

WORK PLAN

FINAL
INTERIM SITE CHARACTERIZATION
REPORT
FOR
NORTH CAVALCADE STREET
HOUSTON, TEXAS

REMEDIAL INVESTIGATION/FEASIBILITY STUDY

DOCUMENT NO. 141-WP1-AZZG-3

AUGUST 28, 1985

R E M I I

**PERFORMANCE OF REMEDIAL RESPONSE
ACTIVITIES AT UNCONTROLLED
HAZARDOUS WASTE SITES**

U.S. EPA CONTRACT NO. 68-01-6939

**CAMP DRESSER & MCKEE INC.
PRIME CONTRACTOR**

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CDM

environmental engineers, scientists,
planners & management consultants

CAMP DRESSER & MCKEE INC.

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August 28, 1985

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Project: REM II - EPA Contract No. 68-01-6939/141/WP1

Document No.: 141-WP1-EP-BKZD-1

Subject: Work Plan
North Cavalcade Street
Houston, Texas

Dear Mr. Hanneschlager and Mr. Cochran:

Camp Dresser & McKee Inc. (CDM) is pleased to submit this final Work Plan for the North Cavalcade Street Site. It consists of two volumes: Volume 1 is the technical portion of the Work Plan; Volume 2, previously delivered, contains the costs. These costs are estimates, and they assume the use of outside, private analytical laboratories and subsurface contractors approved for Basic Ordering Agreements under our REM II contract.

The two volumes of the Work Plan are accompanied by four other documents: an Interim Site Characterization Report, a Quality Assurance Project Plan, a Site Plan, and a Project Operations Plan (POP). These documents have been revised based on written oral review comments received from Mr. Cochran.

Call us if you have comments or questions.

Sincerely,

CAMP DRESSER & MCKEE INC.



Robert S. Kier, Ph.D.
Site Manager

RSK/WFB/mem

CAMP DRESSER & MCKEE INC.



William F. Buchholz, Jr., P.E.
Region VI Manager

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COMPANY CONFIDENTIAL

This Interim Site Characterization Report, prepared by the REM II
Team in accordance with the items of USEPA Contract No. 68-01-6939 is
Company Confidential.

Work Assignment No.: 45-6L78

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1.0 INTRODUCTION

This Interim Site Characterization Report has been provided in accordance with Task 1, Subtask 1.1 of the January 18, 1985, Work Plan Memorandum prepared by CDM for the North Cavalcade Street Site. The purpose of this subtask is to provide a description of the current situation of the North Cavalcade Street Site in relation to the site's Hazardous Ranking System Score of 37.1 on the National Priority List (NPL). Data pertinent to the site and its contamination problem were gathered, organized, and reviewed.

Major issues addressed in this report are as follows:

Site Background

Provides a summary of the regional location, pertinent area boundary features, existing ownership and use (subdivision of the property), and the general physiography, hydrology, and geology of the site, from secondary sources.

Nature and Extent of Problem

Summarizes the actual and potential onsite and offsite health and environmental effects that can be anticipated from pre-remedial investigation sources. This may include, but is not limited to, the types, physical characterization and amounts of any hazardous substances; and the potential pathways of exposure, contaminant release, and human exposure.

History and Response Actions

Describes any previous response or remedial actions conducted by either local, state, federal, or private parties, including site inspection, technical reports and their results.

2.0 BACKGROUND

2.1 SITE LOCATION AND HISTORY

The North Cavalcade Street Site is located within the incorporated boundaries of the City of Houston, Texas, the state's largest city and the fifth largest in the nation.

The site covers about 21 acres in northeast Houston, about one mile west of the intersection of Interstate Loop 610 North and U.S. Route 59 (Figure 2-1). The site is bounded on the north by Loop 610, on the south by Cavalcade Street, on the west by the Houston Belt and Terminal (HB&T) Railroad Passenger Main and Maury Street, and on the east by the HB&T Freight Main (now the Missouri and Pacific R.R.). The site is triangular in shape, with its base about 600 feet in length along Cavalcade Street and its apex about 3,000 feet to the north.

The North Cavalcade Site was undeveloped land until after World War II. In 1946, a Mr. Leon Aaron acquired the site and established a small wood preservative business, Houston Creosoting, Inc. (HCI), on about ten acres of the southern portion of the site just north of the present location of Cavalcade Street. The HCI facility included initially creosote wood preservative operations, wood storage and pole peeling areas, a treatment plant with storage tanks and pressure cylinders, a blow-down area and waste pit, and other support facilities. In about 1955, HCI operations apparently expanded to include pentachlorophenol (PCP) preservative services and additional storage tanks and treatment facilities were added.

At least two waste pond areas, designated on Figure 2-2 as Contaminant Areas 1 and 2, have been identified from aerial photos of the period, and from an interview with a former HCI employee, Mr. Lloyd Martin. Contaminant area No. 1, includes one or more small open pits near the HB&T R.R. along the east side of the site that were used to dispose of process blow-down wastes from both creosote and PCP preserving operations. A larger triangular shaped pit, Contaminant Area No. 2 on Figure 2-2, was used to

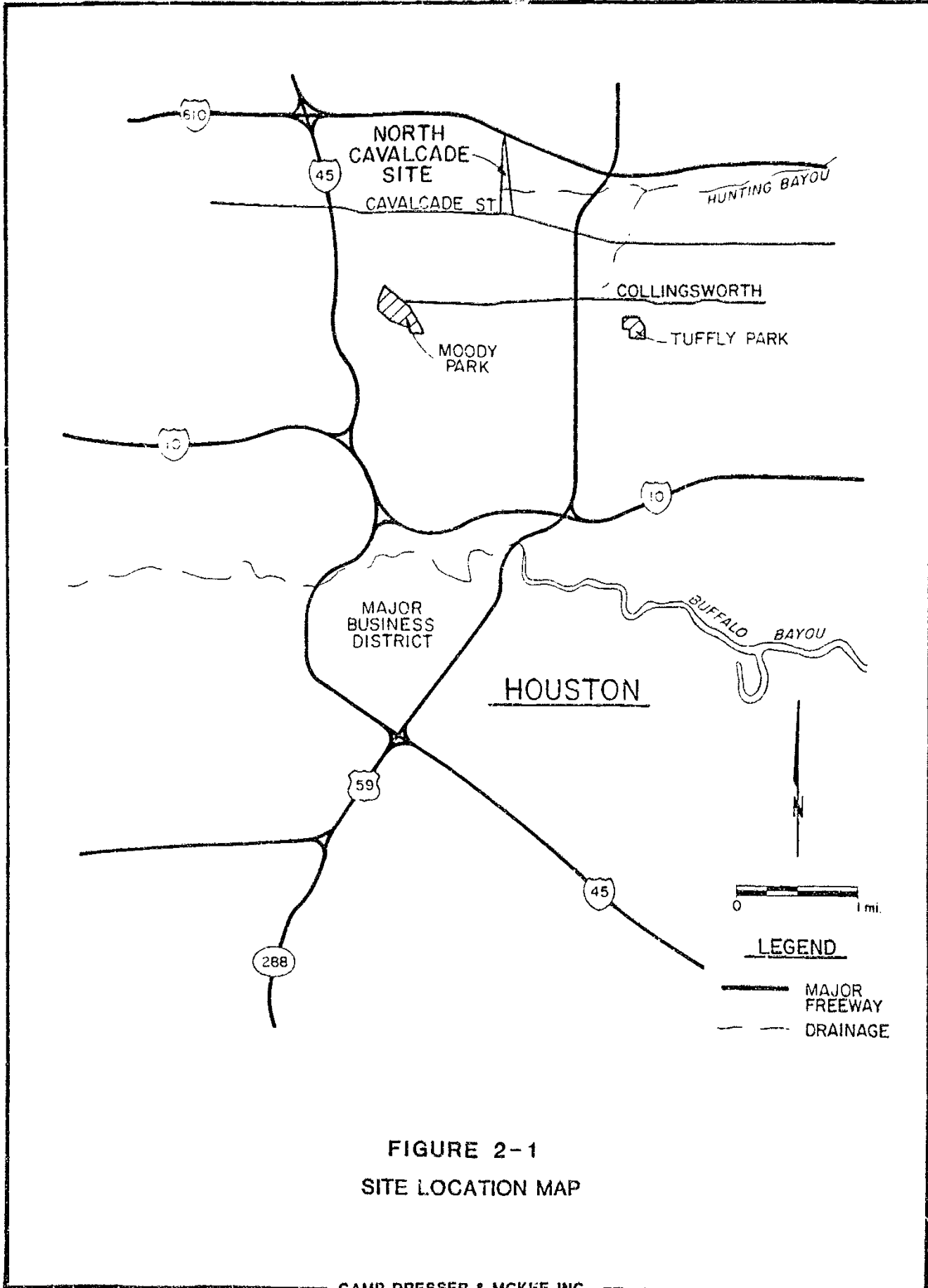


FIGURE 2-1
SITE LOCATION MAP

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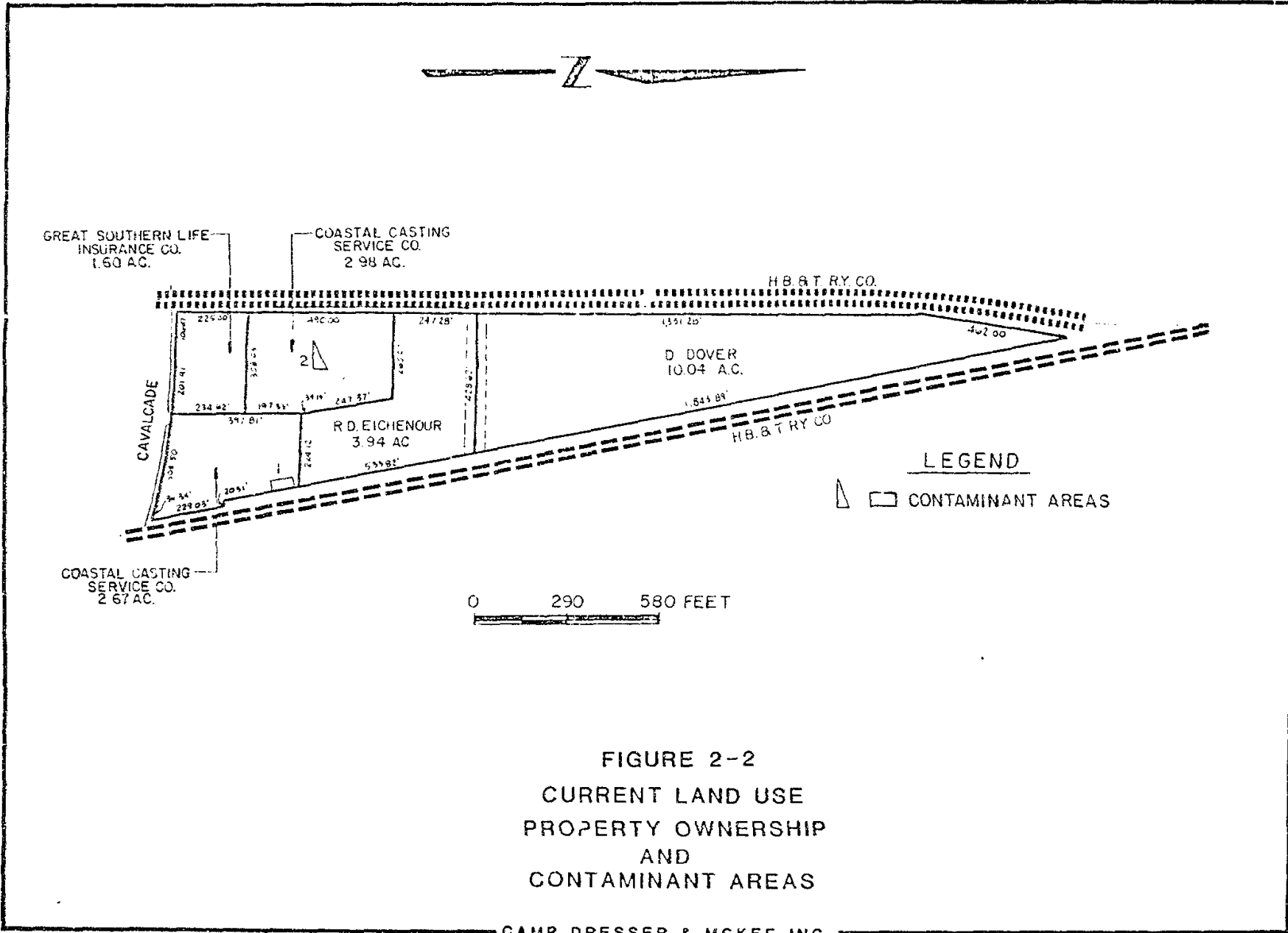


FIGURE 2-2
 CURRENT LAND USE
 PROPERTY OWNERSHIP
 AND
 CONTAMINANT AREAS

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contain creosote and other waste products from HCI operations, including used (waste) petroleum products such as motor oil and industrial lubricants introduced into HCI operations.

In 1961, the End End Bank of Houston foreclosed a mortgage on HCI. The operation's of the firm apparently continued, however, for another two or three years under a lease-back arrangement with the bank. The wood treatment operations at the North Cavalcade Site were discontinued about 1964.

Subsequently, the property was divided into smaller tracts and sold to a variety of current owners. The Great Southern Life Insurance Company (GSLI) acquired a small property tract of about 1.6 acres in the southwest corner of the site, and constructed a building that occupies most of its property. The Coastal Casting Services Company (CCS) now owns two small tracts in the southern portion of the site (Figure 2-2). The CCS tracts encompass the two previously identified waste pit contaminant areas. Two other tracts, as shown on Figure 2-2, are owned by R. D. Eichenour and A. D. Dover, and occupy the remainder of the site.

The Harris County Flood Control District (HCFCD) has a 60-foot easement and drainage ditch along the property line separating the Eichenour tract from the A. D. Dover property. This drainage ditch not only provides surface drainage to most of the North Cavalcade Site, but also drains a part of the residential area to the northwest of the site. The HCFCD ditch drains to the east into Hunting Bayou, a tributary to the Houston Ship Channel.

The Houston Metropolitan Transit Authority (MTA), as part of its proposed METRO Stage One Regional Rail System (RRS) study, investigated the feasibility of including the property designated in this report as the North Cavalcade Street Site as a yard, shop and terminal facility for the RRS. Under contract to the Houston Transit Consultants (HTC), prime contractor to the MTA, the firm McClelland Engineers, Inc. (MEI) performed a geotechnical investigation of the site. During the course of that investigation, observations were made of probable contamination of the site with toxic waste materials from previous commercial or industrial users.

Early in 1983 the state agency responsible for hazardous waste control, the Texas Department of Water Resources (TDWR), was notified of the probable contamination of the site. The TDWR then initiated the state's process of investigating the nature and extent of the problem, the present and prior ownership and use of the site, and the possibility of voluntary compliance with remedial clean-up operations at the site.

At the same time, the Houston MTA, acting through HTC and its geotechnical consultant MEI, contracted with Camp Dresser & McKee Inc. (CDM) to perform a comprehensive contaminant survey of the site. A CDM report entitled "Cavalcade Contaminant Survey" in three volumes, dated July 11, 1983, provided the first detailed assessment of the extent and nature of hazardous contamination at the Cavalcade Site.

