Final
May 25, 2000

COST AND PERFORMANCE REPORT

On-Site Incineration of Contaminated Soil at OU-3
Drake Chemical Superfund Site
Lock Haven, Pennsylvania

May 2000

SITE INFORMATION

IDENTIFYING INFORMATION (1)

Site Name: Drake Chemical Superfund Site
Location: Lock Haven, Pennsylvania
Operable Unit: OU-3
CERCLIS #: PAD003058047
ROD Date: September 29, 1988
Technology: Incineration
Type of Action: Remedial

Figure 1 shows the location of the Drake Chemical Superfund (DCS) Site in Pennsylvania and the site layout.

TECHNOLOGY APPLICATION

Period of Operation (3,12):
Trial Burn – January 25 through February 4, 1997
Full-Scale Operation – March 4, 1998 through April 22, 1999

Quantity of Material Treated During Application (11,17):
273,509 tons or 180,296 cubic yards (CY) of soil - The weight of the material treated in the incinerator was measured directly; the volume of treated material was estimated using a 1.517 tons per CY conversion factor.

BACKGROUND

Site History (1,2,5,17):

- The DCS Site is located in Clinton County, Pennsylvania, in the city of Lock Haven. The site was a chemical manufacturing facility that operated from 1951 to 1982. During its operation, the Drake Chemical Company produced chemical intermediates used in dye, cosmetic, textile, pharmaceutical, pesticide and herbicide manufacturing. The total area of the site is 9.6 acres and includes the previous location of the Drake Chemical Company and the adjacent Gorham property.

- The Drake Chemical plant included several major buildings, two lined wastewater treatment lagoons, a dry unlined sludge lagoon, and an unlined leachate lagoon. The lagoons were constructed during the late 1950s, probably for use as waste impoundments. The leachate lagoon was constructed in the lowest portion of the site, and is assumed to be the collection point for all surface runoff at the site. Approximately 60 process tanks and reactors were located inside and surrounding the process buildings. Approximately 10 additional larger tanks were staged outside of the buildings for bulk storage of acids, bases, and fuel oils.

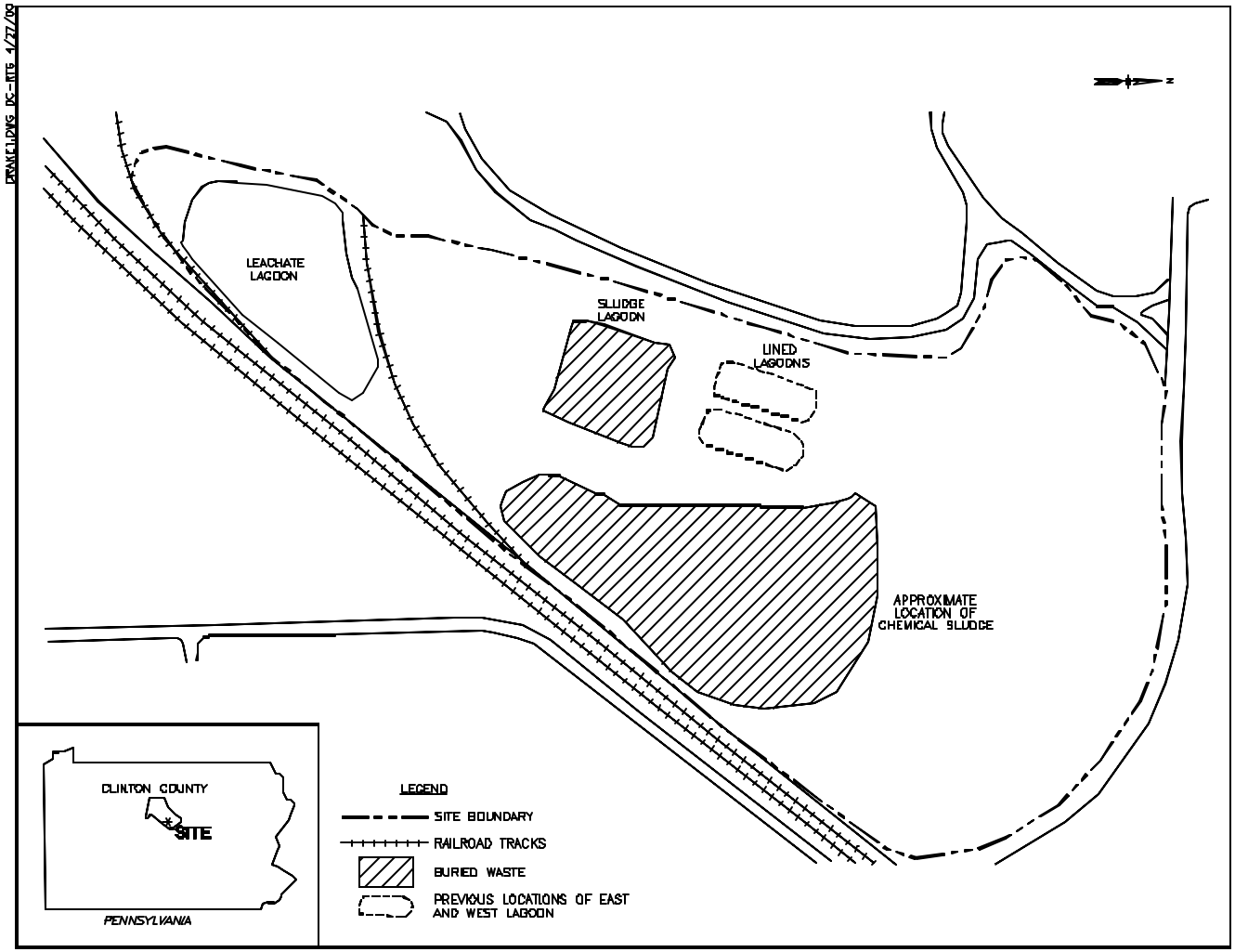

Figure 1. Drake Chemical Superfund Site

- Drake Chemical was cited many times by state and federal agencies for violating environmental and health and safety regulations. In 1982, after Drake Chemical failed to respond to the U.S. Environmental Protection Agency's (USEPA's) request to clean up the site, the USEPA initiated an emergency removal action during which drums, surface sludges, and storage tanks were removed. During this removal action, USEPA removed 1,700 exposed drums and drained and neutralized approximately 10 large tanks used for bulk storage of acids, bases, and fuel oil. Access to the site was controlled using an 8-foot fence, and warning signs were posted.

- A Superfund remedial investigation and feasibility study (RI/FS) was initiated in 1983. The first two phases of the RI/FS led to interim remedial actions, specifically: (1) the remediation of a leachate stream that was discharging to an off-site area; and (2) the removal of the two lined wastewater treatment lagoons and the on-site structures. Phase I was completed in 1987. Phase II was completed in 1988.

- The September 1988 ROD addressed both soil/sludge/sediment contamination and groundwater contamination at the DCS Site. Groundwater treatment is not addressed in this report.

- The Phase III RI/FS was initiated in January 1987. During Phase III field investigations, samples of soil, groundwater, surface water and sediment were collected. Forty-one test pits were excavated to characterize contaminated soil and sludge at the site. Each test pit was excavated to the water table or to a depth of 15 feet below ground surface (bgs), whichever was more shallow.

Waste Management Practices that Contributed to Contamination (1,10):

From the late 1950s through the early 1980s, four waste management lagoons (waste impoundments) were operated at the DCS Site. The two wastewater lagoons were lined, but the sludge lagoon and leachate lagoon were unlined. Additionally, drums of chemical waste, chemical sludge, and demolition debris were disposed on the ground surface and in the shallow subsurface at the site.

Remedy Selection (1):

Based upon CERCLA requirements and a detailed analysis of the alternatives, USEPA and the Pennsylvania Department of Environmental Resources (PADER) recommended incineration of all soil and buried waste within the DCS Site boundary down to the groundwater table. The selected remedy was deemed:

- To be protective of human health and the environment,
- To meet all applicable or relevant and appropriate federal and state requirements (ARARs), and
- To be cost-effective.

This remedy satisfies the statutory preference for remedies that employ treatment that reduces toxicity, mobility or volume as a principal element and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable.

The selected remedy for the DCS Site included:

- Excavation of approximately 252,000 CY of contaminated sludge, soil, and sediments,
- Treatment of excavated materials in an on-site mobile rotary kiln incinerator,
- Backfilling all excavations (potentially with incinerator ash), and
- Installation of a vegetative cover.

