes are of interest, the largest individual intake for the given route would be appropriate.

Step 4: Toxicity Assessment presents critical toxicity values for the indicator chemicals, to be used in conjunction with the results of exposure assessment for characterization of risks. The U.S. EPA has developed a tabulation of values which describe the degree of toxicity posed by various chemicals [7], as follows:

acceptable intake for subchronic exposure (AIS),
acceptable intake for chronic exposure (AIC),
carcinogenic potency factor (carcinogens only),

The AIC and AIS values were derived from quantitative information available from animal toxicity studies and limited human epidemiological data, and stated in units of mg/kg body weight/day. The values are intended to be protective of sensitive populations. The carcinogenic potency factors have units of lifetime cancer risk per (mg/kg body weight/day).

Step 5: Risk Characterization makes the comparison between projected intakes and reference levels for non-carcinogens. When carcinogens are present, Step 5 compares the calculated risks to target risks . This is in addition to earlier comparison of exposure point concentrations vs. applicable or relevant and appropriate requirements (ARAR) or other standards and criteria.

To assess the overall potential for non-carcinogenic effects posed by multiple chemicals, EPA developed a Hazard Index approach which assumes that multiple sub-threshold exposures may result in an adverse effect, and that the magnitude of the adverse effect will be in proportion to the summation of the ratios of the individual subthreshold exposures (intakes) to acceptable intake levels for each chemical, i.e.,

$$\text{Subchronic Hazard Index} = (IS_1/AIS_1 + IS_2/AIS_2 + \ldots)$$

$$\text{Chronic Hazard Index} = (IC_1/AIC_1 + IC_2/AIC_2 + \ldots)$$

The assumption of additivity is best applied to compounds that induce the same effect by the same mechanism. Applying the hazard index to a mixture of compounds that are not expected to induce the same type of effects could overestimate the risk.

The Hazard Indices are determined individually for the oral and the ingestion routes (and separately for subchronic and chronic exposures). It is not appropriate to combine the two because toxicity data are route specific.

The formal risk assessment procedure concludes with a review of site-specific factors that may increase uncertainty. Sensitive populations, such as hospitals or institutions, could require a more conservative interpretation of hazards. Exposure uncertainties and non-quantifiable exposure routes were noted above. Overall data adequacy, indicator chemicals evaluated (number and volume), chemical or biological interactions and other factors should be reviewed.

2. Baseline Risk Assessment - Existing Conditions

Step 1: Selection of Indicator Chemicals - for the area near Building 49 affected by the discharges of torpedo testing wastewater, only two chemicals are of concern: Propylene Glycol Dinitrate (PGDN) and Cyanides.

PGDN is the principal component of Otto Fuel II, a combustible chemical in its purified form, which is stable at ambient conditions (and not flammable according to U.S. Department of Transformation criteria). It is chemically similar to Nitroglycerin and to Ethylene Dinitrate (EDN), a byproduct of Nitroglycerin manufacturing.

mobility - PGDN is essentially immiscible with water but soluble in organic solvents, such as acetone or methanol. Once absorbed in the soil, it can be mobilized only by erosion of the host soil particles. It is not volatile, hence the principal pathways for exposure are by dermal contact or by ingestion.

toxicity - PGDN is known to have toxic effects on humans; low level acute occupational exposure affecting the nervous system has been discussed in the U. S. Navy manual [1]. Its toxicity can be estimated, based on documented data for Nitroglycerin or EDN [6].

persistence - Otto Fuel II is a mixture of PGDN with non-toxic organic stabilizer compounds. It is considered to have a useful shelf life exceeding two years in storage at ambient conditions.

concentrations (detectable only in the top 1 ft of sample cores) -

300 sq ft area near the former discharge pipe site:
average of all detectable concentrations = 1900 mg/kg
maximum concentration observed = 4900 mg/kg

in the runoff stream sediments:
average for the two isolated samples with detectable concentrations = 160 mg/kg
maximum concentration observed = 240 mg/kg