In response to initiatives by the TDWR to secure remedial measures by current owners of the site, two of the owners, GSLI and CCS, each retained consultants to conduct site investigations. Those investigations were completed in October 1983. The consultants of GSLI, William F. Guyton Associates and Southwestern Laboratories, both of Houston, concluded that no significant contamination existed on the GSLI property and that no remedial actions were needed. The consultant for CCS, McClelland Engineers, Inc. of Houston, relied upon the information collected previously for the Houston MTA and recommended further investigation of the CCS properties to more fully ascertain the contaminant problems and any remedial needs.

In April 1984, the TDWR recommended the site to the U.S. Environmental Protection Agency (EPA) for inclusion on the National Priority List (NPL) of hazardous waste sites. On October 2, 1984, the North Cavalcade Site was placed on the NPL, with EPA taking the lead responsibility for subsequent Remedial Investigation/Feasibility Study (RI/FS) efforts. The site has been assigned a Hazardous Ranking System score of 37.1 on the NPL.

In December, 1984, EPA authorized a work assignment for an RI/FS on the North Cavalcade Street Site to CDM under project REM II - EPA Contract No. 68-01-6939/141/WP1, Document Control No. 141-WP1-EP-APMU-1. A Work Plan

Memorandum by CDM for RI/FS on the North Cavalcade Street Site, dated January 18, 1985, has been submitted to the EPA.

2.2 CONTAMINATION PROBLEM

The North Cavalcade Street Site has over a 30-year history of industrial/commercial use with potential for long-term contaminant pollution of the site. A report "Cavalcade Contaminant Survey", in three volumes by Camp Dresser & McKee, Inc. dated July 11, 1983, first documents the general nature and extent of site pollution. Section 3.0 presents review of data in this report.

2.3 DESCRIPTION OF NATURAL FEATURES OF THE SITE

Present Land Use

The present land use of the North Cavalcade Street Site is predominately commercial, made up of several small tracts as shown on Figure 2-2. The area around the North Cavalcade Site is mixed residential, commercial and industrial. The nearest residential area is located to the west, an old, low-income neighborhood. Commercial properties are located mainly along major thoroughfares, including Cavalcade Street, Loop 610 North, and U.S. Highway 59.

The area has a previous history of industrial and commercial use. Rail lines have served the area since the late 1800's, supporting a variety of industries over the years. Industries reported to have operated in the vicinity in the past, or are still in operation (denoted with an asterisk, *, below) include:

1. Rendering plants
2. Liquid fertilizer company*
3. Chemical companies*
4. Metal processing plants*
5. Metal recycling plants*
6. Liquid feed plant*

7. Wood treatment and preserving facilities
8. Coal tar distillation facilities
9. Cotton seed oil plant
10. Industrial gas manufacturing plant*
11. Trucking companies*
12. Petroleum products distribution facilities*

Physiography

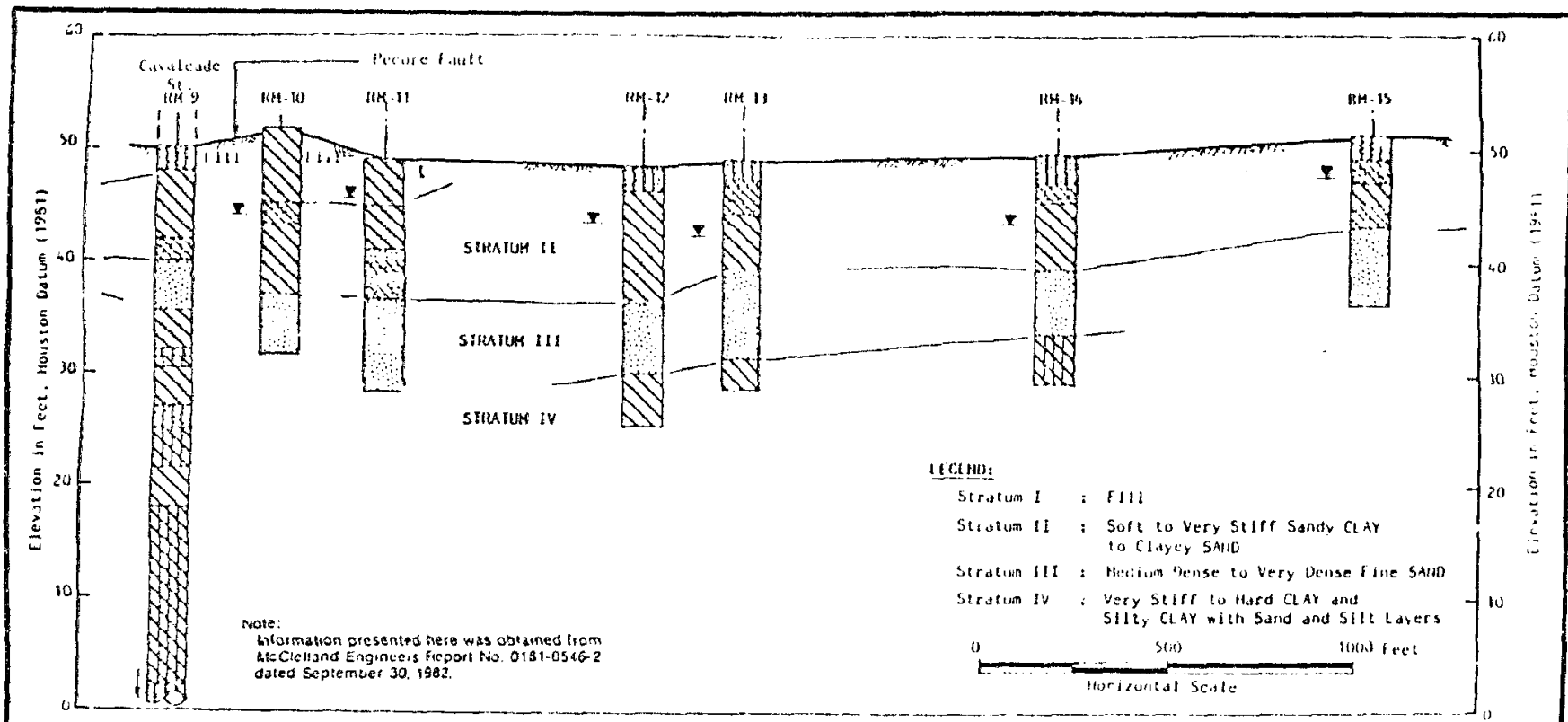
The general physiography of the site is a relatively flat plain with a very gentle slope to the south and east. Elevations range from about 59.0 feet mean sea level (msl) on the north to about 52.1 feet msl along Cavalcade Street on the south, an average slope of about 0.2 percent. Drainage is generally to the south and east to local tributaries of Buffalo Bayou and the Houston Ship Channel.

Soils

Local soil conditions have previously been investigated at the North Cavalcade Site (see McClelland Engineers Report No. 0182-0282, Volume II, dated May 20, 1983). A generalized soil profile of the site shows four distinct soil strata. Figure 2-3 depicts the soil conditions throughout the site based on reconnaissance borings. Although there are variations in strata elevation and thickness, the following generalized soil strata appear to the present throughout the site:

<u>Strata</u>	<u>Depth, ft.</u>	<u>Description</u>
I	0-2	Fill: silty fine sand
II	2-10	Soft to very stiff sandy clay and clayey sand
III	10-20	Medium dense to very dense fine sand
IV	20-80	Very stiff to hard clay and silty clay, with sand and silt layers

Figure 2-3 also indicates the presence, at the time of the reconnaissance soil borings in early 1983, of shallow water table conditions at depths of one to five feet beneath the surface throughout the site. The shallow sand



Note:
Information presented here was obtained from McClelland Engineers Report No. 0181-0546-2 dated September 30, 1982.

Notes:
1. Data concerning subsurface conditions have been obtained at boring locations only. Actual conditions at locations between borings may differ from the generalized profile shown here.

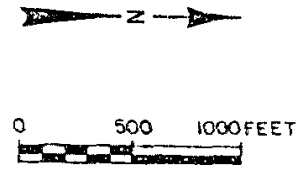
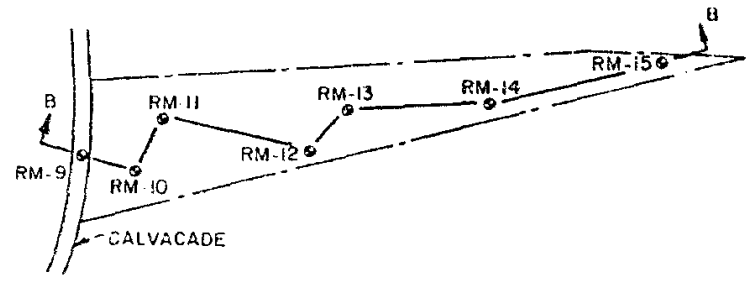


FIGURE 2-3
GENERALIZED SOIL PROFILE

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strata (Strata III in Figure 2-3) appear to be consistently present the site and to have a regional extent and significance off-site as well (Figure 2-4). Typical shallow sand layers common to the Texas Gulf Coast area usually contain various amounts of silt. The relative permeability of the sand strata depends largely on the silt content, which varies significantly from place to place. Permeabilities will need to be determined on a site-by-site basis.

Geology

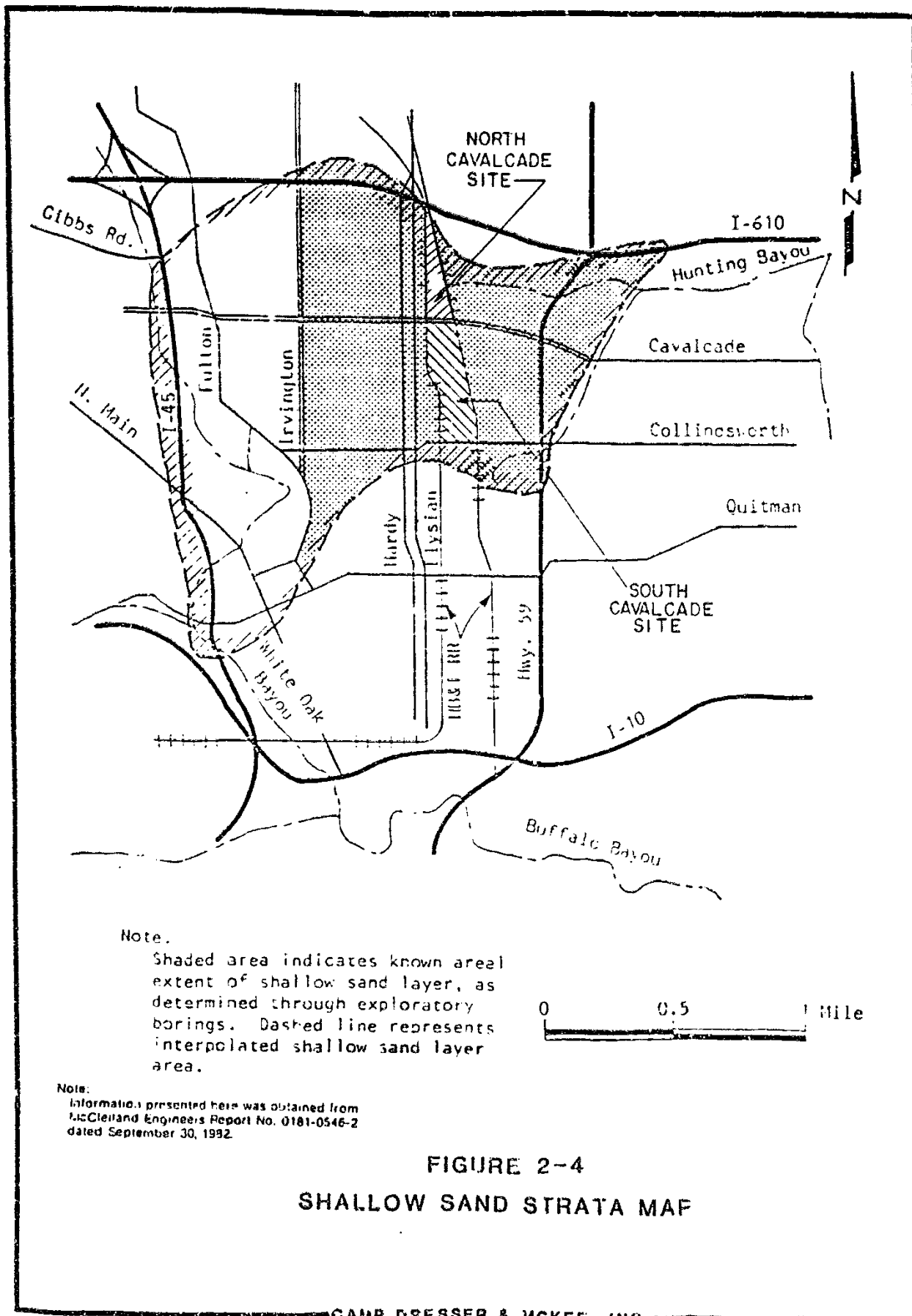
The geologic strata underlying the North Cavalcade Site consist principally of interbedded sands, silts, and clays of the Beaumont Formation, deposited in fluvial (river) and deltaic environments of the Pleistocene Epoch. Clay and silt materials predominate in the upper 200 to 300 feet of the Beaumont Formation, with thin discontinuous layers of sand occurring randomly. Thicker, more continuous sand deposits occur in deeper parts of the Beaumont. The Lissie Formation, underlying the Beaumont, also shows extensive sand deposits in the upper strata of the formation.

Hydrology

Both the Lissie Formation and the lower Beaumont Formation are common sources of groundwater supplies in the Houston area, although yields are small and considered inadequate for major exploitation. The deeper sands of the Chicote and Evangeline Aquifers, at depths of over 1,000 feet, are the local sources for major groundwater supplies.

The Beaumont Formation dips generally to the southeast. The regional dip of the strata and the presence of the interbedding sands and clays influence the regional hydrogeology of the entire area. Published geologic literature indicate that the principal areas of recharge for the Chicote and Evangeline Aquifers occur several miles north of the site area.

The predominately clay and silty soils in the upper strata of the Beaumont Formation, in conjunction with the southeastward dip of the formation, serve as a confining layer for the underlying Chicote Aquifer, producing



artesian groundwater conditions in the aquifer. Discontinuous sand layers in the overlying Beaumont are considered too limited for effective recharge to the deeper aquifers.