SITE LOGISTICS/CONTACTS

Role	Contact Information
Site Lead	Mr. William Werntges U.S. Army Corps of Engineers (USACE) Harrisburg Area Office - CENAB-COF-HA 285 18th Street – DDRE, Bldg. S-285 Newcumberland, PA 17070-5016 (717) 782-8750 william.h.werntges@usace.army.mil
Project Oversight	Mr. Mike Ogden USACE Harrisburg Area Office - CENAB-COF-HA 285 18th Street – DDRE, Bldg. S-285 Newcumberland, PA 17070-5016 (717) 782-3750 m.ogden@usace.army.mil
Regulatory Contacts	Mr. Gregg Crystall, Drake Project Manager USEPA Region 3 1650 Arch St. Philadelphia, PA 19103-2029 (215) 814-3207 crystall.gregg@epa.gov Mr. Michael Welch, Regional Manager Pennsylvania Department of Environmental Protection (PADEP) 208 West 3rd Street, Suite 101 Williamsport, PA 17701-6448 (570) 321-6518 WELCH.MICHAEL@a1.pader.gov
Remediation Contractor	Mr. Frederick Santucci, Drake Project Manager OHM Remediation Services Corporation 180 Myrtle Street Lock Haven, PA 17745 (570) 748-4102 santucci@ohm.com

MATRIX AND CONTAMINANT DESCRIPTION

MATRIX IDENTIFICATION

Soil (ex situ)

SITE GEOLOGY/STRATIGRAPHY (1)

The general lithology of the upper 15 feet of overburden material at the DCS Site consists of sandy clay floodplain deposits with various lenses of clay dispersed throughout. Below approximately 15 feet, the alluvial sediments increase in grain size with increasing depth to sand and gravel and then to sand with gravel and cobble-sized sandstone fragments. The bedrock is a soft gray to shaley claystone and medium hard limestone ranging from less than 1 foot to 31 feet in thickness, and occurs at approximately 110 feet bgs.

Groundwater at the DCS Site flows to the north, east and south. Local groundwater flows to the south and southeast toward Bald Eagle Creek. Groundwater is typically encountered at 12 to 15 feet bgs.

CONTAMINANT CHARACTERIZATION

Primary Contaminant Group:

Organic Compounds
- Volatiles (Halogenated)
- Volatiles (Nonhalogenated)
  - BTEX (benzene, toluene, ethylbenzene, xylenes)
- Semivolatiles (Halogenated)
  - Herbicides
- Semivolatiles (Nonhalogenated)
  - Polycyclic Aromatic Hydrocarbons

Key Specific Contaminants (12): β-Naphthylamine and Fenac (2,3,6-Trichlorophenyl-acetic acid)

Table 1 lists selected properties for the key specific contaminants present at the DCS Site.

Table 1. Contaminant Properties (13,14)

Property	Units	b-Naphthylamine	Fenac
Chemical Formula	-	$C_{10}H_9N$	$C_8H_5Cl_3O_2$
Molecular Weight	g/mole	143.18	239.5
Specific Gravity	-	1.061 at 98°C	Not available
Vapor Pressure	mm Hg	1 at 108°C	0.008 at 100°C
Melting Point	°C	111 – 112	156 – 160
Boiling Point	°C	306.1	Not available
Octanol-Water Partition Coefficient	log K_{ow}	2.02	3.20
Soil-Water Partition Coefficient	log K_{oc}	Not available	Adsorbed on soils; resists leaching
Solubility in Water	-	Very soluble	200 mg/L at 28°C; Very slightly soluble

Nature and Extent of the Contaminants (1,2,5):

During the Phase III RI/FS, soil, groundwater, surface water, and sediment contamination was observed throughout the site. The degree of contamination varied throughout the study area. In general, the frequency of occurrence and concentrations of contaminants were greatest on the Drake Chemical property and immediately off site, particularly on the Gorham property, which is located immediately north of the Drake Chemical property. Based on local groundwater patterns, the Gorham property is considered to be down gradient of the Drake Chemical Property.

Chemical sludge and contaminated soil were observed in all of the open area on the DCS Site. The soil and sludge were contaminated with volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), Fenac, β-naphthylamine, and metals. Organic contaminants (i.e., Fenac) were consistently observed in samples collected throughout the site. Field screening revealed that the vadose zone at the site was contaminated at varying concentrations with chlorinated solvents and BTEX. Substituted chlorinated phenols and alkyl phenols were also present. These compounds occurred throughout the site regardless of sampling depth; therefore, no one particular area of the Drake Chemical property or the adjacent Gorham property could have been considered the most likely source of contamination. Metals were also detected in soil samples; however, it is not clear whether activities at the Drake Chemical plant were the source of metals contamination.

Table 2 summarizes the results of the soil sampling conducted during the Phase III RI/FS.

Table 2. DCS Site Soil Concentrations

Parameter (units)	Concentration Range		Number of Detects Versus Total Number of Analyses
	Minimum	Maximum	
Volatile Organics			
Chlorobenzene (μg/kg)	2	14,000	24 of 42
Ethylbenzene (μg/kg)	1	27,000	11 of 42
Total Xylenes (μg/kg)	3	220,000	15 of 42
Semivolatile Organics			
Benzo(a)anthracene (μg/kg)	100	42,000	15 of 42
1,2-Dichlorobenzene (μg/kg)	200	100,000	10 of 42
1,4-Dichlorobenzene (μg/kg)	190	12,000	12 of 42
Fenac (μg/kg)	3.8	8,200	32 of 42
Naphthalene (μg/kg)	74	7,000	8 of 42
β-Naphthylamine (μg/kg)	470	1,500,000	18 of 42
Pentachlorophenol (μg/kg)	1,200	130,000	3 of 42
Phenanthrene (μg/kg)	120	140,000	6 of 42
1,2,4-Trichlorobenzene (μg/kg)	98	21,000	8 of 42
Metals			
Total Arsenic (mg/kg)	2	21	29 of 42
Chromium (mg/kg)	6.8	269	40 of 42
Lead (mg/kg)	3.3	1,170	31 of 42
Nickel (mg/kg)	3	41	37 of 42

MATRIX CHARACTERISTICS AFFECTING TECHNOLOGY COST OR PERFORMANCE

Table 3 lists selected characteristics for the soil at the DCS Site. Except where noted, data provided are average values for pre-treatment soil samples collected during the 1997 trial burns.

Table 3. Matrix Characteristics (7,12,17,19)

Characteristic	Value	Measurement Procedure
Soil Classification[a]	SM (silty sands and silt-sand mixtures)	USCS
Clay Content[a]	3.8 to 8.8%	ASTM D422
Moisture Content	16%[b]	ASTM D-3173
Total Organic Carbon	Not Available	Not Available
BTU Value	274 BTU/lb	ASTM D-2015
Halogen Content	260 mg/kg Chlorine	ASTM E-442 or D-808/D4327
Metal Content		
Arsenic	7.65 mg/kg	ICP
Beryllium	0.67 mg/kg	ICP
Cadmium	0.16 mg/kg	ICP, GFAA
Chromium	24.5 mg/kg	ICP
Lead	41.6 mg/kg	ICP

[a] These data correspond to treated soil samples. Data was not available for untreated soil.
[b] During full-scale operations, the soil moisture content ranged from 10.0 to 25.5% and averaged 17.6%.

TECHNOLOGY SYSTEM DESCRIPTION

PRIMARY TECHNOLOGY (7)

Incineration

SUPPLEMENTARY TECHNOLOGY TYPES (7)

Pre-Treatment (Solids): Screening, Source Separation, Shredding, Blending, and Dewatering
Post-Treatment (Solids): Quench, Stabilization and Compaction
Post-Treatment (Air): Cyclone, Secondary Combustion, Evaporative Cooler, Baghouse, and Scrubber

SYSTEM DESCRIPTION AND OPERATION

System Description (3,7,8,10,11,17)

A mobile, on-site incineration system was used to decontaminate soil, sludge, and sediment at the DCS Site. The incineration system consisted of a rotary kiln, a secondary combustion chamber (SCC), and an air pollution control system (APCS). Rotary kiln incinerators are able to process a wide variety of waste feed compositions and handle oversized wastes with minimal processing pre-treatment. The rotary kiln portion of the system is used to volatilize and destroy the majority of the organic contaminants. The remaining organic contaminants exit the kiln with the hot gases into the SCC where additional destruction occurs. The APCS is used to provide particulate matter and acid gas control. A schematic diagram of the soil treatment system is provided in Figure 2.