Cyanides, which are present as a result of incomplete combustion of Otto Fuel in torpedo testing, are characterized as follows:

mobility - Cyanides, being generally soluble in water, are capable of leaching either into surface runoff or into ground water flow. Cyanide concentrations of 0.3 to 1.2 mg/L were observed in the actual runoff stream flow.

toxicity - Cyanides are notorious for toxicity to humans and animals, due to interference with oxygen metabolism.

persistence - Cyanides do degrade in the environment. Under acidic conditions, cyanides are converted to the volatile hydrocyanic acid (HCN) and released to the atmosphere. Other mechanisms of cyanide degradation, including ultraviolet light, bacterial action, and direct uptake by plants are known to occur. [5]

concentrations in the top 1 ft of sample cores -
(note that detectable but generally much smaller concentrations are present further below the soil surface)

approximately 1000 sq ft area near the former discharge pipe:
average of all detectable concentrations = 10 mg/kg
maximum concentration observed = 54 mg/kg

in the runoff stream sediments:
average of all detectable concentrations = 6 mg/kg
maximum concentration observed = 18 mg/kg

in a belt of detectable but low cyanide concentrations 100 to 200 ft from Building 49:
average of all detectable concentrations = 1 mg/kg
maximum concentration observed = 4 mg/kg

Step 2: Estimation of Exposure Point Concentrations - Table C-1 summarizes a qualitative exposure pathway analysis for the existing conditions baseline case, which reviewed the sources and the potential mechanisms for chemical releases. The sources in this case are soils and sediments containing the chemical residues from torpedo test waste-water discharges. The mechanisms for release from these sources include volatilization and fugitive dust emission into air, leaching and erosion into surface water, leaching into ground water, and dermal contact. The

qualitative exposure pathway analysis then considers the potential human and animal populations that may be affected.

The only known human populations exposed directly to the soils or sediments containing the PGDN and/or cyanide residues or to inhalation of volatilized air emissions are maintenance and security personnel who enter the area occasionally. The only work areas within 400 ft are the Boiler House (Building 38) and the torpedo test compound. The former discharge area is remote from other buildings on the TAPCO site and an adjoining industrial property. The torpedo test compound gate is locked when Building 49 is not in actual use. There is a wooded buffer zone between the former discharge area and the roadway. Access into the plant grounds by non-employees is inhibited by warning signs for television surveillance, and security personnel regularly inspect the area.

No significant present or future human exposure to PGDN and cyanides seems possible via pathways involving surface water or ground water. The shallow ground water aquifer is not suitable for water supply, and there are no known water well users in the vicinity. Since the runoff stream is tributary to the TAPCO Plant Storm Sewer system, which discharges into Lake Erie near-shore waters (after considerable dilution), fish in Lake Erie may be exposed to sediments containing PGDN and/or cyanides, transported with the runoff stream. Human exposure by ingestion of such fish would be very rare in the absence of commercial fishing in Lake Erie

Small mammals, birds and geese wander freely into the former discharge area south of Building 49. These animal populations are subject to risks of exposure to PGDN and cyanides by several pathways, including inhalation of volatilized air emissions; dermal contact with soil particles containing the chemical residues; and ingestion of runoff stream water containing leached residues. However, no dead animals were observed in any of the field soil sampling or monitoring of ground water and surface water. ⇒ No acute tox

Cyanide volatilization was estimated, based on a transfer rate coefficient value of 0.23 mg CN/hr per sq metre from "still waters" containing 0.5 mg CN/L into the atmosphere, which was referenced in a study for a risk assessment on mineral leaching residues [5]. Assuming a concentration of 1.2 mg CN/L in ponded surface water (i.e., the maximum concentration observed in the runoff stream) covering an effective transfer area of 58 sq metres (625 sq ft) and a twofold increase in the transfer rate coefficient due to wind-induced agitation the estimated volatilization would be 65 mg CN/hr. Further assuming a 1 km/hr wind velocity and uniform dispersion in a 30 sq metre cross section air current, the resultant maximum exposure point concentration for the human and animal populations would be 0.0022 mg/cu m of HCN. This value, which is believed to be an overestimate of the actual exposure point concentration, is well below the 5 mg/cu m occupational health standard for HCN [7].