Drainage

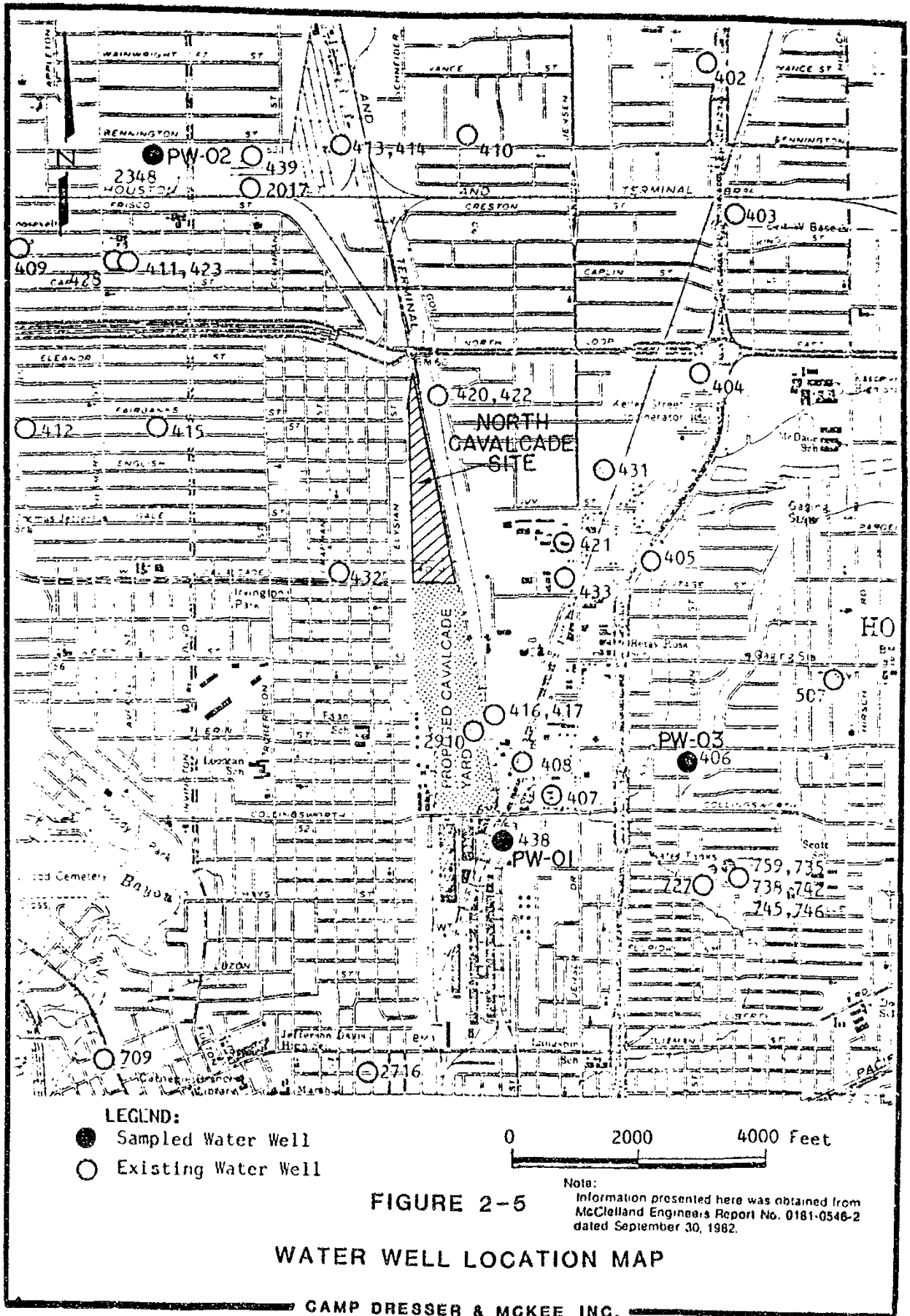
Surface drainage from the site consists of a system of poorly defined surface ditches. Most surface drainage internal to the site is conveyed to the Harris County Flood Control District (HCFCD) ditch that bisects the site west to east (Figure 2-2). The undeveloped northern parts of the site are poorly drained, with surface ditches draining to runoff ditches along the east and west property borders in the railroad right-of-ways. The extension of the HCFCD ditch drains much of the site into Hunting Bayou to the east and ultimately into the Houston Ship Channel several miles downstream of the site.

Groundwater

A survey of existing water wells in the vicinity of the North Cavalcade Site was conducted for the earlier McClelland Engineers study (report No. 0181-0546-2, dated September 30, 1982). Figure 2-5 depicts the location of known wells in relation to the site. Three common strata used for groundwater supplies in the site area were identified. The more shallow of the local aquifers is located at elevations of about 170 to 220 feet below ground surface. This aquifer does not have a high yield and is restricted primarily to domestic uses. The second aquifer is found approximately at depths of 400 to 600 feet. This aquifer is developed locally mainly for industrial purposes. A third aquifer is located typically below 1,000 feet and is used primarily as a municipal supply for the City of Houston.

Faulting

The Pecore Fault is the only known active fault in the vicinity of the North Cavalcade Site. The fault trends approximately east-west and intersects the surface just north of Cavalcade street (Figure 2-6). The predicted annual differential movements across the fault are about 0.4



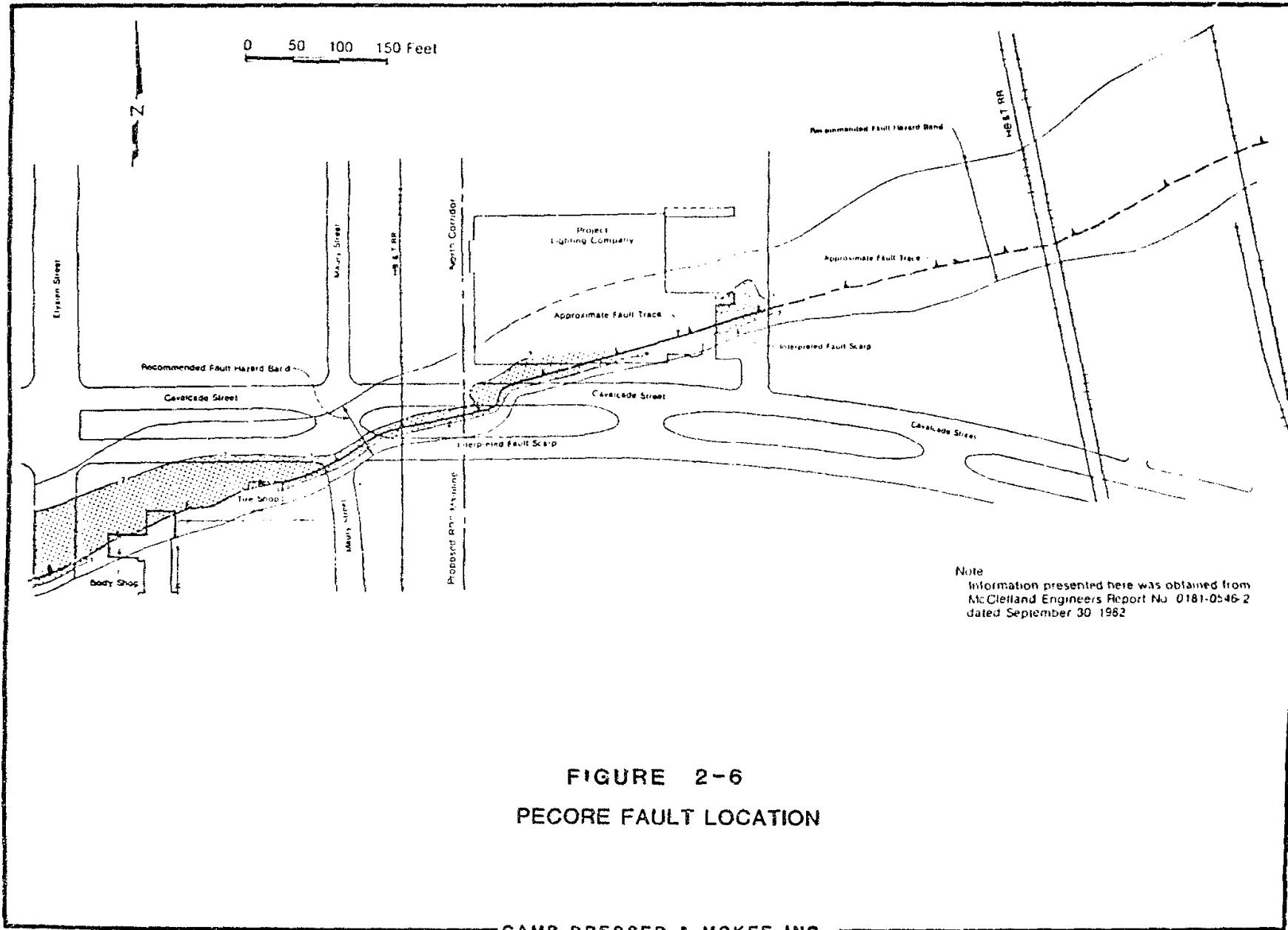


FIGURE 2-6
PECORE FAULT LOCATION

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inches vertical and 0.1 inch horizontal. Many faults in the Houston area tend to act as partial hydrogeologic barriers to groundwater movements. Isolated portions of an aquifer may thus have different hydrogeologic characteristics due to local faulting. The extensive withdrawal of groundwater and petroleum supplies in the Greater Houston Area, resulting in active land subsidence, has caused accelerated fault movements during recent years.

3.0 REVIEW OF EXISTING INFORMATION

A preliminary description of contaminants found at the North Cavalcade Site during previous investigations provides a basis for future remedial investigations. Any actual or potential health or environmental hazards already identified will be described as to types, physical characteristics and quantities, if known. The most probable pathways of exposure and escape of hazardous materials will also be described.

Recent 1982-83 investigations of the North Cavalcade Street Site for the Houston Metropolitan Transit Authority (MTA) revealed areas of localized soil and shallow groundwater contamination. McClelland Engineers, Inc. (MEI) performed a reconnaissance geotechnical survey in 1982 for MTA in relation to then pending plans for a Metro Regional Rail System (RRS). The MEI survey included general soil borings and preliminary foundation investigations for the proposed RRS yard and shop facility at the Cavalcade Site.

Creosote odors were detected during the MEI investigations and soil and groundwater samples were collected for analysis. Trace amounts of naphthalene and phenanthrene were identified, and it was subsequently determined that the site was contaminated from previous wood preserving operations. It was recommended to MTA that additional investigations be conducted to assess the extent of the contamination problem.

In April of 1983, Camp Dresser & McKee, Inc. (CDM) performed a contaminant survey of the Cavalcade Site. A CDM report, entitled "Cavalcade Contaminant Survey", and dated July 11, 1983, provides a comprehensive assessment of their environmental study. CDM's site investigation program consisted of the following types and number of samples for the North Cavalcade Site:

<u>TASK</u>	<u>PREFIX</u>	<u>NUMBER COMPLETED</u>
Sediment Sampling	SD	1
Surface Soil Sampling	SL	3
Subsurface Soil Samples	SL	2
Shallow Observation Wells	OW	3
Production Well Sampling	PW	3

In addition to CDM's soil sampling program, three soil borings were made along the northern edge of the Great Southern Life Insurance Company (GSLI) property. A consortium of consultants, including William F. Guyton Associates, Inc., Southwestern Laboratories, Inc., and Randy V. Dormon, consultant, performed soil investigations and analysis to determine the nature and extent of any contaminant problems on the GSLI property.

Two reports, entitled 1) "Geotechnical and Environmental Testing at 2001 Cavalcade Street, Houston, Texas" by Southwestern Laboratories, dated September 1983, and 2) "Investigation of Shallow Subsurface Conditions at 2001 Cavalcade Street, Houston, Texas" by William F. Guyton Associates, dated January 1984, summarize the results of those investigations. In general, no significant level of contamination was found on the GSLI property. The only indication of contamination was a slight creosote odor detected in a sample obtained between 19.5 and 20.5 feet in one of the three test holes drilled by Southwestern Laboratories near the northern boundary of the GSLI property. The remaining two test borings along the north edge of the GSLI property indicated no contamination detectable by visual or olfactory observations.

Comprehensive investigative results, methods and documentation are available in the three-volume report "Cavalcade Contaminant Survey" by CDM, in association with MEI, dated July 11, 1983. Results of the CDM contaminant survey are summarized in the following paragraphs. Well logs from previous investigations are included in Appendix I. Also included are Site Characterization Memorandum, Site Personnel Protection and Safety Forms, Site Expendable Equipment Forms (Appendix II) and pertinent toxicological information (Appendix III). The most complete set of toxicological information is in Appendix III of the Project Operations Plan - Volume II.

3.1 SOIL INVESTIGATIONS

Soil borings at areas related to the locations of earlier wood treatment facilities during the 1946-1964 period were made to investigate subsurface contamination and migration of contaminants in the near-surface soil profile. Figure 2-3 exhibits the locations of the soil boring localities.

In all cases, rotary drilling rigs were employed in conjunction with 3 inch thin wall Shelby tube samplers, 2 feet in length, which were attached to the bottom of the drill stem. Samples were taken by pressing the tube into undisturbed material at selected depths. The soil sampling analysis disclosed contamination with both organic and inorganic compounds in the vicinity of suspected disposal areas, particularly near the soil surface. Concentrations of contaminants consistently decreased with depth in the soil profile.

CDM's soil boring program also provided visual and olfactory evidence of contamination in subsurface soil samples. Observations of soil contaminants were limited mainly to areas of previously known or suspected waste disposal, with the exception of two off-site borings designated as SL-26 and SL-27 on Figure 3-1. These observations are probably not related to the previous users of the North Cavalcade Site, but to other commercial or industrial sources in the area.

3.2 SEDIMENT SAMPLING

Bottom sediment samples were collected from surface drainage areas at the HCFCO ditch, indicated as SD-05 on Figure 3-1. Detailed analytical results of the sediment sampling for toxic compounds are presented in Section 6.3, Vol. I of the CDM report. The only findings of significance were the presence of low-level refractory organic compounds, fluoranthene (320 ppb) and pyrene, (260 ppb) and a volatile organic-methylene chloride (39 ppb). These results are consistent with the site's history of wood preserving operations. Toxic metal contamination detected was: arsenic (As -1.5 ppm), beryllium (Be -0.2 ppm), chromium (Cr -6.8 ppm), copper (Cu -21.0 ppm), lead (Pb -20.0 ppm), mercury (Hg -0.006 ppm), nickel (Ni -2.7 ppm), and zinc (Zn -30.0 ppm). The low-level toxic metal/inorganic contamination may be due in some cases to naturally occurring concentrations of some metals in local soils.