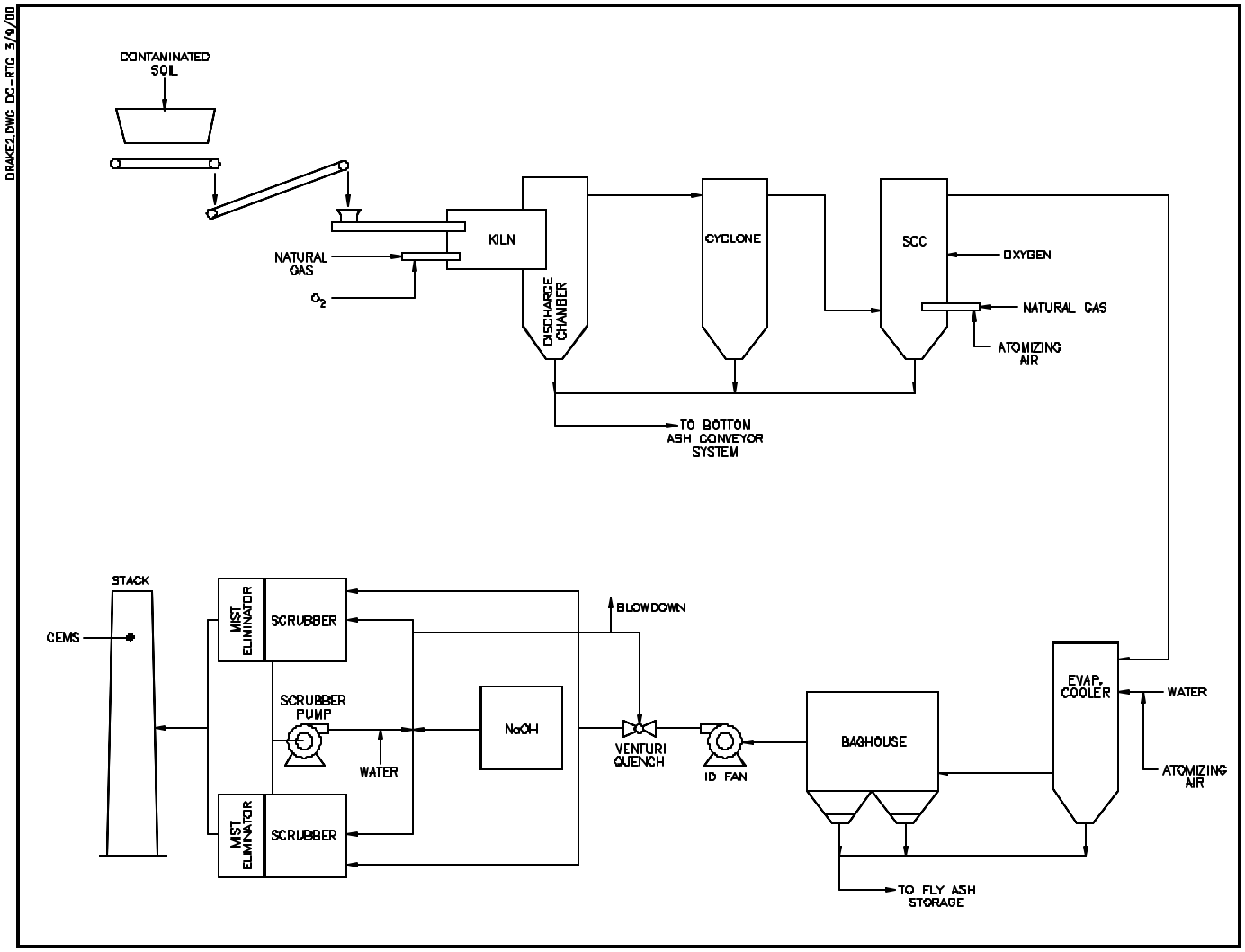

Figure 2. Schematic Diagram of the DCS Site Incinerator

The treatment system was operated using the following steps:

- Contaminated soil was excavated down to the water table over the entire site and was dried by adding cement kiln dust or lime. Soil was then transported to the debris separation building. Material greater than 4 inches in diameter was removed from the soil by rotating barrel screens and underwent manual segregation into organic and inorganic debris. Organic debris (e.g., wood) was shredded. Inorganic debris was either landfilled (e.g., plastic), recycled (e.g., steel) or cleaned for backfill (e.g., rocks). Material less than 4 inches in diameter was stockpiled in the feed preparation building after ferrous material was electromagnetically removed.

- Soil was blended with shredded brush, roots, trees, and other combustible material. The soil was fed onto a variable-speed, apron conveyor, a weigh belt conveyor, and into the kiln feed hopper. Feed material was delivered from the hopper to the kiln via dual, water-cooled, feed screws. The feed material was sampled and analyzed for metals, SVOCs (including β-naphthylamine), VOCs, Fenac, and physical/chemical parameters (e.g., BTU, moisture, ash, and chlorine).

- The rotary kiln was 60 feet long and had an inside diameter of 11 feet. The kiln was operated co-currently with the waste feed located at the same end as the oxygen-natural gas burners. Contaminated soil traveled through the kiln via gravity. The kiln was operated at a minimum exit gas temperature of 1599°F.

- The kiln discharge chamber was sized to reduce the flue gas velocity and remove large particulate matter in the exit gas stream. The hot gas cyclone subsequently removed additional particulate matter in the flue gas prior to entering the SCC. The SCC was operated at a minimum temperature of 1801°F and a minimum gas retention time of 2 seconds.

- Exhaust gases from the SCC were cooled to 400°F using air-atomized, water spray nozzles in an evaporative cooler. The cooled flue gases then passed through a baghouse for removal of particulate matter. The baghouse was designed with a 3-to-1 air-to-cloth ratio.

- The baghouse gas discharged to an induced draft (ID) fan, which drew gases through the entire system and discharged them through the wet scrubber system to the discharge stack. The fan produced negative pressure throughout the incineration system to eliminate fugitive emissions.

- Exhaust gases from the baghouse were cooled from approximately 350°F to 185°F with water sprays in the venturi quench unit. A mildly caustic scrubber water solution neutralized dissolved acid gases in one of two countercurrent, packed-bed absorbers, which were operated in parallel. The pH of the scrubber water was maintained between 6.5 and 9 by addition of a sodium hydroxide solution. The cleaned gas passed through a high-efficiency, multi-pass mist eliminator for removal of entrained water droplets.

- Cleaned flue gas was exhausted through a 150-foot tall stack equipped with continuous emission monitors (CEMs) that analyzed the gas for oxygen (O_2), carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbons (THC), and nitrogen oxides (NO_x).

- Bottom ash and fly ash were segregated prior to disposal. Bottom ash consisted of treated soil from the kiln and ash collected by the cyclone and SCC. Fly ash consisted of ash from the evaporative cooler and baghouse. Each ash stream was cooled and wetted by spraying with excess scrubber system water, after which it was conveyed to the ash storage area. A 10,000 CFM scrubber and Lamella clarifier system captured steam issuing from the wet ash drag conveyor to prevent off-site migration of particulate matter.

- Fly was were tested for TCLP metals as each storage bin was filled. Each day's production of bottom ash was separated for testing of TCLP metals, Fenac, SVOCs (including â-naphthalamine), and VOCs. Ash failing the cleanup criteria was retreated. Ash meeting the cleanup criteria was backfilled on site. Ash with TCLP concentrations greater than 25 times any of the drinking water standards was stabilized prior to backfill.

In addition to the incineration system, a 100-gpm wastewater treatment plant (WWTP) was installed and operated at the site to remove metals and organic compounds from various water streams generated during the project. Treated wastewater was discharged to Bald Eagle Creek. Wastewater treated at the WWTP included: incineration system pad cleaning water; ash handling pad cleaning water; wash water from equipment and personnel decontamination activities; water collected from the leachate lagoon; water collected from the soil excavation cavities; and potentially-contaminated storm water. The WWTP included the following treatment technologies:

- Primary settling;
- Wastewater equalization tanks;
- Metals removal through chemical addition, flocculation, and clarification;
- Neutralization;
- Sand filtration for suspended solids removal;
- Air stripping with activated carbon columns for treating organics transferred to the air stream;
- Bag filtration for removal of small-diameter suspended solids;
- Activated carbon adsorption for removal of residual organics; and
- Sludge dewatering with a filter press.

System Operation (1,3,5,9,17)

A background air monitoring study was performed prior to on-site construction activities. The study was conducted from October 10 through December 5, 1994. The perimeter air monitoring program was initiated in March 1995, and excavation began in April 1995. In order to support the vertical excavation at the site boundaries, a sheet pile excavation support system was installed to allow "straight cut" excavations. Soil excavation was the first step in incinerator construction, because the unit was sited on imported clean fill placed after the initial excavation. Construction of the incineration system was completed in December 1995. System shakedown and a clean burn were conducted on January 13, 1996. The incinerator was then shut down until September 23, 1996 due to a lawsuit that was filed by a local opposition group against the USEPA to stop the remediation project. Approval to continue the project was issued on August 14, 1996.