In the absence of a comparable volatilization data base for PGDN, a value from the same reference [5] of 0.04 kg moles/hr per sq metre, per atmosphere equilibrium vapor pressure driving force for the cyanide transfer rate coefficient was reduced by a factor of 2.5, to account for the larger PGDN molecule. For a transfer area of 27 sq metres (300 sq ft) and the maximum driving force of 0.0001 atmospheres (the vapor pressure of pure PGDN) the volatilization rate would be 7200 mg/hr of PGDN, and the resultant exposure point concentration would be 0.24 mg/cu m of PGDN. This value, which is believed to be an overestimate of the actual exposure point concentration, is within the 2 mg/cu m Federal occupational health standard for Nitroglycerin [7].

For inhalation, the human occupational threshold limit value (TLV) which applies to acute subchronic exposure, is not acceptable as an ARAR for chronic exposure. Accordingly, the discussion above for cyanides and PGDN is not applicable for chronic exposure.

The exposure point concentrations for animal ingestion of cyanide in the runoff stream were taken as the values determined during the surface water sampling program (0.3 to 1.2 mg/L). This would exceed the 0.2 mg/L chronic exposure ARAR value (the Water Quality Limit for drinking water supply [3], but it is well below lethal levels. Soluble PGDN concentrations would be negligible, since it is water-immiscible. Concentrations of PGDN in the runoff stream in particulate form (droplets or soil particles) were also assumed to be negligible, due to the episodic nature of the erosion process.

The exposure point concentration for animal direct dermal contact with PGDN is the observed 80 to 4900 mg/kg range in surface soils near the former discharge pipe from Building 49. No ARAR value is available for PGDN or for its close relatives, Nitroglycerin and EDN. However, protective clothing is strongly advised for human occupational exposure to PGDN [1] or to Nitroglycerin [6].

Table C-2 summarizes the estimated exposure point concentrations and lists the Applicable or Relevant and Appropriate Requirements (ARARs). The only complete pathway having an ARAR value available for comparison is for animal ingestion of cyanides, where the human water quality limit of 0.2 mg/L is assumed to apply. The exposure point concentrations of 0.3 to 1.2 mg/L exceed this ARAR, indicating risk for the animal populations for exposure to cyanide ingestion.

In a situation such as this, where one or more of the indicator chemicals does not have an ARAR value available, it would be prudent to continue with the remaining steps of the Risk Assessment Procedure. However, no values have been established for acceptable intakes (AIC or AIS) for PGDN ingestion and for dermal contact with cyanide or PGDN. Hence, the formal Estimation of Chemical Intakes, the Toxicity Assessments and the Risk Characterization steps would not provide additional insight.

3. Risk Assessment for Remedial Alternatives

3.1 Risk Assessment Procedure for Remedial Alternatives

Remedial Alternatives can be classified as either source control or management of migration. Source control remedial actions reduce the amount of mobile contaminant present in the soil, before it has migrated much beyond the initial discharge area, e.g., by excavation or by immobilization. Management of migration alternatives would address contaminants that have migrated away from the source to reduce the exposure point concentrations, e.g., by treating ground water or runoff. Whichever type of alternative is considered, the objective is to reduce the risk level for exposure point populations to be within an acceptable target risk range.

For non-carcinogens, an ARAR provides a specific target exposure point concentration as a performance goal for each indicator chemical. If no ARAR value is available, the intakes in mg/kg body weight for exposure point populations should be reduced to acceptable levels (AIC or AIS). For carcinogenic indicator chemicals, remedies must reduce exposure point chemical concentrations to levels associated with a carcinogenic risk range of 0.0001 to 0.0000001.

In general, the concentration of chemical residues in soil required to achieve the desired exposure point concentration for a given alternative is not known in advance. Thus, evaluation of alternatives follows a tiered approach, as follows:

1) reassess the indicator chemicals to determine whether any additions are necessary (usually required only for management of migration alternatives, in the event that an indicator chemical used for the baseline study is not treatable)

2) determine exposure pathways for each alternative, if different from the baseline study (usually required only for management of migration alternatives)

3) develop preliminary target concentrations , based either on ARAR or potential carcinogenic indicator chemicals (carcinogens usually drive the final design).