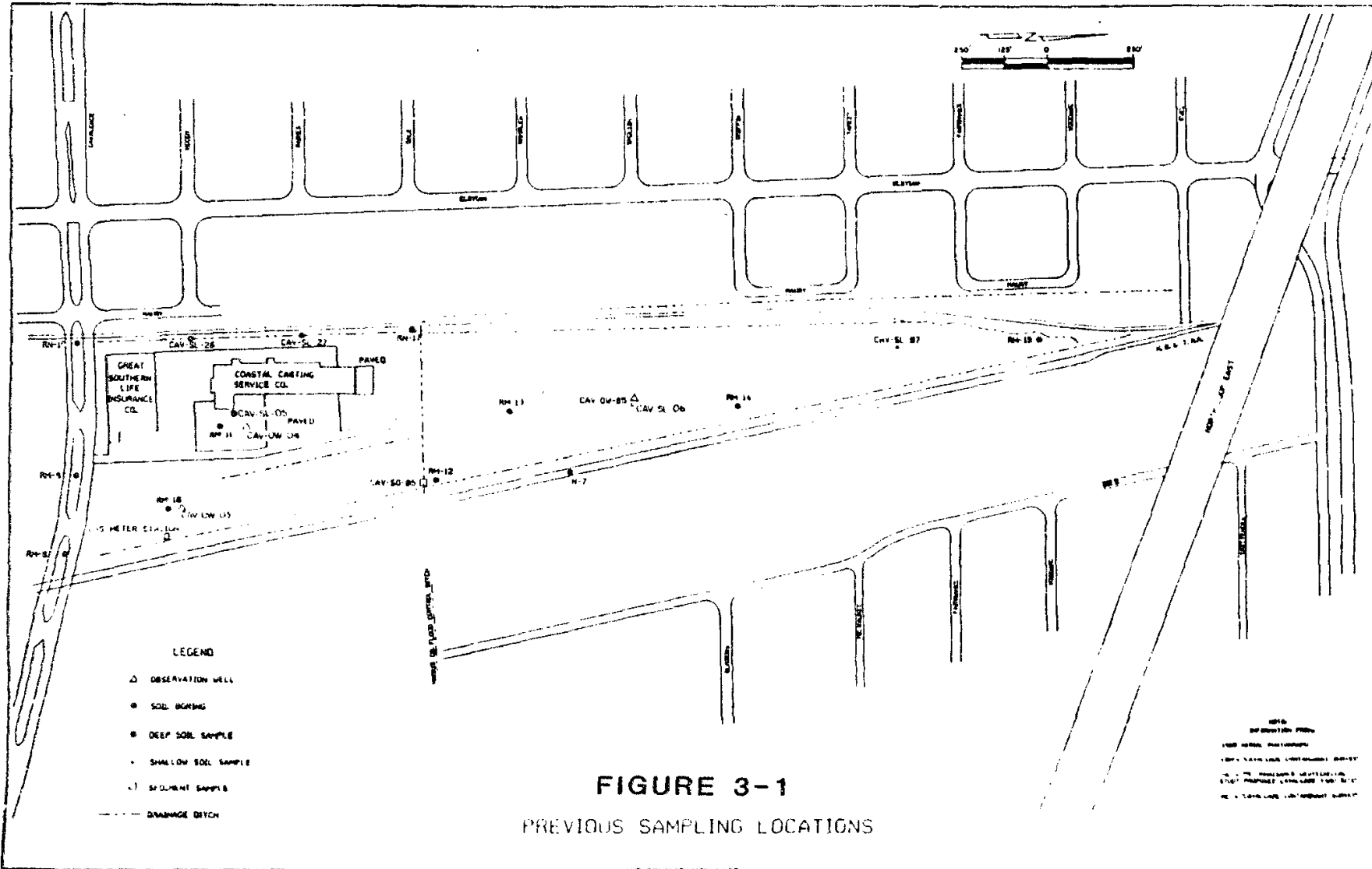


FIGURE 3-1

PREVIOUS SAMPLING LOCATIONS

3.3 SHALLOW SOIL SAMPLING

Two shallow soil sampling locations, designated SL-06 and 07 on Figure 3-1 were inspected for contamination. All samples were collected at locations suspected of prior use for disposal of creosote or other wood preserving products. Contaminant analysis results from these samples were not included in the original CDM/MEI reports due to the emphasis on the South Cavalcade Street Site; however, analytical results for sites SL-06 and 07 are shown in Table 3-1.

3.4 SUBSURFACE SOIL SAMPLING

One deep onsite soil boring (SL-05) was drilled. Its location is shown on Figure 3-1 with analytical results in Table 3-2. Two off-site soil borings, designated SL-26 and 27 on Figure 3-1, were made. Only visual and olfactory evidence of contamination were sought, and no laboratory analyses were made of samples from these borings. No observable contaminants were detected. Details of the subsurface soil sampling program are found in Section 6.6 of the CDM report. (Cavalcade Contaminant Survey, Volume I, July 11, 1983.)

3.5 SHALLOW GROUNDWATER SAMPLING

Three shallow groundwater observation wells (OW-03, -04 and -05) were located on the North Cavalcade Site to determine the extent of groundwater contamination in the upper (shallowest) aquifer beneath the site and to determine the direction of flow of the local groundwater system. The wells were sampled for contamination. Contaminant analysis results for shallow groundwater samples at the North Cavalcade Site locations are shown on Table 3-3.

3.6 PRODUCTION WELL SAMPLING

Selected production wells located within close proximity to the site were sampled to determine the extent of any external migration of contaminants. Production well depths ranged from 300 to 500 feet below ground surface.

TABLE 3-1

SHALLOW SOIL SAMPLING ANALYTICAL RESULTS

Sample No. Sample Horizon (ft. below ground surface)	SL-06 ^a (2.5)	SL-07 (2.75)
CONTAMINANTS:		
<u>Organics (ppb)</u>		
Acenaphthene	17000.	16000.
Benzo(A) anthracene	4000.	8600.
Benzo(A) pyrene	ND	2200.
3,4-Benzofluoroanthene	ND	8600.
Benzo(K)fluoranthene	ND	8600.
Chrysene	ND	7800.
Ethy/Benzene	ND	20.
Fluoranthene	40000.	130000.
Fluorene	17000.	16000.
Methylene Chloride	33.	28.
Naphthalene	27000.	33000.
Pentachlorophenol		720.
Phenanthrene	56000.	54000.
<u>Metals/Inorganics^b (ppm)</u>		
Arsenic (As)	.530	.260
Beryllium (Be)	.300	.300
Cadmium (Cd)	.560	ND
Chromium (Cr)	40.000	3.500
Copper (Cu)	3.500	150.000
Lead (Pb)	5.800	3.600
Mercury (Hg)	.044	.006
Nickel (Ni)	24.000	6.300
Silver (Ag)	ND	.600
Zinc (Zn)	9.500	5.400

^a Values indicate highest concentration of two duplicate samples

^b Laboratory data reported for metals and inorganics may reflect an error in number of significant digits

TABLE 3-2
SOIL BORING ANALYTICAL RESULTS

SITE NO.: SL-05

Sample No.	0501	0502	0503	0504	0505
Interval Depth (ft below ground surface)	1-2	7-8	21-23	28-30	33-35

CONTAMINANTS:

Organics (ppb)

Methylene Chloride	18.	47.	23.	28.	41.
Acenaphthere	ND	—	ND	22000.	ND
Acenaphthylene	ND	—	ND	360.	ND
Anthracene	5000.	—	ND	ND	ND
Benzo(A)anthracene	17000.	—	ND	2400.	ND
Benzo(A)pyrene	11000.	—	ND	ND	ND
3,4-Benzofluoranthene	25000.	—	240.	2200.	ND
Benzo(K)fluoranthene	25000.	—	240.	2200.	ND
Bis(2-Ethylhexyl) Phthalate	310.	—	ND	ND	ND
Chrysene	17000.	—	ND	1700.	ND
Dibenzo(A,H)anthracene	1000.	—	ND	ND	ND
Di-n-butyl Phthalate	400.	—	ND	14000.	ND
Di-n-octyl Phthalate	420.	—	ND	ND	ND
Fluoranthene	9300.	—	ND	24000.	ND
Fluorene	240.	—	ND	18000.	ND
Napthalene	ND	—	ND	30000.	ND
Phenanthrene	ND	—	ND	54000.	ND
Pyrene	ND	—	ND	18000.	ND
1,2,4-Trichlorobenzene	110000.	—	ND	ND	ND

Metals and Inorganics^a (ppm)

Arsenic (As)	—	.480	.250	ND	.420
Beryllium (Be)	—	.240	.660	.310	.710
Cadmium (Cd)	—	ND	.660	.410	.610
Chromium (Cr)	—	3.700	5.700	4.600	7.400
Copper (Cu)	—	.810	5.600	3.200	5.700
Lead (Pb)	—	4.000	10.000	6.500	10.000
Mercury (Hg)	—	.010	.011	.007	.007
Nickel (Ni)	—	2.500	19.000	3.700	23.000
Silver (Ag)	—	.410	.940	.820	.920
Zinc (Zn)	—	4.200	22.000	14.000	25.000

Other (ppb)

PCB-1260	2300.	ND	ND	ND	ND
----------	-------	----	----	----	----

^a Laboratory data reported for metals and inorganics may reflect an error in number of significant digits.

(—) Indicates no measurement taken.

ND Indicates none detected

TABLE 3-3

SHALLOW OBSERVATION WELLS ANALYTICAL RESULTS^a

Well No.	OW-03	OW-04	OW-05 ^b
Screen Depth (ft. below ground surface)	(11.5-18.5)	(10.5-19.5)	(7.-14.)
CONTAMINANTS:			
<u>Organics (ppb)</u>			
Acenaphthene	450.	250.	ND
Acenaphthylene	ND	13.	ND
Anthracene	96.	94.	ND
Benzene	63.	18.	ND
Bis(2-Ethylhexyl) Phthalate	ND	ND	25.
Butyl Benzyl Phthalate	20.	ND	ND
Ethyl Benzene	68.	17.	ND
Fluorene	260.	100.	ND
Napthalene	770.	7300.	ND
Phenanthrene	180.	150.	11.
Tolyene	130.	38.	ND
2,4-Dimethylphenol	210.	1800.	ND
<u>Metals/Inorganics^c (ppm)</u>			
Arsenic (As)	ND	.050	.940
Beryllium (Be)	ND	ND	.200
Cadmium (Cd)	.020	ND	1.000
Chromium (Cr)	ND	ND	5.700
Copper (Cu)	ND	ND	30.000
Lead (Pb)	ND	ND	444.000
Mercury (Hg)	ND	ND	.023
Nickel (Ni)	ND	ND	4.300
Silver (Ag)	ND	ND	1.600
Zinc (Zn)	.450	.360	23.000
Total Cyanides	.010	.050	ND

^a No field measurements taken other than HNu readings for health and safety reasons.

^b Values indicate highest concentration of two samples.

^c Laboratory data reported for metals and inorganics may reflect an error in number of significant digits.

Sampled production wells, labeled FW-01, -02, and -03 on Figure 2-5, proved to be uncontaminated with any detectable organics. Inorganic concentrations in excess of primary drinking water standards were observed in FW-01 for lead (0.36 ppm), in FW-02 for both cadmium (0.04 ppm) and lead (0.35 ppm), and in FW-03 for lead (0.30 ppm).

4.0 POTENTIAL IMPACTS, EXPOSURE OR CONTAMINANT RELEASE

A preliminary assessment of the available site characterization data summarized above can provide useful direction to the prediction of potential onsite and off-site impacts of possible contaminant exposure or release to other environments. Two principal hazard areas of potential health or environmental impacts can be identified from preliminary assessment of the data. These are the surface and near-surface contamination of the soil materials in the immediate vicinity of previously identified disposal areas, and the associated shallow groundwater contamination observed in the same general areas. Surface water impacts are probably not significant health or environmental concerns based upon preliminary findings and current conditions, use and location. Deep percolation and contamination of local groundwater aquifers used for domestic, industrial or municipal water supplies are also likely not to be threatening to public health or the environment.

4.1 SURFACE AND NEAR-SURFACE CONTAMINATION

Residual contaminants from earlier wood preserving activities at this site are restricted mainly to surface and near-surface (10-foot depths, or less) contamination with both organic (polynuclear aromatic hydrocarbons) and inorganic (toxic metal) compounds in the immediate vicinity of previous disposal areas.

The potential impacts of the surface and near-surface soil contamination in these areas are as sources of continued shallow groundwater contamination, and as sources of contaminant release to local environments from future development or use of the site. The soil contaminants do not appear to be an imminent threat to health or the environment due to volatilization, direct contact, or surface runoff exposures under present conditions.

4.2 SHALLOW GROUNDWATER CONTAMINATION

The groundwater sampling program conducted by CDM indicated that the shallow water table aquifer at the site (see Table 3-3) is locally contaminated with both PAH and toxic metal compounds. This is consistent with the surface soil contamination observed in and near the previous disposal areas. The aerial extent of present groundwater contamination is not yet known, however, due to the limited groundwater sampling carried out during the CDM contaminant survey. It is possible that the shallow groundwater contamination extends off-site. More comprehensive sampling of local groundwater conditions is necessary to determine the extent and rate of migration of contaminants in the shallow groundwater in and near the site. It was not evident at the time of CDM's work that the contamination of the shallow groundwater in the vicinity of the North Cavalcade Site poses any imminent threat to public health or the environment. There are no known users of the shallow groundwater, and no known surface exposures such as ponds or standing water.

It is very likely that the shallow groundwater is also contaminated by a variety of local urban and industrial sources. Contamination of the deeper aquifers in the area, which are known to be used for domestic, industrial or municipal water supplies, was not then considered by CDM to be a significant threat to public health or the environment.

5.0 REFERENCE DOCUMENTS

1. U.S. EPA Region VI File Documents. Copies of relevant EPA file documents on the North Cavalcade Site have been provided to CDM.
2. Texas Department of Water Resources File Documents. Pertinent information on file with the TDWR in relation to state regulatory actions for the site are included in a comprehensive microfiche file made available to CDM by TDWR. Files include correspondence, telephone memos, site summary, report excerpt, TDWR site investigation report and other documentation.
3. Texas Natural Resources Information System. Physical site data, remote sensing data, and other relevant site characterization information is readily available to CDM from the TNRIS Austin, Texas facilities. An index of available aerial photographic coverage of the site has been secured from TNRIS and appropriate photos selected and ordered.
4. U.S. Geological Survey. Recent USGS 7.5' quad sheets for the site and immediately surrounding areas have been obtained by CDM.
5. City of Houston. Land use and storm/sanitary sewer maps of the area of the site have been obtained from the Houston Public Works Department.
6. CDM Report and Files. The report "Cavalcade Contaminant Survey" in three volumes, dated July 11, 1983, is on-hand at CDM's Austin office, along with original data base for the report.
7. McClelland Engineers Reports. The MEI report "Reconnaissance Geotechnical Study, Proposed Cavalcade Yard Site" No. 0882-0282, dated May 20, 1983 is on-hand at CDM's Austin office. Their follow-up report to Coastal Casting Services dated October 25, 1984, is also on-hand at CDM.

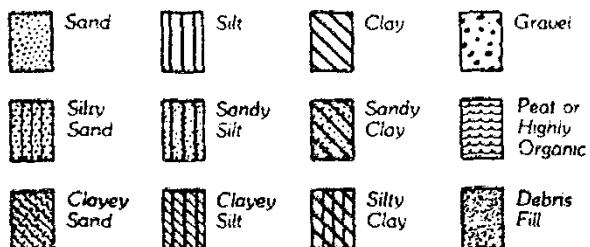
8. William F. Guyton Associates, Inc. The Guyton Report, "Investigation of Shallow subsurface Conditions at 2001 Cavalcade Street, Houston, Texas", dated January, 1984, to the Great Southern Life Insurance Company is on-hand at CDM.
9. Southwestern Laboratories, Inc. The report, "Geotechnical and Environmental Testing at 2001 Cavalcade Street, Houston, Texas", dated September, 1983, for the GSLI Company, is on-hand at CDM.

APPENDIX I

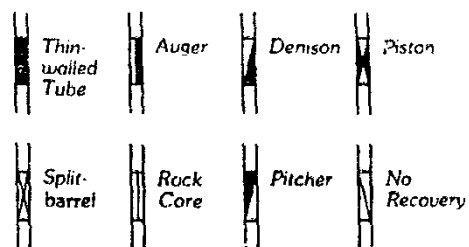
WELL LOGS FROM PREVIOUS INVESTIGATIONS

TERMS AND SYMBOLS USED ON BORING LOGS

SOIL TYPES



SAMPLER TYPES



SOIL GRAIN SIZE U.S. STANDARD SIEVE

		6"	3"	3/4"		4	10			40	200			
BOULDERS	COBBLES	GRAVEL				SAND			SILT		CLAY			
		COARSE		FINE		COARSE	MEDIUM	FINE						
		152	76.2	19.1	4.76	2.00	0.420	0.074			0.002			
SOIL GRAIN SIZE IN MILLIMETERS														

STRENGTH OF COHESIVE SOILS ⁽¹⁾

Consistency	Undrained Shear Strength, Kips Per Sq Ft
Very Soft	less than 0.25
Soft	0.25 to 0.50
Firm	0.50 to 1.00
Stiff	1.00 to 2.00
Very Stiff	2.00 to 4.00
Hard	greater than 4.00

DENSITY OF GRANULAR SOILS ^(2,3)

Descriptive Term	*Relative Density, %
Very Loose	less than 15
Loose	15 to 35
Medium Dense	35 to 65
Dense	65 to 85
Very Dense	greater than 85

*Estimated from sampler driving record

SPLIT-BARREL SAMPLER DRIVING RECORD

Blows Per Foot	Description
25	25 blows drove sampler 12 inches, after initial 6 inches of seating.
50/7"	50 blows drove sampler 7 inches, after initial 6 inches of seating.
Ret. 3"	50 blows drove sampler 3 inches during initial 6-inch seating interval.