In September 1996, the optimization phase started, which consisted of testing the incinerator under different operating conditions. These tests include a clean burn, mini-trial burns, and mini-risk burns.

The trial burn was conducted from January 25 through February 4, 1997 to demonstrate the ability of the incinerator to meet the performance standards while treating contaminated soil from the DCS Site. Trial burn operating conditions were selected to represent expected conditions during full-scale operation of the incinerator.

Two risk burns were conducted under trial burn conditions with no spiking conducted. The risk burns generated data for performing a risk assessment of full-scale incinerator operations. Risk Burn 1 was conducted from January 20 through 22, 1997, and Risk Burn 2 was conducted from February 7 through 9, 1997. At this point the incinerator was shut down, pending approval of trail burn and risk burn results.

Following approval of the trial burn and risk assessment results for the Drake incineration project, the kiln burners were ignited on February 21, 1998. A clean burn demonstration was performed. Full-scale incineration operations were conducted from March 4, 1998 through April 22, 1999. In April 1998, the kiln lost refractory brick. After initial repairs failed, the kiln was re-lined with a castable refractory material. Once per month for the first three months of full-scale operation, the stack gases were tested for dioxins/furans. After that, and for the duration of the project, stack gases were tested quarterly for metals and particulate matter.

Perimeter air monitoring was conducted routinely at four fixed sampling locations. Automatic and real-time monitoring was conducted for non-methane organic compounds (NMOCs) and specific VOCs using an HNu Model 501 DP Environmental Chromatograph System. Time-integrated samples were collected and analyzed for VOCs, SVOCs, metals, and total suspended particulate. Ambient air sampling was conducted routinely at four fixed sampling locations within the local community. Time-integrated sampling at these sites was conducted for VOCs, SVOCs (including β-naphthylamine), Fenac, dioxins/furans, metals, and total suspended particulate.

At the end of full-scale operations, the incineration system was dismantled, decontaminated, and demobilized. Treated soil and imported clean fill was backfilled into the excavations and was compacted and contoured to facilitate drainage from the site following remediation. The soil was amended with compost to aid in establishing vegetative cover at the site. Project close-out inspections were conducted in November 1999. The remediation contract was completed on November 23, 1999. Over 294,000 tons of soil were treated on site; all treated soil was used as fill at the site.

OPERATING PARAMETERS AFFECTING TECHNOLOGY COST OR PERFORMANCE

The following table lists the operating limits for the incineration system that were approved by the USEPA and PADER prior to full-scale operation of the system. These operating limits were developed based on the results of the trial burns and risk burns.

Table 4. Operating Limits (9)

Parameter	Value
Waste Feed Rate, Maximum Allowable	47.3 tons/hr rolling average
Kiln Hood Pressure, Maximum Allowable	0 inches water column (wc) instantaneous -0.1 inches wc for 10 seconds or more
Kiln Exit Temperature, Minimum Allowable	1599ºF hourly average 1000ºF instantaneous
Kiln Exit Temperature, Maximum Allowable	2200ºF
Kiln Rotation, Minimum Allowable	0.4 revolutions per minute (rpm)
SCC Temperature, Minimum Allowable	1801ºF
SCC Temperature, Maximum Allowable	2600ºF
SCC Residence Time, Minimum Allowable	2 seconds
Baghouse Inlet Temperature, Maximum Allowable	500ºF
Baghouse Air-to-Cloth ratio, Maximum Allowable	3.6 to 1
Bag House Pressure Drop, Minimum Allowable	1.0 inches wc for more than 5 minutes
Bag House Pressure Drop, Maximum Allowable	6 inches wc for more than 5 minutes
Scrubber Inlet Temperature, Maximum Allowable	250ºF
Scrubber Liquid pH, Minimum Allowable	6.5
Scrubber Liquid Feed Rate, Minimum Allowable	450 gallons per minute (gpm) hourly average
CO Emissions, Maximum Allowable	200 parts per million by volume (ppmv) instantaneous 100 ppmv hourly rolling average
NO_x Emissions, Maximum Allowable	300 ppmv daily average
Stack Gas Velocity, Maximum Allowable	46.2 ft/sec hourly average

Table 5 lists values for selected parameters observed during incineration operations at OU-3. Observed values are compared to design values for each parameter. The parameters were selected for this report based on USACE guidance. Data provided are based on average conditions during full-scale operation of the incinerator system.

Table 5. Operating Parameters (7,9,11)

System Parameter	Design Value	Actual Value
Air Flow Rate	29,250 dry standard cubic feet per minute (dscfm)	Parameter not measured
Residence Time	>2 seconds (air in SCC) 30 minutes (soil in kiln)	Parameter not measured Parameter not measured
System Throughput	60 ton/hr	40.4 tons/hr (average)
Flue Gas Temperature	Information not available Information not available	>1599 °F (kiln) >1801 °F (SCC)

TIMELINE (2,3,4)

Date	Activity
September 8, 1983	Drake Chemical Site placed on NPL
1983 – 1984	Phase I RI/FS performed
1984 – 1986	Phase II RI/FS performed
1987	Phase I remediation completed
January 1987	Phase III RI/FS initiated
August 31, 1988	Proposed Plan for remedial action at OU-3 released to public
September 7, 1988	Public comment period on the Proposed Plan
September 29, 1988	ROD signed by the U.S. EPA and the Army
Spring 1989	Phase II remediation completed
October 1990 – August 1991	Incineration feasability study conducted
September 30, 1993	Contract awarded
November 15, 1993	Notice to proceed issued
November 14, 1994	Mobilization to the site
May 13, 1995	WWTP put into operation
January 3, 1996	Construction of incinerator and supporting facilities complete
January 13, 1996	Shakedown and clean burn complete
January 14, 1996 – August 14, 1996	Stop work in effect due to lawsuit
September 19, 1996	Public meeting held on the revised trial burn risk assessment protocol
January 20 – 22, 1997	Risk Burn No. 1 conducted
January 25 – February 4, 1997	Trial Burn conducted
February 7 – 9, 1997	Risk Burn No. 2 conducted
February 10, 1997 – March 4, 1998	Project shutdown for risk and trial burn data review
February 10, 1998	Public meeting held on the risk assessment
March 9, 1998	Full-scale operations started
April 22, 1999	Soil incineration completed
November 23, 1999	Project completion

TECHNOLOGY SYSTEM PERFORMANCE

CLEANUP GOALS/STANDARDS (7,8,9,17)

The following table provides the performance objectives that were established for the DCS Site incinerator:

Table 6. Incinerator Performance Objectives

Parameter	Performance Criteria
Principal Organic Hazardous Constituent (POHC) DRE	≥ 99.99%
Particulate Matter (PM) Emissions	≤0.01 grains/dry standard cubic foot (gr/dscf) @ 7% O_2
Hydrochloric Acid (HCl) Emissions	≤4 lb/hr or 99% reduction
Total Dioxins and Furans Emissions	≤30 nanograms/dry standard cubic meter (ng/dscm) @ 7% O_2
NO_x Emissions	≤300 ppmv @ 7% O_2 (daily average)
CO Emissions	≤100 ppmv @ 7% O_2 (hourly rolling average)
Metal Emissions	
As	<0.11 g/sec
Be	<0.20 g/sec
Cd	<0.27 g/sec
Cr^{+6}	<0.04 g/sec
Cr	<0.12 g/sec
Pb	<1,384 g/sec

The following table lists the remediation objectives for soil treated in the incinerator operated at the DCS Site. These objectives were established in the ROD to meet PADER requirements.

Table 7. Treated Soil Objectives

Contaminant	Cleanup Level (µg/kg)
Volatile Organics	
Benzene	100
Chlorobenzene	10,000
1,2-Dichloroethene	7,000
Ethylbenzene	70,000
Tetrachloroethane	2,000
Toluene	100,000
Trichloroethene	2,000
Total Xylenes	5,000
Semivolatile Organics	
Benzo(a)anthracene	6,000
Benzo(b)fluoranthene	6,000
Benzo(k)flouranthene	60,000
Benzoic Acid	3,300
Benzo(a)pyrene	660
Chrysene	300,000
1,2-Dichlorobenzene	7,000
1,4-Dichlorobenzene	8,000
Fluoranthene	400,000
Naphthalene	8,000

Table 7. Treated Soil Objectives (Continued)

Contaminant	Cleanup Level (■g/kg)
Pentachlorophenol	40,000
Phenanthrene	80,000
Phenol	400,000
Pyrene	300,000
1,2,4-Trichlorobenzene	20,000
β-Naphthylamine	55
Chlorinated Herbicide	
Fenac	1,000

Fly ash and bottom ash were analyzed for metals using the toxicity characteristic leaching procedure (TCLP). The results were compared to the Pennsylvania drinking water standards listed in Table 8. Ash meeting these standards could be backfilled on site without restriction. Ash failing these standards, but with TCLP concentrations less than 25 times the drinking water standards, could be returned to the site as fill material but could not be placed below 553 feet mean sea level (8 feet above the average water table). Treated soil with TCLP concentrations greater than 25 times the drinking water standard required stabilization prior to backfill.