4) If no ARARs are available for the non-carcinogenic indicator chemicals, estimate the long term concentrations to ensure that acceptable risk levels (chronic hazard index) are attained.

5) Estimate the target release rates, i.e., back calculate release rates which would result in target concentrations at the exposure points. Repeat steps 1)-4), if necessary.

6) Assess potential short-term health effects of remedial alternatives, including subchronic exposures, management practices during remediation, and any potential effects that might result from failure.

3.2 Remedial Alternatives for the Former Building 49 Spill Area

The remedial actions considered for the Building 49 torpedo test wastewater discharge area were source control alternatives. Although PGDN and cyanides have migrated away from the former discharge area due to erosion, only isolated locations in the runoff stream have been affected. The situation does not require management of migration alternatives.

It is ES' opinion that no alternative can be considered acceptable, if it leaves the chemical residues near Building 49 unchanged. The cyanide concentrations may eventually decrease to acceptable levels due to chemical degradation, volatilization, bacterial action, plant uptake or leaching. However, in the absence of some remedial action, the threats to animal populations of PGDN or cyanide ingestion and/or PGDN dermal contact would continue indefinitely. Erosion of soil particles containing absorbed PGDN and cyanides would continue to threaten possible mobilization of toxic material through the storm sewer system, and eventually into Lake Erie.

It is recommended to undertake a remedial action to remove soil from the area of highest chemical residue concentrations, for appropriate disposal off site and with due precautions to avoid mobilization of PGDN or cyanide during removal. (See Section 6, Figures 5 and 6, and appended Drawing 7.) This would result in excavation of soil from an irregular polygon area (about 625 sq ft) around the former discharge pipe and dredging of the entire length of the runoff stream (about 120 ft). All soils containing detectable PGDN and/or cyanides at concentrations exceeding 10 mg/kg would be removed. However, soil outside of these areas containing cyanide at concentrations below 10 mg/kg would remain undisturbed.

Alternatives which would not involve removal of soil and sediments for treatment and disposal (i.e., capping the polygon area and regrading to divert both surface runoff and ground water flow from that area) were considered qualitatively. However, any such remedial action would be required to include facilities for monitoring and control of any leachate and/or post-closure ground water quality monitoring for at least 30 years.

3.3 Quantitative Risk Assessment for the Recommended Alternative

A formalized risk assessment of the soil excavation for off-site treatment and disposal alternative follows. This risk assessment evaluates the hazards that may result from allowing low concentrations of cyanide, below 10 mg/kg, to remain in the soil on site, based on the rationale that the cyanide concentrations which would leach into surface water or ground water would not pose a risk for public health or the environment. A similar rationale was followed in recent actions by state agencies and the U.S. Environmental Protection Agency with respect to cyanides in mineral processing residues [5].

Step 1: Review of Indicator Chemicals is cursory at this stage, since PGDN will have been removed to below detectable concentrations. Only Cyanides will be of concern.

Concentrations:

near the former discharge pipe site, Cyanides will have been removed to below 10 mg/kg, with the resultant distribution in an approximately 400 sq ft area as follows:

average of all detectable concentrations = 2 mg/kg
maximum concentration remaining = 5 mg/kg

in the runoff stream, the entire channel will have been dredged, which will remove all cyanides previously there;

however, the belt of soil containing detectable but low cyanide concentrations, will remain as before:

average of all detectable concentrations = 1 mg/kg
maximum concentration observed = 4 mg/kg

Step 2: Estimation of Exposure Point Concentrations is concerned only with Cyanides, and only for the same human and animal populations as in the Baseline Assessment. The exposure pathways previously identified for cyanides would remain, but with decreased exposure point concentrations. The exposure point concentration estimates in Table C-3 are based on reductions of the affected area size and its cyanide concentrations. The recommended remedial action will reduce the soil area containing cyanides to about 40% of its original size. The average of detectable cyanide concentrations would be about 20% of the present value, and the maximum cyanide concentration remaining would be 8% of the present maximum.