Note: To avoid damage to sampling tools, driving is limited to 50 blows during or after seating interval.

SOIL STRUCTURE ⁽¹⁾

- Slickensided Having planes of weakness that appear slick and glossy. The degree of slickensidedness depends upon the spacing of slickensides and the ease of breaking along these planes.
- Fissured Containing shrinkage or relief cracks, often filled with fine sand or silt; usually more or less vertical.
- Pocket Inclusion of material of different texture that is smaller than the diameter of the sample.
- Parting Inclusion less than 1/8 inch thick extending through the sample.
- Seam Inclusion 1/8 inch to 3 inches thick extending through the sample.
- Layer Inclusion greater than 3 inches thick extending through the sample.
- Laminated Soil sample composed of alternating partings or seams of different soil type.
- Interlayered Soil sample composed of alternating layers of different soil type.
- Intermixed Soil sample composed of pockets of different soil type and layered or laminated structure is not evident.
- Calcareous Having appreciable quantities of carbonate.

REFERENCES:

- (1) ASTM D 2488
- (2) ASCE Manual 56 (1976)
- (3) ASTM D 2049

Information on each boring log is a compilation of subsurface conditions and soil or rock classifications obtained from the field as well as from laboratory testing of samples. Strata have been interpreted by commonly accepted procedures. The stratum lines on the logs may be transitional and approximate in nature. Water level measurements refer only to those observed at the times and places indicated, and may vary with time, geologic condition or construction activity.

LOG OF BORING NO. CAV-OW-03
CAVALCADE CONTAMINANT SURVEY
METRO-STAGE ONE, REGIONAL RAIL SYSTEM
HOUSTON, TEXAS

DEPTH, FT	SYMBOL	SAMPLES	LOCATION: N 734,599; E 3,157,963	SURFACE EL. 49.1'	SAMPLE NUMBER	MATERIALS ZONE	UNIT DRY WT. LB PER CU FT	WATER CONTENT, %			UNDRAINED SHEAR STRENGTH					ORGANIC MATTER, %			
								Plastic Limit	Natural	Liquid Limit	KIPS PER SQ FT								
											0.5	1.0	1.5	2.0	2.5				
5																			
10																			
15																			
20																			
25																			
30																			
35																			
40																			
45																			
50																			

JOB NO 0183-0008
 COMPLETION DEPTH 19.0'
 DATE: February 7, 1983
 DEPTH TO WATER IN BORING 1.7'
 DATE: May 17, 1983

SAMPLER: No samples taken
 DRILLING METHOD: Wet Rotary

STRENGTH LEGEND
 ● Unconfined Compression
 ▲ Unconsolidated-Undrained Triaxial Compression
 ◆ Miniature Vane
 (open symbols above indicate remolded tests)
 ⚡ Torvane
 ⊠ Hand Penetrometer

LOG OF BORING NO. CAV-OW-04
CAVALCADE CONTAMINANT SURVEY
METRO-STAGE ONE, REGIONAL RAIL SYSTEM
HOUSTON, TEXAS

DEPTH, FT	SYMBOL	SAMPLES	LOCATION: N 734,773; E 3,157,676	SAMPLE NUMBER	BORING ZONE	WATER CONTENT, %			UNDRAINED SHEAR STRENGTH					BURIED SAMPLES	
						Plastic Limit	Natural	Liquid Limit	KIPS PER SQ FT						
									0.5	1.0	1.5	2.0	2.5		
			SURFACE EL. 51.1'												
5			Clay with creosote wastes												
10															
15			Brown and gray fine sand												
20															
25															
30															
35															
40															
45															
50															

JOB NO. 0183-0006
 COMPLETION DEPTH 19.5'
 DATE: February 6, 1983
 DEPTH TO WATER IN BORING: 4.8'
 DATE: May 17, 1983

SAMPLER: No samples taken
 DRILLING METHOD: Wet Rotary

- STRENGTH LEGEND**
- Unconfined Compression
 - ▲ Unconsolidated-Un drained Triaxial Compression
 - ◆ Miniature vane
 - (open symbols above indicate remolded tests)
 - ⊕ Torvane
 - ⊞ Hand Penetrometer

MCCLELLAND
 ENGINEERS
 CAMP DRESBACH & McKEE

PLATE

LOG OF BORING NO. CAV-OW-05
CAVALCADE CONTAMINANT SURVEY
METRO-STAGE ONE, REGIONAL RAIL SYSTEM
HOUSTON, TEXAS

DEPTH, FT	SYMBOL	SAMPLES	LOCATION: N 735.883; E 3,157.557	SAMPLE NUMBER	MONITORING ZONE	UNIT DRY WT (LB PER CU FT)	WATER CONTENT, %			UNDRAINED SHEAR STRENGTH					ORGANIC MATTER, PPR	
							Plastic Limit	Natural	Liquid Limit	KIPS PER SQ FT						
										0.5	1.0	1.5	2.0	2.5		
							20	40	60	KILOPASCALS						
												25	50	75	100	125
			SURFACE EL. 51.0'													
			Brown fine sand -asphalt fill to 0.3'													
5																
10																
15			Clay													
20																
25																
30																
35																
40																
45																
50																

JOB NO. : 0183-0008
 COMPLETION DEPTH 14.0'
 DATE : February 7, 1983
 DEPTH TO WATER IN BORING : 4.9'
 DATE : May 17, 1983

SAMPLER : No samples taken
 DRILLING METHOD : rot Rotary

- STRENGTH LEGEND**
- Unconfined Compression
 - ▲ Unconsolidated-Undrained Triaxial Compression
 - ◆ Miniature vane
 - (open symbols above indicate remolded tests)
 - ⊕ Torvane
 - ⊞ Hand Penetrometer

M C GLELLAND
 ENGINEERS
 CAMP DRESSER & Mc KEE

PLATE

LOG OF BORING NO. CAV-SL-05
CAVALCADE CONTAMINANT SURVEY
METRO-STAGE ONE, REGIONAL RAIL SYSTEM
HOUSTON, TEXAS

DEPTH FT	SYMBOL	SAMPLES	LOCATION N 734.650; E 3.157.622	SURFACE EL 50.3'	SAMPLER	PASSING NO. 200 SIEVE	UNIT DRY WT LB PER CU FT	WATER CONTENT %			UNDRAINED SHEAR STRENGTH					DRILLING METHOD	
								Plastic Limit	Natural	Liquid Limit	K.PS PER SQ FT						
											20	40	60	25	50		75
0-5				Fill: Brown fine sand and clay Fill: Intermixed brown fine sand and clay with organic matter	01												
5-10				Gray fine sand, slightly clayey -brown below 10'													
10-15																	
15-20																	
20-25				very stiff brown clay, slickensided with sand layers, 19.5' to 21'	03												
25-30				-with silt partings and layers, 26' to 32'													
30-35				-with creosote wastes below 28'	04												
35-40																	
40-45					05												
45-50																	
50-55																	
55-60																	

JOB NO. : 0191-0008
 COMPLETION DEPTH : 40.0'
 DATE : February 3, 1993
 DEPTH TO WATER IN BORING : Grouted upon completion

SAMPLER : 3" thin-walled tube
 DRILLING METHOD : Jet Rotary

- STRENGTH LEGEND**
- Unconfined Compression
 - ▲ Unconsolidated-Undrained Triaxial Compression
 - ◆ Miniature Vane
 - (open symbols above indicate remolded tests)
 - ◇ Torvane
 - ⊠ Hand Penetrometer

LOG OF BORING NO. CAV-SL-26
CAVALCADE CONTAMINANT SURVEY
METRO-STAGE ONE, REGIONAL RAIL SYSTEM
HOUSTON, TEXAS

DEPTH FT	SYMBOL	SAMPLES	LOCATION N 734,595; E 3,157,355	SAMPLE NUMBER	% PASSING NO 200 SIEVE	UNIT DRY WT LB PER CU FT	WATER CONTENT %			UNDRAINED SHEAR STRENGTH					ORGANIC MATTER, %
							Plastic Limit	Natural	Liquid Limit	KIPS PER SQ FT					
										0.5	1.0	1.5	2.0	2.5	
SURFACE EL 51.2'						20	40	60	KILOPASCALS						
									25	50	75	100	125		
			Fill: Gravel and sand	01											1500
			Gray and brown sandy clay												2000
5				02											
10				03											1800
15															
20															
25															
30															
35															
40															
45															
50															

JOB NO.: 0193-0090
 COMPLETION DEPTH 10.0'
 DATE May 7, 1983
 DEPTH TO WATER IN BORING Grouted upon completion

SAMPLER: 3" thin-walled tube
 DRILLING METHOD Dry Auger

STRENGTH LEGEND
 ● Unconfined Compression
 ▲ Unconsolidated-Undrained Triaxial Compression
 ◆ Moisture Vane
 (open symbols above indicate rammed tests)
 ⬢ Torvane
 ⊞ Hand Penetrometer

LOG OF BORING NO. CAV-SL-27
CAVALCADE CONTAMINANT SURVEY
METRO-STAGE ONE, REGIONAL RAIL SYSTEM
HOUSTON, TEXAS

DEPTH FT	SYMBOL	LOCATION N 734,900; E 3,157,354 SURFACE EL 50.9'	SAMPLE NUMBER	% PASSING NO 200 SIEVE	UNIT DRY WT LB PER CU FT	WATER CONTENT %			UNDRAINED SHEAR STRENGTH					ORGANIC MATTER %
						Plastic Limit	Natural	Liquid Limit	KIPS PER SQ FT					
									0.5	1.0	1.5	2.0	2.5	
						KILOPASCALS								
						20	40	60	25	50	75	100	125	
		Fill: Gravel and dark gray sandy clay	01											
5		Gr. and brown sandy clay	02											1300
10			03											1200
15														
20														
25														
30														
35														
40														
45														
50														

JOB NO. 0153-0090 COMPLETION DEPTH 10.0' DATE: May 7, 1983 DEPTH TO WATER IN BORING: Grouted upon completion	SAMPLER: 3" thin-walled tube DRILLING METHOD: Dry Auger	STRENGTH LEGEND ● Unconfined Compression ▲ Unconsolidated-Undrained Triaxial Compression ◆ Miniature Vane <i>(open symbols above indicate remolded tests)</i> ◇ Torvane ⊠ Hand Penetrometer
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McClendon engineers		LOG OF BORING				BORING NO. 04-5					
PROJECT: Reconnaissance Study - METRO - Stage One, P-5 - Houston, Texas				JOB NO. 0152-0252		SHEET NO. 1 OF 3					
CLIENT: Houston Transit Consultants				LOCATION N 31.265.8		DATE STARTED 12-13-52					
DRILLING BY: McClendon Engineers				DATE FINISHED 12-13-52		STATION					
EQUIPMENT USED: Silling 36, truck mounted		TYPE: STEEL		DRILLER: S. Martin		OFFSET					
METHOD OF BOREHOLE ADVANCEMENT: Rot. Rotary - 3 7/8" bottom discharge bit		SIZE: 4" x 3"		ENGINEER: C. Rivette		ELEVATION					
WEIGHT&FALL: Push						DATE FINISHED 12-13-52					
DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
0	12.0		1H		FILL: Dark gray, silty SAND with little clay						
5	7.0		2H		-hard, dark gray, CLAY, sandy CLAY and SAND with occasional bricks and gravel (1/8" to 1/2") to 2'						
			3H								
			4H		Firm, light brown and brownish yellow, sandy CLAY (CL)	112					
10	2.0		5H		Medium dense, light gray, fine SAND with trace silt (SP-SH)						
			6S		-with trace to little clay to 12'						
15	-3.0		7H		Very stiff, reddish brown and greenish gray, CLAY with frequent calcareous nodules (1/8" to 1/2") (CH)	102					
			8S		-with frequent silt and sand seams below 19'						
20	-8.0		9H		Dense, reddish brown and light gray, SILT with occasional clay seams (ML)						
			10S								
25	-13.0		11H		Interlayered, stiff, silty CLAY and CLAY with numerous silt and sand partings (CH/CL)						
			12S								
30	-18.0		13H		-slickensided at 30'	94					

SAMPLE IDENTIFICATION:		WATER LEVEL DATA				STRENGTH LEGEND:	
S	H	DATE	TIME	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	COMMENTS
		12-17-52		6.3		10.2	
		12-18-52	1500	6.3		10.2	
		12-20-52		6.5		10.3	Sealed

STRENGTH LEGEND:	
●	UNCONFINED COMPRESSION
▲	UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
◆	TORVANE
⊠	HAND PENETROMETER

BORING NO. 04-5

LOG OF BORING (CONT'D)

BORING NO. 2-4

JOB NO. 52-0262
SHEET NO. 3 OF 3

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
30					Interlayered, stiff, silty CLAY and CLAY with numerous silt and sand partings (CH/CL) (32.0)						
35			10H		Hard, reddish brown and greenish gray CLAY, slightly slickensided (37.0)						
40			11H		Stiff, light gray and brownish yellow, silty CLAY (CL) (39.0)	116					
45			12H		Hard, light brown, CLAY with frequent ferrous stains, slightly slickensided (CH) (42.0)						
50			13S		Stiff, light brown and brownish yellow sandy CLAY with trace to little silt (CL-ML) -with frequent sand seams below 45' (46.5)	117					
55			14H		Very dense, light gray, silty fine SAND (SM) (51.0)	35					
60			15H		Very stiff, reddish brown, CLAY (Ch) -with occasional greenish gray vertical and horizontal silt partings to 57' -highly slickensided, with occasional sand pockets (1/2") to 61' (58.0)						
65			16H		-sand layer, 61' to 62' -moderately slickensided, 62' to 64' -slightly slickensided, 64' to 69' -with frequent sand partings, 64' to 72' (64.0)	78					

SAMPLE IDENTIFICATION:
S - SPLIT BARREL
H - THIN-WALLED TUBE (HOUSTON)

NOTES:
(1) REFER TO SHEET 1 FOR BORING LEGEND.
(2) REFER TO PLATE 19 FOR KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS.

STRENGTH LEGEND:
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
◆ TORVANE
⊠ HAND PENETROMETER
BORING NO. 2-4

LOG OF BORING (CONT'D)

BORING NO. 514

JOB NO. 24-1052
SHEET NO. 1 OF 2

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIFVE	NATURAL WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	UNDRAINED SHEAR STRENGTH
64			17H		Very stiff, reddish brown, CLAY (CH) -slightly slickensided, 64' to 69' -with frequent sand partings, 64' to 72'						
69					-with partings inclined at 45 degree angle, 69' to 70' -brown, 69' to 72'						
72			18H		-reddish brown and light gray with trace silt below 72'	108					
75											
79			19H		Very stiff, reddish brown and greenish gray, silty CLAY (CL) -with frequent silt and sand pockets below 79'						
80					Bottom of Boring at 80.0'						
85											
90											
95											
100											

SAMPLE IDENTIFICATION:
S - SPLIT BARREL
H - THIN-WALLED TUBE (HOUSTON)

NOTES:
(1) REFER TO SHEET 1 FOR BORING LEGEND.
(2) REFER TO PLATE 19 FOR KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS.