Table 8. Ash TCLP Concentration Objectives

Metal	Drinking Water Standard (mg/L)	25 x Standard (mg/L)
Arsenic	0.05	1.25
Barium	1.0	25
Cadmium	0.01	0.25
Chromium	0.05	1.25
Lead	0.05	1.25
Mercury	0.002	0.05
Selenium	0.01	0.25
Silver	0.05	1.25

As discussed previously, perimeter air monitoring was routinely performed at the site. Three VOCs were selected as key indicator compounds to be monitored by the HNu if the average NMOC reading exceeded 1 ppm. Perimeter action levels were set at 10% of the OSHA permissible exposure limits (PELs) for each of the three selected contaminants. The perimeter action levels were:

- 9.146 ppm for toluene
- 7.777 ppm for chlorobenzene
- 2.511 ppm for tetrachloroethene

Table 9 provides the discharge limitations for the WWTP at the DCS Site. Weekly samples of the WWTP effluent were required whenever the WWTP was in operation.

Table 9. Wastewater Discharge Limitations

Parameter	Monthly Average (mg/L)	Daily Maximum (mg/L)
β-Naphthylamine	0.012	0.024
Fenac	0.100	0.200
Toluene	0.010	0.020
Chlorobenzene	0.010	0.020
1,2-Dichlorobenzene	0.010	0.020
1,4-Dichlorobenzene	0.010	0.020
1,2-Dichloroethane	0.010	0.020
Trichloroethene	0.005	0.010
Total Arsenic	0.100	0.200
Total Barium	2.000	4.000
Total Cadmium	0.060	0.120
Total Nickel	0.200	0.400
Total Chromium	0.150	0.300
Total Lead	1.000	2.000
pH	6 to 9 standard units	6 to 9 standard units

PERFORMANCE DATA (12,17)

A trial burn was conducted from January 25 through February 4, 1997. This test consisted of two conditions and four runs were performed for each condition. These eight runs were used to develop emissions estimates under worst-case conditions. Condition 1 testing was performed under high waste feed rate and minimum combustion temperature conditions. During this condition, the contaminated soil was spiked with naphthalene and 1,4-dichlorobenzene. Condition 2 testing was performed under lower waste feed rates and maximum combustion temperature conditions. During this condition, the contaminated soil was spiked with metals in addition to naphthalene and 1,4-diclorobenzene). The trial burn confirmed that the incineration system could meet the performance criteria for soil treatment, as well as air emission requirements. Table 10 summarizes the results of the trial burn.

Table 11 presents analytical data on the physical characteristics and VOC, SVOC, and metal concentrations for the soil fed to the incinerator during the trial burn. Before treatment, feed material exceeded the clean up goal for β-naphthylamine and fenac in all runs, and benzo (a) pyrene in one run. During full-scale operations, the only parameters to exceed the cleanup goal in the feed material were 1,2-dichlorobenzene, benzo(a)anthracene, β-naphthylamine and fenac.

Tables 12 and 13 provide VOCs, SVOCs and TCLP metal results for bottom ash (treated soil) and fly ash during the trial burn. The treated soil objectives for β-naphthylamine and Fenac were exceeded in most or all Condition 1 runs in bottom ash samples. Condition 1 was designed to demonstrate the incinerator's effectiveness in meeting stack emissions criteria for particulate matter, hydrochloric acid, PCDD/PCDF, emissions and DRE at high feed rates and low temperatures, without regard to ash quality. Condition 2 was designed to demonstrate compliance with stack emissions criteria noted above plus metals emissions rates while meeting the treated soil objectives.

Table 10. Trial Burn Performance Results

Parameter	Units	Performance Standard	Cond 1 Run 1	Cond 1 Run 2	Cond 1 Run 3	Cond 1 Run 4	Cond 2 Run 5	Cond 2 Run 6	Cond 2 Run 7	Cond 2 Run 8
DRE naphthalene	%	≥ 99.99	99.999941	99.999896	99.999935	99.999871	99.999961	99.999942	99.999941	99.999938
DRE 1,4-dichlorobenzene	%	≥ 99.99	99.999983	99.999961	>99.999984	99.999949	>99.999985	>99.999984	>99.999984	>99.999985
PM Emissions	gr/dscf @ 7% O_2 equiv.	≤ 0.01	0.0011	0.00082	0.00112	0.00091	0.00072	0.00077	0.00084	0.00084
HCl Emissions	lb/hr	≤ 4	<0.0094	<0.0088	0.043	<0.0094	0.018	0.017	0.017	0.021
HCl removal	%	> 99	>99.986	>99.987	99.942	>99.987	99.973	99.972	99.974	99.968
Dioxins/Furans Emissions	ng/dscm @ 7% O_2 equiv.	<30	0.87	1.87	1.42	1.50	1.22	1.94	1.21	1.72
NO_x Emissions	ppm @ 7% O_2 equiv.	<300	165	173	185	162	77	74	72	71
CO Emissions	ppm @ 7% O_2 equiv.	<100	3	5	1	5	3	3	3	4
Metal Emissions										
As	g/sec	<0.11	Not Analyzed	Not Analyzed	Not Analyzed	Not Analyzed	1.87E-5	1.34E-5	2.38E-5	2.46E-5
Be	g/sec	<0.20					3.5E-7	3.4E-7	3.4E-7	2.5E-7
Cd	g/sec	<0.27					1.73E-5	8.88E-6	7.85E-6	1.01E-5
Cr^{+6}	g/sec	<0.04					<1.2E-5	<1.2E-5	<1.2E-5	<1.1E-5
Cr	g/sec	<0.12					2.38E-5	2.09E-5	2.91E-5	2.31E-5
Pb	g/sec	<1384					6.26E-6	3.67E-6	7.40E-6	2.60E-6
β-Naphthylamine (fly ash)	µg/kg	55	<9	<9	<9	<9	<9	<9	<9	<9
β-Naphthylamine (bottom ash)	µg/kg	55	<16	72/356	<16/135	56/<16	<16	<16	<16	<16

The two numbers presented for β-Naphthylamine are analytical results for two separate samples during each run. Where only one β-Naphthylamine result is presented, both samples yielded the same result.

Table 11. Trial Burn Contaminated Soil Feed Analysis (mg/kg except where otherwise noted)

Parameter	Cond 1 Run 1	Cond 1 Run 1D	Cond 1 Run 2	Cond 1 Run 3	Cond 1 Run 4	Cond 2 Run 5	Cond 2 Run 5D	Cond 2 Run 6	Cond 2 Run 7	Cond 2 Run 8
Moisture (%)	16.28	15.50	15.84	16.85	16.86	15.76	16.09	16.69	15.82	15.71
Ash (%)	78.67	78.68	76.52	77.14	77.41	77.54	77.26	77.32	78.21	77.72
Heating Value (BTU/lb)	101	133	649	232	187	229	<84	349	251	249
Chlorine (mg/kg)	270	270	220	310	310	290	240	210	240	250
Benzene	<2.3	NS	<2.3	<2.3	<2.3/<2.3	<6.1	<6.1	<6.1	<6.1	<6.1
Chlorobenzene	294	NS	306	204	384/319	378	364	438	439	337
1,2-Dichloroethene	<3.2	NS	<3.2	<3.2	<3.2/<3.2	<8.5	<8.5	<8.5	<8.5	<8.5
Ethylbenzene	14	NS	15	9	19/17	23	21	24	29	21
Tetrachloroethene	2	NS	3	<2.3	3/<2.3	<6.1	<6.1	<6.1	<6.1	<6.1
Toluene	41	NS	55	37	56/46	40	42	78	44	42
Trichloroethene	5	NS	3	2	3/2	5	<2.4	4	3	<2.4
Total Xylenes	116	NS	129	73	165/138	182	159	185	265	185
Benzo(a)anthracene	3400	2890	3180	2900	3470	2740	3820	3810	2700	3010
Benzo(b)fluoranthene	595	526	382	474	487	424	914	507	426	532
Benzo(k)flouranthene	513	376	350	495	488	373	917	497	317	486
Benzoic Acid	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
Benzo(a)pyrene	597	482	374	545	551	422	991	536	393	536
Chrysene	646	598	521	741	693	549	1370	637	572	643
1,2-Dichlorobenzene	972	1150	1360	839	795	992	1380	1240	586	1400
1,4-Dichlorobenzene	634	512	577	270	<100	658	576	562	126	520
Fluoranthene	1420	1340	1220	2040	1740	1250	3120	1690	1340	1730
Naphthalene	511	519	544	450	432	556	665	683	630	576
Pentachlorophenol	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100