Step 3: The target concentration for cyanide at the exposure points is the ARAR value of 0.2 mg/L, the Water Quality Limit for water supply. It is seen that the estimated exposure point concentration of cyanide does not exceed this. Hence, the recommended remedial action recommended would be adequate.

TABLE C-1
Qualitative Analysis of Exposure Pathways

Air Emissions

Mechanism: Volatilization from surface soil or ponded surface water
Release Time Frame: chronic
Release amounts:

PGDN - low: vapor pressure = 0.0001 atmospheres at 77 ^{o}F for PGDN in pure liquid form

Cyanide - low, and requires neutral or acidic pH to be mobilized for air emission. Estimated vapor pressure of HCN for water containing 1 mg/L of cyanide = 0.00002 atmospheres at 77 ^{o}F

Primary Exposure Points:

Workers within 500 feet of the site

Exposure Route: Inhalation
Number of Persons Potentially Exposed:
only maintenance and security personnel, briefly, and on isolated occasions
Pathway completion: Possible

Animals entering the site

Exposure Route: Inhalation
Pathway completion: Possible

Mechanism: Fugitive Dust Generation
Release Time Frame: episodic, at times of high wind
Release amounts: none, due to wet environment for soils and sediments

Surface Water Runoff (overland flow and ground water flow discharging into the runoff stream)

Mechanism: Erosion of soil particles
Release Time Frame: episodic, following heavy rainfall
Release amounts: low; only occasional isolated particles have been released, based on sampling results for runoff stream sediments
Primary Exposure Points:

Fish populations in Lake Erie

Exposure Route:
Ingestion of sediments transported through the runoff stream, the Tapco Plant storm sewers and the City of Euclid storm sewers into Lake Erie
Pathway completion:
Possible, but highly unlikely, due to episodic time frame and isolated individual particles

Mechanism: Leaching
Release Time Frame: chronic
Release amounts:

PGDN - none: not miscible with water

Cyanide - low, ranging from 0.01 to 1 gram/day, based on observed concentrations and flows

TABLE C-1 (cont'd)
Qualitative Analysis of Exposure Pathways

Surface Water Runoff (cont'd)
- Mechanism: Leaching (cont'd)
- Primary Exposure Points:
  - Animals in the discharge area, drinking from the runoff stream
    - Exposure Route: Ingestion
    - Pathway completion: possible
  - Fish populations in Lake Erie
    - Exposure Route:
      - Ingestion or absorption of cyanides transported through the runoff stream, the Tapco Plant storm sewers and the City of Euclid storm sewers into Lake Erie
    - Pathway completion:
      - Possible, but highly unlikely, due to low release amounts and significant dilution by runoff from other areas served by these storm sewers

Ground Water (shallow aquifer)
- Mechanism: Leaching
- Release Time Frame: chronic
- Release amounts:
  - PGDN - none: not miscible with water
  - Cyanide - low, based on concentrations below the detection limit observed in the ground water monitoring wells and detectable-but-low concentrations found in deeper subsurface soil samples
- Primary Exposure Points:
  - Drinking water well users downgradient from the site
    - Exposure Routes: Ingestion and Dermal Absorption
    - Number of Persons Potentially Exposed:
      - None; the shallow groundwater aquifer is not suitable as a water supply for any significant use. Domestic and industrial water supplies in the area use municipal systems, drawing Lake Erie water.
    - Pathway Completion: not complete

Soils containing PGDN and/or Cyanides
- Mechanism: Dermal Contact
- Release Time Frame: episodic
- Release amounts:
  - PGDN - low
  - Cyanide - negligible
- Primary Exposure Points:
  - Animals entering the discharge area
    - Exposure Routes: Dermal Absorption
    - Pathway Completion: Possible

TABLE C-2

BASELINE EXPOSURE POINT CONCENTRATIONS AND
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)