STRENGTH LEGEND:
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
◆ TORVANE
⊠ HAND PENETROMETER

BORING NO. 514-B

LOG OF BORING

BORING NO. RM-9

PROJECT Reconnaissance Study - METRO - Stage One, MHS - Houston, Texas
 CLIENT Houston Transit Consultants
 DRILLING BY McClelland Engineers

JOB NO. 0192-025
 SHEET NO. 1 OF 3
 LOCATION N 33-29-2
E 135-57-9

EQUIPMENT USED Falling 36, truck mounted
 METHOD OF BOREHOLE ADVANCEMENT Rotary - 7/8" bottom discharge bit

TYPE Steel
 SIZE 6" x 2.5'
 HAMMER Push
 WEIGHT&FALL

DRILL CREW
 DRILLER G. Hooney
 ENGINEER D. Lourie

STATION
 OFFSET
 ELEVATION 50.0
 DATE STARTED 12-16-52
 DATE FINISHED 12-16-52

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT			UNDRAINED SHEAR STRENGTH
								w _n	P _L	w _L	
			1H		FILL: Dark gray and brown, silty fine SAND with little fine to medium gravel and shells and roots (2.0')						
			2H		Firm, dark gray and brownish yellow, sandy CLAY (CL)						
5			3H		-with crawfish hole, 5' to 6'	111					
			4H		-light gray and brownish yellow with frequent sand pockets and ferrous nodules (1/8" to 1/4") below 6' -stiff below 7' (8.0')						
			5H		Light gray and brownish yellow clayey SAND with frequent ferrous nodules (1/8" to 1/4") (SC) (10.0')		36				
10					Light gray, fine SAND with trace silt (S)						
			6S		-greenish gray, silty clay seam below 14.3' (14.5')						
15					Very stiff, reddish brown and greenish gray CLAY (CH) (18.0')						
			7S		Reddish brown and greenish gray SILTY with trace to little clay (18.8')						
20					very stiff, reddish brown, silty CLAY with trace sand and frequent calcareous nodules (1/8") (CL) (19.7')						
					very stiff, reddish brown, CLAY with frequent calcareous nodules (1/4") (CH) (23.0')						
			8H		Reddish brown and greenish gray, silty fine SAND (SH) (25.0')		26				
25					Very stiff, reddish brown, silty CLAY (CL) (28.5')						
			9H		very stiff, reddish brown and brownish yellow, CLAY with frequent silt partings and calcareous nodules (1/8" to 1/4") (CH) (28.5')						
30											

SAMPLE IDENTIFICATION:
 S - SPLIT BARREL
 H - THIN-WALLED TUBE (HOUSTON)

WATER LEVEL DATA					
DATE	TIME	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	COMMENTS
12-16-52	1500	5.3'	-	10.4'	
12-17-52	-	5.5'	-	9.1'	
12-20-52	-	5.9'	-	9.4'	Sealed

STRENGTH LEGEND:
 ● UNCONFINED COMPRESSION
 ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
 ◆ YORVANE
 ⊗ HAND PENETROMETER

BORING NO. RM-9

LOG OF BORING (CONT'D)

BORING NO. 24-9

JOB NO. W-22-0252
SHEET NO. 2 OF 2

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOMS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
32.0	22.0				very stiff, reddish brown and brownish yellow, CLAY with frequent silt partings and calcareous nodules (1/8" to 1/4")						
33.0	21.0		10H		very stiff, greenish gray and brownish yellow, silty CLAY with trace fine sand (CL)	118					
38.0	16.0		11H		-with frequent calcareous nodules (1/8" to 1/4"), 38' to 40' -little fine sand below 36'						
43.0	11.0		12H		-greenish gray and reddish brown below 43'						
46.0	8.0				(46.0')						
48.0	6.0		13H		Reddish brown, sandy SILT (ML)		68				
50.0	4.0				(50.0')						
54.0	0.0		14H		very stiff, reddish brown and greenish gray, CLAY (CH) -with occasional sandy silt pockets and frequent calcareous nodules (1/8" to 1/4") to 55'						
59.0	-5.0		15H		-reddish brown, silty clay seam, 58.9' to 59'						
63.0	-9.0		16H		-with frequent silty fine sand and sandy silt partings, 63' to 64'						
64.5	-10.5				Laminated, reddish brown clay and light gray sandy SILT (CH/ML)						

SAMPLE IDENTIFICATION:
S - SPLIT BARREL
H - THIN-WALLED TUBE (HOUSTON)

NOTES:
(1) REFER TO SHEET 1 FOR BORING LEGEND.
(2) REFER TO PLATE 19 FOR KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS.

STRENGTH LEGEND:
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
⊕ TORVANE
⊞ HAND PENETROMETER

BORING NO. 24-9

LOG OF BORING (CONT'D)

BORING NO. RM-9
 JOB NO. 0152-0257
 SHEET NO. 2 OF 3

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
65					Laminated reddish brown, CLAY and light gray sandy SILT (CH/ML)						
67.0'		18 24	17H		Very stiff, reddish brown, CLAY with frequent sandy silt partings, pockets and calcareous nodules (1/8" to 1/4") (CH)						
69.2'					Light gray and reddish brown, clayey SILT (ML)						
71.0'					Very stiff, reddish brown, silty CLAY with some sand (CL)						
77.0'		24 24	18H		Very stiff, reddish brown, CLAY with frequent silty clay seams and pockets (CH)	112					
80.0'			19H		Bottom of Boring at 80.0'						

SAMPLE IDENTIFICATION:
 S - SPLIT BARREL
 H - THIN-WALLED TUBE (HOUSTON)

- NOTES:
- (1) REFER TO SHEET 1 FOR BORING LEGEND.
 - (2) REFER TO PLATE 19 FOR KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS.

STRENGTH LEGEND:
 ● UNCONFINED COMPRESSION
 ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
 ◆ TORVANE
 ⊠ HAND PENETROMETER

BORING NO. RM-9

McClelland engineers		LOG OF BORING				BORING NO. RM-10					
PROJECT Reconnaissance study - METRO - Stage 1 - Houston, Texas				JOB NO. 113-1002		SHEET NO. 1 OF 1					
CLIENT Houston Transit Consultants				LOCATION 34.565.7		DATE FINISHED 11-29-52					
DRILLING BY McClelland Engineers				ELEVATION 21.0		DATE STARTED 11-29-52					
EQUIPMENT USED Raynew 250, buggy mounted		TYPE CASING		DRILLER CREW		STATION					
METHOD OF BOREHOLE ADVANCEMENT		SIZE		DRILLER		OFFSET					
Rotary - 3 7/8" bottom discharge bit		HAMMER		ENGINEER		ELEVATION					
		WEIGHT/FALL		Push		DATE FINISHED					
DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT	PLASTIC LIMIT	LIQUID LIMIT	UNDRAINED SHEAR STRENGTH
0	21.0		1H		FILL: Intermixed, reddish brown, dark gray and greenish gray CLAY and dark gray sandy CLAY with frequent cinders, glass and shell fragments						
1	20.0		2H		-with roots to 1'						
2	19.0		3H		-dark gray, sandy clay with some silt and little gravel, 2' to 4'						
3	18.0				-dark gray to dark brown silty fine sand with roots and creosote odor below 4'						
4	17.0										
5	16.0		4S		Medium dense, dark gray clayey SAND with roots and creosote odor (SC)						
6	15.0		5H		Very stiff, light gray and brownish yellow, sandy CLAY with frequent vertical sand partings, creosote odor and occasional ferrous nodules (1/2") (CL)						
7	14.0		6S								
8	13.0										
9	12.0		7H		Light gray, fine SAND with little silt and creosote odor (SH)						
10	11.0										
11	10.0										
12	9.0										
13	8.0										
14	7.0										
15	6.0										
16	5.0										
17	4.0										
18	3.0										
19	2.0										
20	1.0				Bottom of Boring at 20.0'						
21	0.0										
22											
23											
24											
25											
26											
27											
28											
29											
30											

SAMPLE IDENTIFICATION:		WATER LEVEL DATA				STRENGTH LEGEND:	
S	H	DATE	TIME	WATER OF CASING	BOTTOM OF HOLE	COMMENTS	
		12-11-52			15.0'		● UNCONFINED COMPRESSION
		12-17-52			12.0'	Sealed	▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
							◆ TORVANE
							⊠ HAND PENETROMETER

BORING NO. RM-10

LOG OF BORING

BORING NO. BH-11

PROJECT: Reconnaissance Study - METRO - State - RR - Houston, Texas
 CLIENT: Houston Transit Consultants
 DRILLING BY: McClelland Engineers

JOB NO. 015-31
 SHEET NO. 02
 LOCATION: H-6-9-4

EQUIPMENT USED: Mayhew 250, buddy mounted	TYPE: Steel	DRILLER: J. Gooney	STATION:
METHOD OF BOREHOLE ADVANCEMENT: Wet Rotary - 3 7/8" bottom discharge bit	SIZE: 6" x 2 1/2"	ENGINEER: G. Lourie	OFFSET:
WEIGHT/FALL: Push			ELEVATION: -
			DATE STARTED: 1-9-52
			DATE FINISHED: 1-9-52

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BINS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
0 - 4.0			1H, 2H	Fill	Fill: Dark brown, sandy CLAY with frequent shell fragments, roots and sand pockets -silty fine sand to 0.3' -with shells and gravel, 1' to 2' -dark brown and dark gray, sandy clay below 2'	54					
4.0 - 8.0			3H, 4H	Firm	Firm, light gray and brownish yellow, sandy CLAY with roots and frequent sand pockets (CL) -dark brown and brownish yellow to 6' -with frequent ferrous nodules (1/4" to 1/2") below 6'	109	58				
8.0 - 12.5			5S	Intermixed	Intermixed, clayey SAND and fine SAND with some clay and frequent ferrous nodules (1/4" to 1/2")	114					
12.5 - 19.0			63, 65, 75	Very dense	very dense, light gray, fine SAND with little silt and frequent ferrous nodules (1/2") (SM) -with occasional sandy clay pockets below 19'	17					
19.0 - 20.5					Bottom of Boring at 20.5'						

SAMPLE IDENTIFICATION:
 S - SPLIT BARREL
 H - THIN-WALLED TUBE (HOUSTON)

DATE		TIME		WATER LEVEL DATA		COMMENTS
				BOTTOM OF CASING	BOTTOM OF HOLE	
1-11-52				5.5	2.5	
12-17-52				3.2	11.0	Sealed

STRENGTH LEGEND:
 ● UNCONFINED COMPRESSION
 ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
 ◆ TORVANE
 ⊠ HAND PENETROMETER
 BORING NO. BH-11

McClelland engineers		LOG OF BORING				BORING NO. RM-12					
PROJECT: Reconnaissance Study - McHwy - Stage 11, 495 - Houston, Texas				JOB NO. 213-100		SHEET NO. 02 OF 05					
CLIENT: Houston Transit Consultants				LOCATION N 35° 15' W		STATION					
DRILLING BY: McClelland Engineers				DATE FINISHED: 1-2-52		DATE STARTED: 12-2-51					
EQUIPMENT USED: Rayne 250, Dandy mounted		TYPE: CASE	DRILL: DP	GRILL: DP	STATION						
METHOD OF BOREHOLE ADVANCEMENT: Jet Rotary - 1 3/8" bottom discharge bit		SIZE: 12.0"	ENGINEER: J. E. ...	ELEVATION: ...							
		WEIGHTS/FALL: ...			DATE FINISHED: 1-2-52						
DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (CN)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
0	12.0		1H		Dark gray, silty fine SAND with roots	43					
5	7.0		25		Firm to stiff, dark gray, sandy CLAY (CL)	48					
10	2.0		35		-light gray and brownish yellow below 8'	114					
			44								
			55			44					
15	-2.8		65		Dense, light gray, fine SAND with little clay and occasional clay seams (SH)	16					
					-with occasional calcareous nodules (1/8") and sand seams below 13.5'						
20	-7.8				Stiff, greenish gray, CLAY with frequent sandy silt pockets and occasional clayey silt partings (CH)						
					-slickensided at 23'	101					
25	-12.8				Bottom of Boring at 23.0'						
30	-17.8										

SAMPLE IDENTIFICATION:		WATER LEVEL DATA				STRENGTH LEGEND:	
S	T	DATE	TIME	WATER OF CASING	BOTTOM OF HOLD	COMMENTS	
S		12-9-51		5.0	7.0		● UNCONFINED COMPRESSION
T		12-20-51		5.5	5.5	Sealed	▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
							◆ TORVANE
							⊗ HAND PENETROMETER

McClelland engineers		LOG OF BORING				BORING NO. RM-13					
PROJECT: reconnaissance study - MTRG - State Ave., HPS - Houston, Texas				JOB NO. 44-0762		SHEET NO. 07					
CLIENT: Houston Transit Consultants				LOCATION: N. 75.511		DATE: 12-20-82					
DRILLING BY: McClelland Engineers				STATION: OFFSET: ELEVATION: 45.9		DATE STARTED: DATE FINISHED:					
EQUIPMENT USED: Maxam 130, Dugout mounted		TYPE: SIZE: HAMMER: WEIGHT/FALL:		CASING: Step: 6" x 2.5		DRILL CREW: DRILLED: S. Mooney; ENGINEER: D. Lourie					
METHOD OF BOREHOLE ADVANCEMENT: 4" Rotary - 3 7/8" bottom discharge bit				Push							
DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
0	45.9	1	1H		Dark gray to black, silty fine SAND with roots -trace gravel (1" to 1' (1.5'))						
1.5	44.4	2	2H		very loose, dark gray, clayey fine SAND (SC) -with roots to 3'	42					
5	40.4	5	3S		Firm, light gray and brownish yellow, sandy CLAY intermixed with clayey sand and sand (CL, SC/SP)						
6	39.4	4	4H		-with frequent ferrous nodules (1/8" to 3/8") below 6' -with vertical sand seam at 7'	113					
7	38.4	5	5H		-light gray and brownish yellow with frequent clayey sand and sand particles and seams below 6' (9.5')						
10	35.4	7	6S		Reddish brown, fine SAND with little to some clay (SP-SH) -with occasional sandy clay pockets to 14' -with little silt below 10.5'						
15	30.4	7	7S		-light gray below 14' (17.5')	11					
20	25.4	7	7H		very stiff, reddish brown and greenish gray CLAY (CH) -moderately slickensided to 19.5' -frequent clayey silt seams below 19.5'	86					
20.0	25.4				Bottom of Boring at 20.0'						

SAMPLE IDENTIFICATION:		WATER LEVEL DATA					STRENGTH LEGEND:	
S	H	DATE	TIME	WATER OF CASING	BOTTOM OF CASING	BOTTOM OF HOLE	COMMENTS	
S	H	12-9-82		2.5		10.0		● UNCONFINED COMPRESSION
S	H	12-11-82		2.5		10.0		▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
S	H	12-20-82		3.6		5.0	Sealed	◆ TORVANE
								⊠ HAND PENETROMETER