Table 11. Trial Burn Contaminated Soil Feed Analysis (µg/kg except where otherwise noted) (Continued)

Parameter	Cond 1 Run 1	Cond 1 Run 1D	Cond 1 Run 2	Cond 1 Run 3	Cond 1 Run 4	Cond 2 Run 5	Cond 2 Run 5D	Cond 2 Run 6	Cond 2 Run 7	Cond 2 Run 8
Phenanthrene	845	801	788	1470	865	732	2050	1350	876	1140
Phenol	433	411	457	501	413	512	607	679	635	529
Pyrene	1220	1110	814	1430	1200	926	2440	1510	987	1370
1,2,4-Trichlorobenzene	1020	805	855	727	707	886	968	1010	1370	1090
β-Naphthylamine	1820	NA	2970	4190	1820	8630	NA	8030	3670	3280
Fenac	9900	NS	13600	11100	18300	9470	NS	9940	19700	8960
Arsenic (mg/kg)	7.67	NS	7.91	6.55	7.74	3.52	NS	8.25	9.43	10.2
Barium (mg/kg)	NA	NS	NA	NA	NA	85.5	NS	88.3	93.2	90.3
Cadmium (mg/kg)	0.13	NS	0.14	0.13	0.35	0.117	NS	0.172	0.132	0.116
Chromium (mg/kg)	27.8	NS	26.4	19.6	24.5	24.1	NS	24.8	24.1	24.4
Lead (mg/kg)	39.1	NS	45.6	42.3	44.1	42.5	NS	39.3	41.2	38.4
Mercury (mg/kg)	0.31	NS	0.25	0.27	0.29	0.295	NS	0.276	0.261	0.292
Selenium (mg/kg)	NA	NS	NA	NA	NA	0.37	NS	0.24	0.33	0.50
Silver (mg/kg)	NA	NS	NA	NA	NA	<0.30	NS	<0.23	<0.26	<0.29

NS – Not sampled; NA – Not analyzed

Table 12. Trial Burn Bottom Ash Analysis (µg/kg except where otherwise noted)

Parameter	Criteria	Cond 1 Run 1		Cond 1 Run 2		Cond 1 Run 3		Cond 1 Run 4		Cond 2 Run 5		Cond 2 Run 6		Cond 2 Run 7		Cond 2 Run 8	
Benzene	100	2.1	2.8	1.7	2.5	2.2	3.0	2.4	3.0	18.5	15	19	18	17	16	24	18
Chlorobenzene	10,000	2.4	2.2	3.6	4.2	5.1	2.7	2.4	2.7	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
1,2-Dichloroethene	7,000	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Ethylbenzene	70,000	0.6	0.5	0.4	0.7	0.6	0.6	0.5	0.5	1.6	1.2	1.6	1.5	7.8	1.7	2.3	2.1
Tetrachloroethene	2,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	100,000	3.5	2.9	2.9	2.9	2.8	2.8	2.3	2.7	7.4	5.4	8.1	8.3	15	9.2	12	11
Trichloroethene	2,000	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Xylenes	5,000	2.3	1.8	1.9	3.3	3.1	2.3	1.8	2.0	6.95	3.7	4.6	3.8	49.6	9.0	7.4	7.4
Benzo(a)anthracene	6,000	834	810	594	500	919	843	660	715	<140	<140	<140	<140	<140	<140	<140	<140
Benzo(b)fluoranthene	6,000	477.5	230	211	140	247	223	207	274	<140	<140	<140	<140	<140	<140	<140	<140
Benzo(k)flouranthene	60,000	<354	<140	<140	<140	<140	<140	<140	160	<140	<140	<140	<140	<140	<140	<140	<140
Benzoic Acid	3,300	2,420	3,570	1,780	2,220	2,650	2,380	2,220	2,230	495	270	670	280	410	450	610	740
Benzo(a)pyrene	660	<428	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140
Chrysene	300,000	453.5	270	186	160	232	209	217	296	<140	<140	<140	<140	<140	<140	<140	<140
1,2-Dichlorobenzene	7,000	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140
1,4-Dichlorobenzene	8,000	219	230	338	590	348	<140	244	316	<140	<140	<140	<140	<140	<140	<140	<140
Fluoranthene	400,000	682.5	400	279	290	315	280	294	369	<140	<140	<140	<140	<140	<140	<140	<140
Naphthalene	8,000	715	1,170	4,250	1,260	1,300	1,350	693	766	<140	<140	<140	<140	<140	<140	<140	<140
Pentachlorophenol	40,000	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140	<140
Phenanthrene	80,000	377	350	225	220	229	215	233	275	<140	<140	<140	<140	<140	<140	<140	<140
Phenol	400,000	209.5	210	189	<140	279	241	229	292	<140	<140	<140	<140	<140	<140	<140	<140
Pyrene	300,000	397.5	150	<140	<140	142	<140	<140	205	<140	<140	<140	<140	<140	<140	<140	<140
1,2,4-Trichlorobenzene	20,000	<140	<140	<140	<140	<140	<140	<140	149	<140	<140	<140	<140	<140	<140	<140	<140
β-Naphthylamine	55	<16	<16	72	356	<16	135	56	<16	<16	<16	<16	<16	<16	<16	<16	<16
Fenac	1,000	4030	2080	2630	7530	5770	4230	2960	4870	<570	<570	<570	<570	<570	<570	<570	<570
Arsenic (mg/L)	0.05	0.005	0.0124	0.0196	0.0116	0.0064	0.0094	0.0096	<0.0048	0.129	0.196	0.118	0.132	0.223	0.180	0.132	0.150

Table 12. Trial Burn Bottom Ash Analysis (mg/kg except where otherwise noted) (Continued)

Parameter	Criteria	Cond 1 Run 1		Cond 1 Run 2		Cond 1 Run 3		Cond 1 Run 4		Cond 2 Run 5		Cond 2 Run 6		Cond 2 Run 7		Cond 2 Run 8	
Barium (mg/L)	1.0	0.232	0.242	0.245	0.217	0.228	0.228	0.258	0.145	0.166	0.151	0.197	0.183	0.193	0.169	0.146	0.148
Cadmium (mg/L)	0.01	0.0008	0.001	0.0011	0.0009	0.0006	0.001	0.0011	0.0008	0.0559	0.0597	0.0471	0.0848	0.059	0.0634	0.0673	0.0504
Chromium (mg/L)	0.05	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032	0.00451	<0.0032	<0.0032	<0.0032	<0.0032	<0.0032
Lead (mg/L)	0.05	0.0032	<0.00307	0.0056	0.0088	<0.00307	0.0062	0.004	<0.00307	0.171	0.187	0.28	0.222	0.159	0.229	0.172	0.157
Mercury (mg/L)	0.002	0.000277	0.000254	0.000232	0.000257	0.000249	0.000235	0.000216	0.00023	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	0.000211	<0.0002
Selenium (mg/L)	0.01	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	<0.0028	0.003
Silver (mg/L)	0.05	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003

The two numbers presented for VOC and SVOC parameters are analytical results for two separate samples collected during each run. The two numbers presented for metals are analytical results for the sample and a duplicate.