Pathways	Cyanides	PGDN
Air/Volatilization/Inhalation		
Exposure Point Concentration	0.0022 mg/cu m	0.24 mg/cu m
ARAR (short term) [8]	5 mg/cu m	2 mg/cu m
ARAR (long term)	n/a	n/a
Water/Leaching/Ingestion		
Exposure Point Concentration	1.2 mg/L	not applicable
ARAR (short term)	n/a	n/a
ARAR (long term) [6]	0.2 mg/L	n/a
Soil/Dermal Contact		
Exposure Point Concentration	54 mg/L	4900 mg/L
ARAR (short term)	n/a	n/a
ARAR (long term)	n/a	n/a

Note: n/a = no ARAR value currently available

TABLE C-3

EXPOSURE POINT CONCENTRATIONS AND
APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS (ARARs)
FOR THE RECOMMENDED ALTERNATIVE

Pathways	Cyanides
Water/Leaching/Ingestion	
Exposure Point Concentration	0.1 mg/L
ARAR (short term)	n/a
ARAR (long term) [6]	0.2 mg/L
Soil/Dermal Contact	
Exposure Point Concentration	7 mg/L
ARAR (short term)	n/a
ARAR (long term)	n/a

Note: n/a = no ARAR value currently available

APPENDIX D

Summary of Western State Regulations or Guidelines for Required Cyanide Content of Spent Heap Leach Piles

Source: U.S. Environmental Protection Agency
Water Management Division
State Programs Branch
Denver, Colorado

EPA Contract No. 68-03-6289
Work Assignment No. 1
"Heap Leach Technology and Potential Effects in the Black Hills"

Report prepared by Engineering-Science, Inc.
30 September 1986
pp. 326-327

TABLE B-11

WESTERN STATE REGULATIONS OR GUIDELINES FOR NEUTRALIZATION OF SPENT HEAP LEACH PILES

State	Required Cyanide Content of Rinseate
Arizona	Require the operators to show evidence there is no free cyanide; no recommendations for rinsing process (J. McCutchan, Arizona State Mine Inspector, personal communication, 1986).
California	Guidelines vary between Regional Boards. Region 5 - 0.35 mg/l free cyanide (D. Heiman, California Regional Quality Control Board - Region 5, personal communication, 1986). Region 6 - 0.2 mg/l free cyanide or 10 mg/kg total cyanide (M. Watkins, California Regional Water Quality Control Board - Region 6, personal communication, 1986). Region 7 - 2.0 mg/l or 10 mg/kg free cyanide (California Regional Water Quality Control Board, 1985).
Colorado	Considering developing guidelines. Recommend 2 mg/l free cyanide; in sensitive areas recommend 0.75 mg/l. Recommend fresh water or hydrogen peroxide for rinsing method (A. Baldridge, Colorado Mined Land Reclamation Division, personal communication, 1986).
Idaho	Developing regulations (I. Nautch, Idaho Water Quality Bureau, personal communication, 1986). Requirements for Stibnite (0.2 mg/l free cyanide); recommend hypochlorite rinse.
Montana	Developing regulations/guidelines (D. Smith, Montana Department of State Lands, personal communication, 1986).
New Mexico	Guidelines; 45 kg (100 lb) sample rinsed can not have more than 100 mg/l total cyanide (A. Die, New Mexico Environmental Improvement Division, personal communication, 1986).
Nevada	Required to rinse with water until pH of rinse water is 8.5 for three consecutive days (H. Van Drieun, Nevada Division of Environmental Protection, personal communication, 1986).

(Continued)

TABLE B-11 (Continued)

State	Required Cyanide Content of Rinseate
Oregon	Guidelines of 0.01 mg/l total cyanide; recommend hypochlorite rinse (K. Ashbaker, Oregon Department of Environmental Quality, personal communication, 1986).
South Dakota	Guidelines for Wharf Resources (0.75 mg/l total cyanide); currently working on rinsing method recommendation (B. Townsend, South Dakota Department of Natural Resources, personal communication, 1986).
Utah	Guidelines for Mercur Mine (5 mg/l free cyanide); no recommendations for rinsing method (C. Dietz, Utah Water Pollution Control, personal communication, 1986).
Washington	Developing regulations/guidelines (B. Lingley, Washington Department of Natural Resources, personal communication, 1986).
Wyoming	No regulations or guidelines (C. Bosco, Wyoming Land Quality Division, personal communication, 1986).

REFERENCES

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