BORING NO. RM-13

McClelland engineers		LOG OF BORING				BORING NO. RH-14																							
PROJECT: Reconnaissance Study - METRO - Stage One. RFS - Houston, Texas				JOB NO. 0182-150		SHEET NO. 1 OF 1																							
CLIENT: Houston Transit Consultants				LOCATION: N 36.155° E		ELEVATION: 49.4																							
DRILLING BY: McClelland Engineers				DATE STARTED: 12-23-62		DATE FINISHED: 1-6-63																							
EQUIPMENT USED: Haynes 200, buggy mounted		TYPE: HAMMER		CASING: 6" x 2.5"		DRILL CREW: D. Rodney, D. Lourie																							
METHOD OF BOREHOLE ADVANCEMENT: wet rotary - 3 7/8" bottom discharge bit		WEIGHTS: FALL		PUSH		STATION: OFFSET: ELEVATION: 49.4																							
DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (P.C.F.)	PERCENT BY WEIGHT PASSING NO. 400 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)																		
												1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
				1H	Dark gray, silty fine SAND with roots (SH)																								
				2S	Dark gray, clayey SAND (SC)																								
5				3H	Firm, light gray and brownish yellow, sandy CLAY with frequent ferrous nodules (1/8") (CL)	111																							
				4H		111																							
10				5S	Light gray, fine SAND with little silt and frequent brownish yellow sandy clay pockets (SH)																								
				6S																									
15				7H	Very stiff, light gray and brownish yellow, silty CLAY with little sand																								
20					Bottom of Boring at 20.0'																								
25																													
30																													

SAMPLE IDENTIFICATION:		WATER LEVEL DATA					STRENGTH LEGEND:	
DATE	TIME	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	COMMENTS	●	▲	
12-9-62		6.0		9.3		●	▲	
12-20-62		5.5		7.9		●	▲	
12-23-62		6.2		7.4		●	▲	
1-6-63					Sealed	●	▲	

5 - SPLIT BARREL	● UNCONFINED COMPRESSION
H - THIN-WALLED TUBE (HOUSTON)	▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
	◆ TORVANE
	⊠ HAND PENETROMETER

BORING NO. RH-14

McClelland engineers		LOG OF BORING				BORING NO. RH-15					
PROJECT: Reconnaissance Study - METRO - Stage One, H-1 - Houston, Texas				JOB NO. 0150-0252		SHEET NO. 01					
CLIENT: Houston Transit Consultants				LOCATION: N 735,967.9		E 2,357,323.1					
DRILLING BY: McClelland Engineers				EQUIPMENT USED: Maxam 250, Dugan mounted		STATION: _____					
METHOD OF BOREHOLE ADVANCEMENT: 1 1/2" rotary - 1 1/2" 9" bottom discharge bit		TYPE SIZE: HAMMER		CASING: Steel 6" x 2.5"		DRILL CREW: DRILLER: J. Mooney ENGINEER: D. Lourie					
WEIGHT OF FALL: _____		PUSH: _____		DATE STARTED: 12-1-82		DATE FINISHED: 12-1-82					
DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
0			1H		Dark gray, silt, fine SAND with roots and frequent clay pockets (SM)						
2.0			2H		Dark gray, clayey SAND with roots (SC)		50				
4.0			3H		Stiff, dark gray and brownish yellow, sandy CLAY with roots, frequent ferrous nodules (1/8") and vertical fine sand seams (CL)	111					
6.0			4H		Light gray and brownish yellow, clayey SAND with frequent fine sand partings						
8.0			5S		Light gray and brownish yellow, fine SAND with little clay (SM)		13				
10.0					-light gray below 12'						
12.0			36	6S			11				
15.0					Bottom of Boring at 15.0'						

SAMPLE IDENTIFICATION:		WATER LEVEL DATA				STRENGTH LEGEND:	
S	H	DATE	TIME	WATER	BOTTOM OF CASING	BOTTOM OF HOLE	COMMENTS
		12-1-82		3.5'			
		12-1-82		3.0'		5.1'	Sealed

● UNCONFINED COMPRESSION	▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
◆ TORVANE	⊠ HAND PENETROMETER

BORING NO. RH-15

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BOWNS, PER 5 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (CPT)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE		WATER CONTENT (%)	UNSATURATED SWELLING (%)	USE NO. OF SHEET NO.	UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
							PLASTIC LIMIT	LIQUID LIMIT				
20					Interlayered, reddish brown, brownish yellow, and greenish gray, sandy SILT, silty fine SAND and CLAY (ML/SH/CH) (32.0')							
25			10H		Hard, reddish brown and greenish gray, CLAY, heavily slickensided (CH) (34.0')							
30			11H		very stiff, brownish yellow and greenish gray, silty CLAY with some sand (CL) -with frequent sand partings to 37'							
35			11H		-hard, light gray and brownish yellow below 37'							
40			12H		Intermixed, hard, reddish brown, CLAY and light gray sandy CLAY with frequent calcareous nodules (1/8" to 1/4"), slightly slickensided (CH/CL) (42.5')	113						5.0- 2-
45			13H		Hard, reddish brown and greenish gray, CLAY, moderately slickensided with frequent silt pockets (CH) (46.0')							5.0- 2-
50			14S		Interlayered, reddish brown, SILT, clayey SILT and hard CLAY (ML/CH) (52.0')							5.0- 2-
55			15H		Hard, reddish brown, CLAY, highly slickensided (CH) (55.0')							5.0- 2-
60			15H		-with frequent calcareous nodules (1/16" to 1/4") and siltstone seams, 58" to 58.5'							5.0- 2-
65			16S		Dense, reddish brown, SILT with little sand (ML) (61.5')							
70			16S		Hard, reddish brown, CLAY with frequent calcareous nodules (1/16" to 1/8") (CH) (64.5')	89						5.0- 2-

SAMPLE IDENTIFICATION:
S - SPLIT BARREL
H - THIN-WALLED TUBE (HOUSTON)

NOTES:
(1) REFER TO SHEET 1 FOR BORING LEGEND.
(2) REFER TO PLATE A-28 FOR KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS.

STRENGTH LEGEND:
● UNCONFINED COMPRESSION
▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
+ TORVANE
□ WAND PENETROMETER
BORING NO. 11-16

LOG OF BORING (CONT'D)

BORING NO. RH-15

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE TYPES PER 5 FEET OR RECOVERED STANDARD PENETRATION RESISTANCE (N)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL MOISTURE CONTENT (%)	PLASTIC LIMIT	LIQUID LIMIT	WATER	UNDRAINED SHEAR STRENGTH						
												UNCONSOLIDATED-COMPRESSION	UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION	TORVANE	HAND PENETROMETER	KIPS PER SQ. FT.		
0.0					hard, reddish brown, CLAY with frequent calcareous nodules (1/16" to 1/8") (CH)													
15.0			17H		laminated, hard, brown and reddish brown, CLAY and SILT (CH/ML)													
25.0			19H		-inter-layered, very stiff, reddish brown and brownish yellow, sandy CLAY and CLAY, 74' to 74.5' -stiff, brown and light gray below 74.5'	100												
27.0			19H		hard, reddish brown and light gray, sandy CLAY with trace silt (CL)													
80.0					Bottom of Boring at 80.0'													

SAMPLE IDENTIFICATION:
 S - SPLIT BARREL
 T - THIN-WALLED TUBE (HOUSTON)

NOTES:
 (1) REFER TO SHEET 1 FOR BORING LEGEND.
 (2) REFER TO PLATE A-28 FOR KEY TO DESCRIPTION AND CLASSIFICATION OF SUBSURFACE MATERIALS.

STRENGTH LEGEND:
 ● UNCONFINED COMPRESSION
 ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION
 ⊕ TORVANE
 ⊠ HAND PENETROMETER

BORING NO. RH-15

McClelland engineers		LOG OF BORING		BORING NO. RI-17
PROJECT: RECONNAISSANCE STUDY - PLUM - Stage 100, 100, 100 - HOUSTON, TEXAS			JOB NO. 100-100-100	
CLIENT: HOUSTON TRANSIT CONSULTANTS			SHEET NO. 100-100-100	
DRILLING BY: McClelland engineers			LOCATION: 100-100-100	
EQUIPMENT USED: raising to trucks mounted		TYPE: DRILL	TRAIL: SEA	STATION: 100-100-100
METHOD OF BOREHOLE ADVANCEMENT: jet rotary - 1" 5" bottom discharge bit		SIZE: 4" 5"	DRILLER: 100-100-100	OFFSET: 100-100-100
HAMMER: WIGHTS/FALL		ENGINEER: 100-100-100	LABORER: 100-100-100	ELEVATION: 100-100-100
				DATE STARTED: 100-100-100
				DATE FINISHED: 100-100-100

DEPTH (FEET)	ELEVATION (FEET)	SAMPLE BLOWS PER 6 INCHES OR RECOVERY STANDARD PENETRATION RESISTANCE (SP)	SAMPLE NUMBER	STRATIGRAPHY	SOIL CLASSIFICATION AND REMARKS	DRY UNIT WEIGHT (PCF)	PERCENT BY WEIGHT PASSING NO. 200 SIEVE	NATURAL WATER CONTENT (%)			UNDRAINED SHEAR STRENGTH (KIPS PER SQ. FT.)
								W _n	W _p	W _L	
45	45.0		1H		Fine, stiff, dark gray, sandy CLAY with little silt, frequent shell fragments, occasional calcareous nodules (1/16" to 1/8") and roots (CL) (2.0%)						
45	44.0		2H		Very stiff, dark gray, silty CLAY with some sand, frequent calcareous nodules (1/16" to 1/2"), ferrous stains and roots (CL) (4.0%)						
45	43.0		3H		Firm, dark gray, light gray and brownish yellow, sandy CLAY (CL)						
45	42.0		4H		-with vertical clayey sand seams below 6'						
45	41.0		5H		-light gray and brownish yellow below 5'						
35	35.0		6S		Dense, light gray, fine SAND with trace silt (SP-SM) -clayey sand to 10'		10				
30	30.0		7H		Stiff, reddish brown and greenish gray, CLAY (CH) -highly slickensided to 23' -with occasional sandy clay and clayey silt pockets, 19.5' to 20' -with frequent silt layers and sandy silt partings below 20'		59				
25	25.0		8H		-very stiff and moderately slickensided below 23'						
20	20.0		9H		Very stiff, reddish brown and light gray, silty CLAY with frequent clayey silt and sandy clay pockets and occasional ferrous nodules (1/16" to 1/8") (CL)						
					Bottom of Boring at 30.0'						

SAMPLE IDENTIFICATION: S - SPLIT BARREL H - THIN-WALLED TUBE (HOUSTON)	WATER LEVEL DATA					STRENGTH LEGEND: ● UNCONFINED COMPRESSION ▲ UNCONSOLIDATED-UNDRAINED TRIAXIAL COMPRESSION ◆ TORVANE ⊗ HAND PENETROMETER
	DATE	TIME	BOTTOM OF CASING	BOTTOM OF HOLE	COMMENTS	

APPENDIX II

- NORTH CAVALCADE SITE CHARACTERIZATION MEMORANDUM
- SITE PERSONNEL PROTECTION AND SAFETY FORMS
- EXPENDABLE EQUIPMENT REQUEST FORMS

M E M O R A N D U M

TO: R.A. Kier CDM/Austin
FROM: J.D. Gram CDM/Boston
DATE: 7 February 1985
SUBJECT: Cavalcade North - Site Characterization
CONTRACT NO.: 68-01-6939
DOCUMENT CONTROL NO.: 141-WP1-I0-ASTC-1
ACTION:

Objectives: The objective of the site inspection was to confirm the site description contained in the 1983 CDM report and identify any changes in site conditions which may have occurred since that time. Prior to conducting the site inspection the available site information was reviewed. The Interim Site Characterization Report was not available for review prior to conducting the initial site characterization inspection because the site inspection request was made by EPA-Region VI to coincide with the TAT inspections. Therefore, a complete review of available information on site activities could not be conducted.

Introduction

A site inspection was performed at the Cavalcade Yard-North USEPA NPL site on January 16, 1984. This site is located in Houston, Harris County, Texas. The site is triangular in shape, occupies approximately 21 acres and is bounded by Cavalcade Street to the south, Houston Belt and Terminal railroad passenger line to the east and Missouri Pacific railroad freight line to the west. The site is located approximately 1 mile south west of the intersection between U.S. Interstate 610 (North Loop) and U.S. Highway 59 (Eastex Freeway). The site presently consists of two warehouses and vacant land, but was formerly the site of a creosote and wood preserving facility.

A small firm by the name of Houston Creosote began wood treating operations on about 9 acres of defined site between 1944 and 1953. In addition to office areas, the facility consisted of a creosote and pentachlorophenol (PCP) storage area, pressure vessels, a treatment plant, drying and storage areas and two surface impoundments that contained process blowdown wastes and creosote sometime between 1957 and 1964. Sometime after 1964, the

southwest portion of the site was developed for two warehouses, one property owned by Great Southern Life Insurance Company and the other occupied by Coastal Casting Service Company. R.D. Eichenour and Dover Trucking Company, Inc. own additional portions of the site.

In the early 1980's, the Harris County Metropolitan Transit Authority (MTA) became interested in the site for a combined railyard, shop, and station for a proposed light rail transit system. During routine geotechnical investigations by McClelland Engineers Inc. (MEI) for preliminary design purposes, several localized areas were found to be contaminated with creosote waste products. Camp Dresser & McKee Inc. (CDM) was then retained to perform a contaminant survey and to develop remedial measures that would mitigate the contamination and allow use of the land by MTA. CDM's report, "Cavalcade Contaminant Survey", dated July 11, 1983 and other submittals documented the presence of soil groundwater contaminated with creosote waste products and heavy metals. Failure of a bond issue that would have financed the light rail system however resulted in the termination of CDM's work.

Health and Safety

Limited existing data on past site disposal practices were assembled and reviewed prior to conducting the site characterization inspection. Information obtained was then used to complete the Site Evaluation Form (SEF) prior to conducting the site characterization. Based upon the SEF and the site history, it was determined that initial entrance to the site could be conducted using Level D personal protective equipment and monitoring using the HNu photoanalyzer with a 10.2 ionization potential lamp probe, AID Hydrocarbon analyzer, and the Ludlum radiological meter instrumentation.

Personnel and Responsibilities

The site characterization was performed using the following approved CDM site team individuals:

Jeffrey D. Gram - CDM/Boston

Richard S. Lawlis - CDM/Austin

Also presented at the site during the site characterizations were the following individuals:

John Cochran -- USEPA - Region VI/Dallas

Kevin Jackson - R.F. Weston - TAT/Dallas

Warren Zehner - R.F. Weston - TAT/Houston

Prior to going on-site it was determined that REM-II contractor team members were responsible to perform all monitoring with the specified on-site instrumentation. Based upon the SEF for the site, Jeffrey D. Gram conducted a briefing on potential site health and safety concerns, previous remedial investigation activities, identified site hazards and site inspection procedures before going on-site. It was determined that Richard S. Lawlis was designated to perform monitoring with the HNu photoanalyzer and Jeffrey Gram would monitor with the AID and Ludlum meters, respectively. All other personnel present during the inspection had no on-site responsibilities and were observers only.