Table 13. Trial Burn Fly Ash Analysis (mg/kg except where otherwise noted)

Parameter	Criteria	Cond 1 Run 1		Cond 1 Run 2		Cond 1 Run 3		Cond 1 Run 4		Cond 2 Run 5		Cond 2 Run 6		Cond 2 Run 7		Cond 2 Run 8	
Benzene	100	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chlorobenzene	10,000	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
1,2-Dichloroethene	7,000	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Ethylbenzene	70,000	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
Tetrachloroethene	2,000	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	100,000	<0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.5	0.8	0.7	0.5	0.5	0.5	0.6	<0.5
Trichloroethene	2,000	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Total Xylenes	5,000	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7	<0.7
Benzo(a)anthracene	6,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Benzo(b)fluoranthene	6,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Benzo(k)flouranthene	60,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Benzoic Acid	3,300	<70	<70	<70	<70	<70	<70	<70	93	<70	<70	<70	<70	<70	<70	<70	<70
Benzo(a)pyrene	660	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Chrysene	300,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
1,2-Dichlorobenzene	7,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
1,4-Dichlorobenzene	8,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Fluoranthene	400,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Naphthalene	8,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Pentachlorophenol	40,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Phenanthrene	80,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Phenol	400,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
Pyrene	300,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
1,2,4-Trichlorobenzene	20,000	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70	<70
β-Naphthylamine	55	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9	<9
Fenac	1,000	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200	<200
Arsenic (mg/L)	0.05	0.0174	0.0094	0.0173	0.0186	0.0226	0.0142	0.030	0.0116	0.677	0.578	13.6	13.7	18.5	18	30.4	30.7
Barium (mg/L)	1.0	0.152	0.181	0.149	0.169	0.152	0.174	0.0765	0.0887	0.158	0.145	0.167	0.169	0.198	0.187	0.241	0.187

Table 13. Trial Burn Fly Ash Analysis (mg/kg except where otherwise noted) (Continued)

Parameter	Criteria	Cond 1 Run 1		Cond 1 Run 2		Cond 1 Run 3		Cond 1 Run 4		Cond 2 Run 5		Cond 2 Run 6		Cond 2 Run 7		Cond 2 Run 8	
Cadmium (mg/L)	0.01	0.0023	0.0025	0.0023	0.0024	0.0024	0.0021	0.002	0.0016	0.815	0.720	4.49	4.37	4.57	4.78	7.38	7.46
Chromium (mg/L)	0.05	0.203	0.201	0.244	0.233	0.248	0.246	0.226	0.217	0.255	0.255	0.323	0.314	0.257	0.248	0.193	0.202
Lead (mg/L)	0.05	0.013	0.0176	0.0134	0.0108	0.0152	0.0118	0.0144	0.0148	0.204	0.205	0.361	0.339	0.341	0.340	0.383	0.465
Mercury (mg/L)	0.002	<0.0002	0.000204	<0.0002	<0.0002	0.000237	<0.0002	0.00021	0.000203	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Selenium (mg/L)	0.01	0.021	0.020	0.0262	0.0238	0.0324	0.0346	0.0288	0.0244	0.0638	0.0638	0.153	0.155	0.199	0.168	0.162	0.197
Silver (mg/L)	0.05	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003

The two numbers presented for VOC and SVOC parameters are analytical results for two separate samples collected during each run. The two numbers presented for metals are analytical results for the sample and a duplicate.

Table 14 summarizes results from Fenac and β-naphthylamine analyses performed on samples collected from treated soil piles during full-scale treatment. Samples of the treated soil were collected for analysis daily during incinerator operations. If a treated soil sample did not meet the treated soil objectives, the soil was retreated until the objectives were met. During full-scale operations, 8 bins or 2.7% of soil treated required re-treatment.

Table 14. Summary of Organics Results from Treated Soil Analyses (Full-scale Operation) (15,17)

Parameter	USEPA Test Method	No. of Samples	No. of Results Above Detection	Concentration Range	Treatment Criteria
Fenac	8151	344	0	All were ≤ 1000	≤ 1000
β-Naphthylamine	8270SIM	344	8	≤ 55 – 114	≤ 55

Table 15 summarizes results from TCLP analyses performed on samples collected from ash piles during full-scale treatment.

Table 15. Summary of TCLP Results from Soil Analyses (Full-scale Operation) (17)

Bin Classification	No. of Bins Below Drinking Water Standards	No. of Bins Above Drinking Water Standards but Below 25xStandards	No. of Bins Requiring Stabilization
Bottom Ash	298	43	0
Fly Ash	0	71	2

Pollutants were detected in background air samples at concentrations typical for urban areas. Dichloromethane and benzo(a)pyrene were detected at or above Pennsylvania Annual Ambient Toxic Guidance (ATG) values in 1 of 8 and 2 of 8 samples, respectively. Fenac and nitrobenzene were detected in 7 of 8 samples. Several times during full-scale operations, the NMOC action level of 1 ppm was exceeded in real-time perimeter air samples, but in each case the speciated VOC results were below action levels. Time-integrated air samples collected at the perimeter and off-site indicated at least one ATG exceedance for benzo(a)pyrene and discrete metals.

PERFORMANCE DATA ASSESSMENT (6,10,11,17)

- An incineration feasibility study was conducted between October 1990 and August 1991. All test runs met the cleanup criteria established for the DCS Site. The pilot-scale rotary kiln incinerator achieved 99.99% DRE of POHCs, which were spiked into the soil. The leachable metal concentrations in the ash from the pilot study were either non-detect or were below TCLP limits for characteristic hazardous waste, so no fixation or stabilization was required prior to backfilling incinerator ash on site. Some fly ash had TCLP metal concentrations above the drinking water standards.

- A risk assessment concluded that full-scale operation of the incinerator at the DCS Site would not pose a threat to public health. All of the estimated risks were within the range that is considered acceptable for cleanup activities performed under the Superfund hazardous waste program.

- The results from the trial burn demonstrated that the incinerator met the RCRA performance standards of 40 CFR 264 and other regulatory and contractual requirements while burning site soils spiked with POHCs and metals.

- During full-scale operations, all treated soil batches met the cleanup criteria for Fenac after the first pass; eight treated soil batches did not initially meet the cleanup goal for β-naphthylamine. Of the total mass of soil treated, less than 3% required additional thermal treatment after the first pass. Soil not meeting the cleanup criteria was sent back to the feed preparation building where it was blended with the other soil, and then conveyed to the incinerator.

- TCLP metals results for 2 batches of fly ash were greater than 25 times the drinking water standard (once during a metals spiking test and the other time during full-scale operation). The fly ash from these batches was stabilized prior to backfill.

- Stack testing, perimeter air monitoring and ambient air monitoring performed in the community near the project site met all specified objectives.

PERFORMANCE DATA QUALITY (9,12,17)

All trial burn testing was conducted in accordance with the source test sampling and analysis protocols specified in the quality assurance plan for the trial burn. All data gathered during the trial burn were found to be of acceptable quality to demonstrate that the incinerator met the performance standards. The QA/QC results were compared to the data quality objectives specified in the Project Quality Assurance Plan contained in the Trial Burn Plan. This comparison showed that greater than 90% of the accuracy, precision, and method performance objectives were met.

The perimeter air sampling and off-site ambient air sampling were conducted in accordance with the DCS Site Perimeter Air Sampling Plan, including the calibration, sampling and analytical procedures. Other sampling and analysis activities during full-scale operations (e.g., soil and ash tests) were conducted according to the protocols in the Chemical Quality Management Sampling Plan.

COST OF THE TECHNOLOGY SYSTEM

PROCUREMENT PROCESS (3,17)

USACE awarded the contract to perform the soil remediation at OU-3 to RUST International on September 30, 1993, with remediation activities performed by Rust Remedial Services. Rust Remedial Services was subsequently acquired by OHM Remediation Services, which was later acquired by IT Corporation. The contract was awarded using a firm fixed-price cost structure. On September 23, 1996, the contract was converted to a cost plus fixed fee contract.

The following list presents the subcontractors used and their roles on the project:

Subcontractor	Tasks
Midwest Research Institute	Mini Burns, Trial Burns, Risk Burns, and Air Monitoring
Universal Gas	Natural Gas Supplier
Praxair	Oxygen Supplier
Cleveland Brothers Company	Heavy Equipment Service
Environmental Chemical Corporation	Analytical Laboratory Services

COST DATA (3,20)

The contract for this project was originally awarded for $46,378,797 and the actual total expected cost is $112,381,000. Key factors that caused actual costs to differ from estimates included legal delays, additional air monitoring, and additional trial burn and risk burn testing and review. Table 16 provides a breakdown of the costs by task. The technology-specific unit cost is $340 per ton of soil treated.

Table 16. Costs for the Incineration Application at Drake Chemical OU-3A (20)

Cost Category	Cost Element	Total Actual Cost* ($)
Capital	Physical Treatment - Carbon Adsorption - Liquids	
	Mobilization/Setup/Relocate Plant	811,000
	Demobilization Plant	71,000
	Thermal Treatment - Incineration	
	Pads/Foundations/Spill Control	1,914,000
	Mob/Setup Plant	4,420,000
	Startup/Readiness Test/Trial Burn	12,910,000
	Demobilization Plant	2,248,000
	Subtotal	22,374,000
O&M	Physical Treatment - Carbon Adsorption - Liquids (21,000 MGA)	
	O&M Plant (17.3 MO)	2,204,000
	Thermal Treatment - Incineration (194,520 CY)	
	Solids Preparation & Handling	3,380,000
	Ownership Plant	6,564,000
	O&M Plant (14.2 MO)	8,030,000
	Testing – Performance	11,542,000
	Utilities and Fuel	10,541,000
	Waiting Phase	14,268,000
	Stabilization/Fixation	
	Pozzolan Process (3,054 CY) O&M	223,000
	Subtotal	56,752,000
Other Technology Specific	Monitoring, Sampling, Testing, Analysis	
	Air Monitoring & Sampling (17.3 MO)	5,574,000
	On-Site Laboratory Facilities	211,000
	Off-Site Waste Water Analysis (17.3 MO)	268,000
	Solids Collection and Containment	
	Contaminated Soil Excavation (194,520 CY)	2,856,000
	Drums/Tanks/Struct/Misc Removal	
	Drum Handling and Removing (185 EA)	214,000
	Debris Removal (8 ACR)	315,000
	Disposal (Other than Commercial)	
	Load/Haul/Unload (275,467 TON)	3,762,000
	Disposal (Commercial)	
	Load/Haul/Unload (2,200 TON)	604,000
	Subtotal	13,804,000
	Total Technology-Specific Costs	92,930,000

Cost Category	Cost Element	Total Actual Cost* ($)
Other Project Costs	Mobilize and Preparatory Work	
	Health and Safety Equip (PPE)	3,171,000
	Submittals/Implementation Plans	2,683,000
	Setup/Construct Temporary Facilities	2,665,000
	Construct Temporary Utilities	122,000
	Sitework	
	Earthwork - Sheet Piling (87,204 SF)	4,809,000
	Water/Sewer Relocation (2,425 LF)	916,000
	Site Restoration	
	Earthwork	
	Backfill (194,520 CY)	2,544,000
	Borrow (12,376 CY)	195,000
	Earthwork - Backfill @ TDF/Topsoil	378,000
	Permanent Features	245,000
	Seeding/Mulch/Fertilizer (8 ACR)	86,000
	Demobilization	
	Removal of Temporary Facilities	
	Office Trailers	94,000
	Decon Facilities	157,000
	Government Trailers	157,000
	Removal of Temporary Utilities	99,000
	Final Decontamination	812,000
	Demob of Construction Equipment	318,000
	Subtotal	19,451,000
	Project Total	112,381,000

*Actual cost data presented are estimated values.

REGULATORY/INSTITUTIONAL ISSUES

Because this project was performed under CERCLA regulations, it was not necessary to obtain permits from local regulatory authorities for on-site activities. It was necessary, however, to meet the substantive requirements of potentially applicable regulations. The following permitting, approval and public relations issues were encountered on this project (3,18):

- USEPA's proposed plan for remediation of site soils, sludges, and groundwater was published in an advertisement on August 31, 1988. Publishing of the advertisement began the 30-day public comment period. A public meeting to discuss the proposed plan was held on September 7, 1988.

- Additional public meetings were held following the start of the project to discuss the risk assessment protocol and results.

- The project was delayed in response to lawsuits, restraining orders, and injunctions filed by a local group that opposed the incineration project. The USEPA added extensive monitoring to the project to appease local citizens groups.

- The Drake incineration project obtained equivalency permits for air emissions and surface water discharges.

OBSERVATIONS AND LESSONS LEARNED

COST OBSERVATIONS AND LESSONS LEARNED (18)

- Costs on similar future projects could be reduced by taking preliminary steps to minimize the chances for shutdowns caused by legal actions. Five million dollars in costs were incurred while the incinerator was shutdown pending the outcome of a lawsuit brought by an opposition group.

- A significant cost savings was realized due to a change incorporated into the contract specifications allowing for the cleaning and backfilling of excavated rock. The reuse of rock eliminated costs associated with importing stone from an outside source.

- The initial remedial design included laying cover material capable or supporting a vegetative cover over treated soil depleted of organic material. Two studies demonstrated that the addition of compost and fertilizer to the treated soil would be sufficient to allow sustained growth of a vegetative cover. The amended design resulted in elimination of costs associated with importing fill materials and topsoil.

PERFORMANCE OBSERVATIONS AND LESSONS LEARNED (16)

- Project managers of future similar projects should perform a thorough review of the proposed equipment layout plans. Equipment locations are particularly important to consider with material handling systems. Bins and buildings to store and/or stabilize ash should be located in close proximity to ash sources to minimize the amount of high wear/severe duty equipment (e.g., screw augers and drag conveyors) necessary.

- The feed preparation area should be as large as physically possible to allow sufficient room for any additional equipment, which may become necessary for trash separation, drum handling operations, pre-drying and similar operations.

- Dust suppression is an important aspect of managing soil and ash on site. When possible, soil and ash management operations should be conducted within an enclosed structure such as a building under slight negative pressure or enclosed equipment.

- During preliminary site investigation and incinerator conceptual design, the moisture content of site soil should be characterized. Worst case moisture content should be included in the RFP so the contractor design engineers can size the kiln and burners accordingly. Soil moisture will greatly affect the allowable throughput rate and the ability of the system to remove contaminants in the soil. A heat transfer specialist should do a thorough review of the assumptions and calculations used to size the incineration equipment.

- The temperature of the treated soil exiting the kiln is a primary indicator of whether the soil will meet the treatment requirements. The contractor should measure the kiln exit soil temperatures to obtain a real-time indication of the kiln efficiency, rather than waiting 72 hours for the analytical results of the treated soil samples.

- Due to the severe environments under which they operate, the ash conveyance system may be particularly susceptible to mechanical failure. A thorough review of the contractor's proposed system should be performed. The review should draw upon the vast quantity of material handling information and experience available within the combustion industry.

- Whenever cost and space allow, redundant systems should be implemented in order to keep the incinerator operational. The incinerator cannot physically operate without certain systems online (e.g., drag conveyors or pumps) and the incinerator is not allowed to operate if certain equipment is not operational per permit requirements (e.g., CEMs). Incinerator downtime can be costly because site personnel must be paid and equipment rental fees are incurred whether the incinerator is operating or not.

- Performing a clean burn prior to feeding hazardous waste to the incinerator can have the following benefits:

  – Serves as a mechanical shakedown of the system;
  – Provides an opportunity to do performance testing on the CEMs; and
  – Provides an opportunity to debug any programming or control systems without the risk of any sort of a release or labor-intensive decontamination prior to correcting any problems.

- During incinerator optimization and trial burn testing, the incinerator should be operated under a wide range of operating conditions (e.g., varied feed rate, kiln rotation speed, and combustion temperature) to ensure that the permit limits allow the desired level of operating flexibility.

OTHER OBSERVATIONS AND LESSONS LEARNED (16,17)

- The USACE and the state regulatory agency should be involved with a proactive, USEPA-lead public relations effort that is implemented from the beginning of the project. This can be achieved by developing a public relations plan in conjunction with the local community.

- 90 to 120 days should typically be allowed for state review of permit equivalency documents, including the Trial Burn Plan.

- The RFP specifications should delineate which activities are construction-related and which activities are service-related. Difficulties can arise when personnel working side-by-side on the same equipment are paid different wages.

- Staffing requirements for an incineration project are greater than the typical USACE construction project. Required staff include an on-site project chemist, thermal incineration experts, office engineering, project engineering, quality assurance staff, and an on-site authorized contracting officer's representative. In addition, the contracting officer's representative should be given more authority to process changes so the changes can be incorporated in a timely manner.

- A Construction Management Plan should be developed that includes the roles and responsibilities of the participating organizations and individuals.

- The project manager should prepare for the worst weather possible at the site. Freezing pipes, power outages, late deliveries, inability to move equipment and excavations filling with water are examples of weather-related problems. These occurrences can delay the project and be the source of additional costs.

- Local emergency responders should be involved with emergency response planning and drills. They should be provided with training and the necessary response equipment if they are not already prepared for incinerator-related emergencies.

- All pertinent federal and state regulations and guidance documents identified in the project specifications should be available on-site for reference.

- Due to the large volume of information gathered and shared with outside agencies, a computer-based information and issue tracking system would be useful for projects of this type. The system should contain, at a minimum, complete descriptions of the issues, responsible individuals, inception dates, and anticipated resolution dates. The system should be reviewed on a regular basis to track the status of outstanding issues.

- Before initiating site work, a cost-benefit analysis should be performed to determine if a backup to the primary laboratory should be selected. Selection of a backup laboratory at the beginning of the project may eliminate time consumed in laboratory validation and approval, which could impact the project in progress if laboratory selection must be performed once site work has begun.

- An active safety incentive program increases worker safety awareness and reduces injuries and accidents.

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