Equipment

Personnel monitoring instruments used during the investigation consisted of using the HNu photoanalyzer with a 10.2 ionization potential lamp, AID Hydrocarbon Analyzer with a flame ionization detector, and a Ludlum radiological monitoring instrument with a Beta/Gamma pancake probe. Poor weather during the investigation restricted the use of both the AID Hydrocarbon Analyzer and the radiological monitoring instrument. Prior to going on-site, background levels were measured with the instruments. Initial readings with the HNu indicated that Level D would be satisfactory to

conduct the site characterization. The site characterization was then undertaken throughout the boundaries of the site. Areas of concern identified in the previous investigation were examined with the HNu to determine potential impact to the surrounding ambient environment.

Account of Site Inspection

The site characterization was performed using the previously mentioned personal protection criteria. Weather restricted use of the AID Hydrocarbon analyzer and the Ludlum radiological meter; thus, limiting the HNu photoionization meter as the primary monitoring instrument.

The site was entered from south of the east-west drainage ditch that crosses the property. The site inspection team traveled north up a roadway, until it ended, and then walked the center of the site parallel to the western railroad tracks, to the northern end of the site. No elevated HNu readings, above the established background, were noted during the site characterization.

The site currently consists of two warehouses with concrete driveways servicing both warehouses. The area of the site to the east of these warehouses was covered with heavy brush. As indicated, north of the warehouse parking areas, a large drainage ditch transverses the site from west to east. A drainage ditch parallels the eastern railroad tracks and a ditch also parallels the railroad tracks to the north on the west side of the site. No elevated readings above background were observed using the HNu meter. The site inspection team then exited the site following the western tracks. Recent site grading activity was noticeable when traveling to the northern boundry of the site.

Summary

Based upon observations made during the initial site characterizations the following site characteristics can be noted:

Topography - The site is currently level with only one distinct depressed area, the drainage channel, which tranverses center of the site west to east. Recent site grading activity have reduced any small scale depressions or elevated areas. Based upon the USGS 7.5 minute topographic map that encompasses the site, the site slopes to the southwest with a maximum elevation of 60 feet at the northern end of the site and a minimum elevation of 55 feet just south of the site on Cavalcade Road.

Geology - Surfically, exposed soils within the North Cavalcade site consisted of brown/gray sandy clay. During previous remedial investigation activities conducted by Camp Dresser & McKee, Inc. A total of ten subsurface soil boring were made at various locations throughout the site. These borings were drilled to various depths ranging from 15 to 80 feet below the surface elevation. Although there are some variations in the elevations and thickness of the strata, the following generalized soil strata appear to be continuous throughout the site.

<u>Stratum</u>	<u>Depth</u>	<u>Description</u>
I	0-2	Fill: Silty fine sand
II	2-10	Sandy clay and clayey sand
III	10-20	Very dense fine sand
IV	20-80	Very stiff clay and silty clay

Hydrogeology - As part of the previous remedial investigation, a total of three shallow groundwater monitoring wells were installed on the site. Previous groundwater investigation activities indicate that three primary water bearing aquifers located at depths approximately 20, 250, and 550 feet below the surface exist. All of these groundwater aquifers are part of the Beaumont Formation, which is generally found in the Texas Gulf Coast area. All on-site monitoring wells installed were screened into the upper water bearing layer. Measurements of water level elevations in these on-site monitoring wells indicate that groundwater in the shallow aquifer slopes from east to west.

Surface Hydrology - Surface water drainage in the southern portion of the site is primarily provided by drainage ditches which drain north to the Harris County Flood Control Ditch. The HCFCD ditch follows the western

boundary of the northern half of the site and then traverses the site from west to east in the center. This drainage ditch eventually discharges to Hunting Bayou which drains in turn to the Houston Ship Channel.

Air Quality - Air quality at and in the vicinity of the North Cavalcade Street Site appears to be representative of regional air quality. Monitoring, performed during previous remedial investigation and during the initial site inspection with an HNu Photoanalyzer indicated no levels above background throughout the site. During the subsurface investigation conducted as part of the remedial investigation, elevated readings were observed from visually contaminated soils. The current regrading process also covered over known surface soil contamination areas therefore, no potential exists for atmospheric contamination from the site unless subsurface soils are exposed.

Land Use - Two warehouse operations currently exist on the southern portion; the remainder of the site is vacant. To west of the site and the railroad tracks, is a densely populated residential area. To the south of the site lies the South Cavalcade Street Site. The area to the east was becoming developed for commercial purposes. To the north of the site is U.S. Interstate 610 (North Loop).

Site Contamination - Based upon information obtained during the initial site characterization and the previous remedial investigation the following areas of contamination can be identified:

- 1) **Surficial Contamination** - Previous remedial investigation indicated a disposal/lagoon area with noticeable contaminated soils and a heavy creosote odor. During the site inspection this area could not be identified due to the recent grading activity. No other contamination areas of surface soils or surface waters were evident.
- 2) **Subsurface Soil Contamination** - Based upon the previous remedial investigations and site history data, these are two areas on the site in which extensive subsurface contamination may exist. These

areas are: 1) The former operational facility located in the southwest corner of the site and; 2) A suspected disposal trench in which waste products were deposited. This area is located along the eastern boundry of the site in the southern portion of the site. The potential for subsurface contamination also exists in the identified lagoon area in the northern end of the site.

- 3) Groundwater Contamination - Analytical results from monitoring wells in the shallow aquifer indicate extensive groundwater contamination. Compounds identified from this analysis indicate contamination by creosote and wood preserving products. No on-site analytical results are available for the lower water bearing layers. Analyses of groundwater collected from off-site deeper wells indicated no contamination of the deeper aquifers.

Recommendations

Based upon the limited remedial investigation conducted at the North Cavalcade Street Site, site remediation alternatives were identified. The recommendation of the limited feasibility analysis performed for the North Cavalcade Street site was to excavate known contamination areas and cap the site with compacted clay and clean fill. Other site remediation alternatives identified during the feasibility study consisted of:

- o No Action
- o In-Situ Chemical Fixation
- o Incineration
- o Removal Disposal

The feasibility study evaluated these proposed remedial action for appropriateness against specified criteria and concluded the recommended alternative to be most acceptable considering the intended use of the site.

Observations made during the site characterization reveal that any surface activities for the remedial investigation can be conducted in Level D

personnel protection provided adequate foot and hand protection is provided. Subsurface activities should be performed in Level C with the contingency to upgrade or downgrade as appropriate. Air monitoring with the EMU should be performed during all future activities.

cc. EMG File

Document Control - NPMO/Annandale

Attachment: SEF.

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

PAGE 1 OF 6

EPA WA NO. _____ **REM II DOC. NO.** _____

SITE <u>Cavalcade - North & South</u>	EPA REGION <u>VI</u>
LOCATION <u>Cavalcade and Muary St. - Houston, Texas</u>	EVALUATOR <u>J. Gram</u>

SITE DESCRIPTION Former wood treating operation on a 9 acre site from 1943 to 1953.
Suspected contaminants include: creosote, pentachlorophenol, and heavy metals. Presently
no surface contamination source exists.

SITE MAPS ATTACHED Project plan from 1983 CDM report.

BACKGROUND ENVIRONMENT All subsurface contamination.

AIR <u>No contamination noted during site survey on 1/1983</u>	SURFACE WATER <u>None observed.</u>
SOIL <u>Extensive subsurface contamination exists throughout the boundaries of the site.</u>	GROUNDWATER <u>Evidence of groundwater contamination observed during monitoring well sampling - 4/1983</u>

ADDITIONAL HAZARDS ON-SITE Site currently consists of a packing and trucking operation

INFORMATIONAL SOURCES USED CDM report - 7/83

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

REM II DOC. NO. _____

SITE PERSONNEL		SITE ACTIVITY <u>Initial Site Characterization</u>						
PERSONNEL								
NAME	SS. NO	FIRM	REGION	LEVEL OF PROTECTION	CONTINGENCY	VERIFY		
<u>Jeffrey D. Gram</u>	<u>007 60 6115</u>	<u>CDM</u>	<u>NOR</u>	<u>D</u>	<u>C</u>	<u>(u)</u>		
<u>Richard S. Lawlis</u>	<u>467 78 3974</u>	<u>CDM</u>	<u>NOR</u>	<u>D</u>	<u>C</u>	<u>(u)</u>		
						()		
						()		
						()		
						()		

PERSONNEL PROTECTIVE EQUIPMENT	VERIFY
<u>Acid Resistant Coveralls</u>	<u>(u)</u>
<u>Undergloves</u>	<u>(u)</u>
<u>Steel Toe & Shank Boots</u>	<u>(u)</u>
<u>Butyl Bootcovers</u>	<u>(u)</u>
<u>Respirator - GMCH Cartridge - Contingency</u>	<u>()</u>
<u>Syran Suit - Contingency</u>	<u>(u)</u>
	<u>()</u>

FIELD MONITORING EQUIPMENT	VERIFY
<u>H-Nu Photoanalyzer w/ 10.2 probe</u>	<u>(u)</u>
<u>FID Hydrocarbon Analyzer</u>	<u>()</u>
<u>Geiger Counter w/ Pancake probe</u>	<u>()</u>
	<u>()</u>
	<u>()</u>
	<u>()</u>

DECON Dispose of all expendables onsite

REM II DOC. NO. _____

CONTINGENCY CONTACTS			● DENOTES REQUIRED INFORMATION		
AGENCY	CONTACT	PHONE NO	AGENCY	CONTACT	PHONE NO
● FIRE DEPARTMENT	City of Houston	(713) 227-2323	STATE POLICE		(713) 463-8261
POLICE DEPARTMENT	City of Houston Harris County	(713) 222-3131	FA A.		
HEALTH DEPARTMENT		(713) 342-8685	CIVIL DEFENSE		(713) 463-8261
● POISON CONTROL CENTER		(713) 654-1701	● ON SITE COORDINATOR	Mr. John Cochran	(214) 767-2630
● STATE ENVIRONMENTAL AGENCY	TQWR	(713) 479-5981	24-Hour Hotline	Agatha Corp.	1-(800)
● EPA REGIONAL OFFICE	John Cochran	(214) 767-2630			
● EPA ERT, ICOM					
● STATE SPILL CONTRACTOR					

MEDICAL EMERGENCY

NAME OF HOSPITAL Citizen General Hospital ADDRESS 7407 North Freeway - Houston PHONE NO. (713) 691-3531

NAME OF CONTACT _____ ADDRESS _____ PHONE NO. _____

MAP OR ROUTE TO HOSPITAL Take Cavalcade east to Route 59. Route 59 to 610 west. Route 610 west to North Freeway exit at Little York Street. Take right on Molly, Hospital on left.

TRAVEL TIME FROM SITE (MINUTES) 25 DISTANCE TO HOSPITAL (MILES) 10 NAME OF 24 HR AMBULANCE SERVICE (713) 222-3434

SITE PERSONNEL PROTECTION & SAFETY EVALUATION FORM

PAGE 6 OF 6

REM II DOC. NO. _____

SEF REVIEW

I have read, understood, and agreed with the information set forth in this Personnel Protection and Safety Evaluation Form (and attachments) and discussed in Presite Visit Health and Safety briefing

SHSC SIGNATURE _____

DATE _____

RHSS SIGNATURE _____

DATE _____

COMMENTS: _____

COMMENTS: _____

SITE PERSONNEL

Jeffrey D. Gram

Richard S. Lawlis

SITE H & S BRIEFING

CONDUCTED AT On-Site

BY J.D. Gram

ON 1/16/85

BRIEFING TOPICS Site History, Site Health & Safety
Issues, & Site Inspection Protocol


H.S.M. APPROVAL

DATE _____

REM II H & S INPUT BY _____

DATE _____

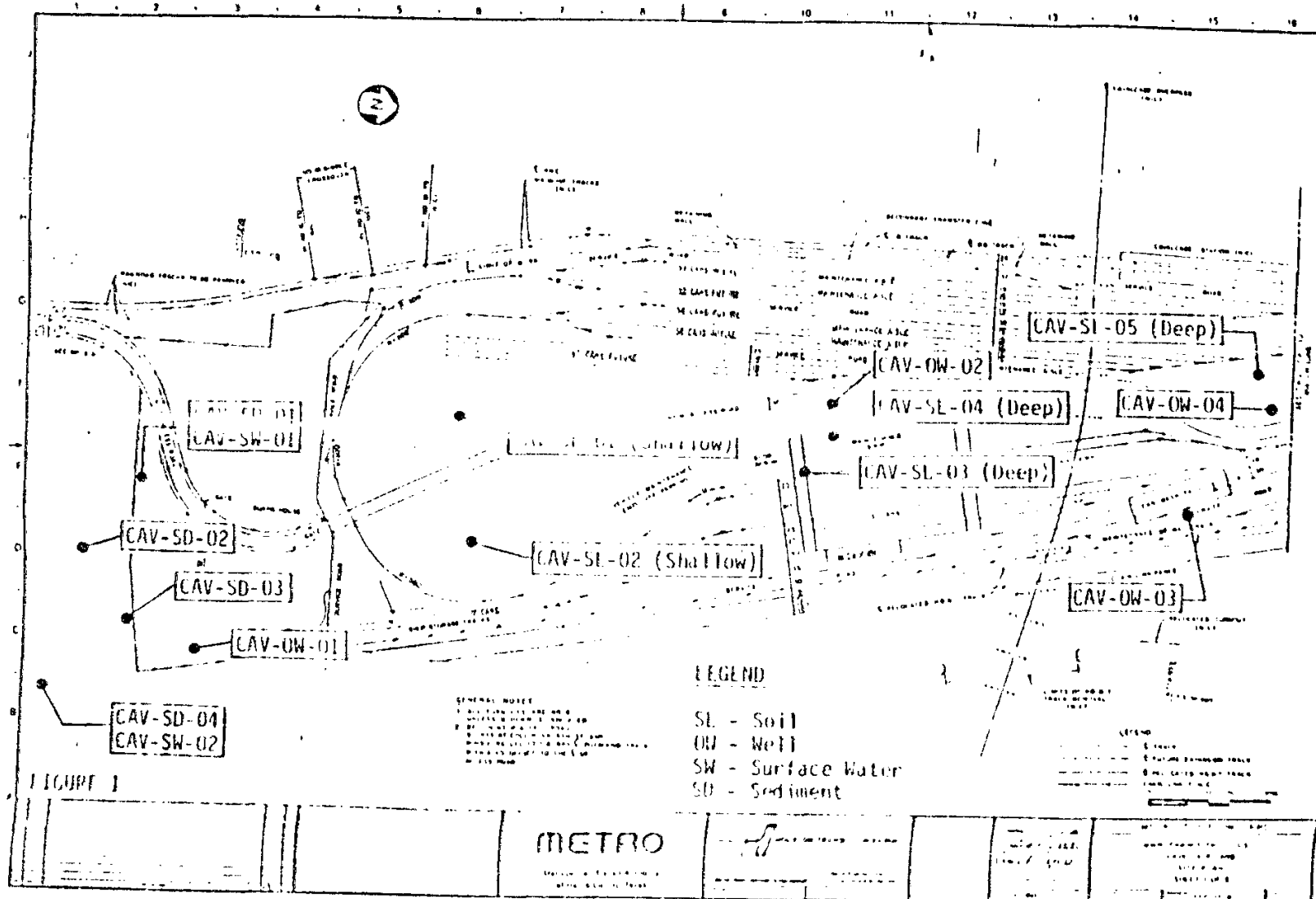


FIGURE 1

METRO

CDM.

CDM CONSULTANTS
 10000 W. CENTURY BLVD. SUITE 1000
 LOS ANGELES, CA 90045

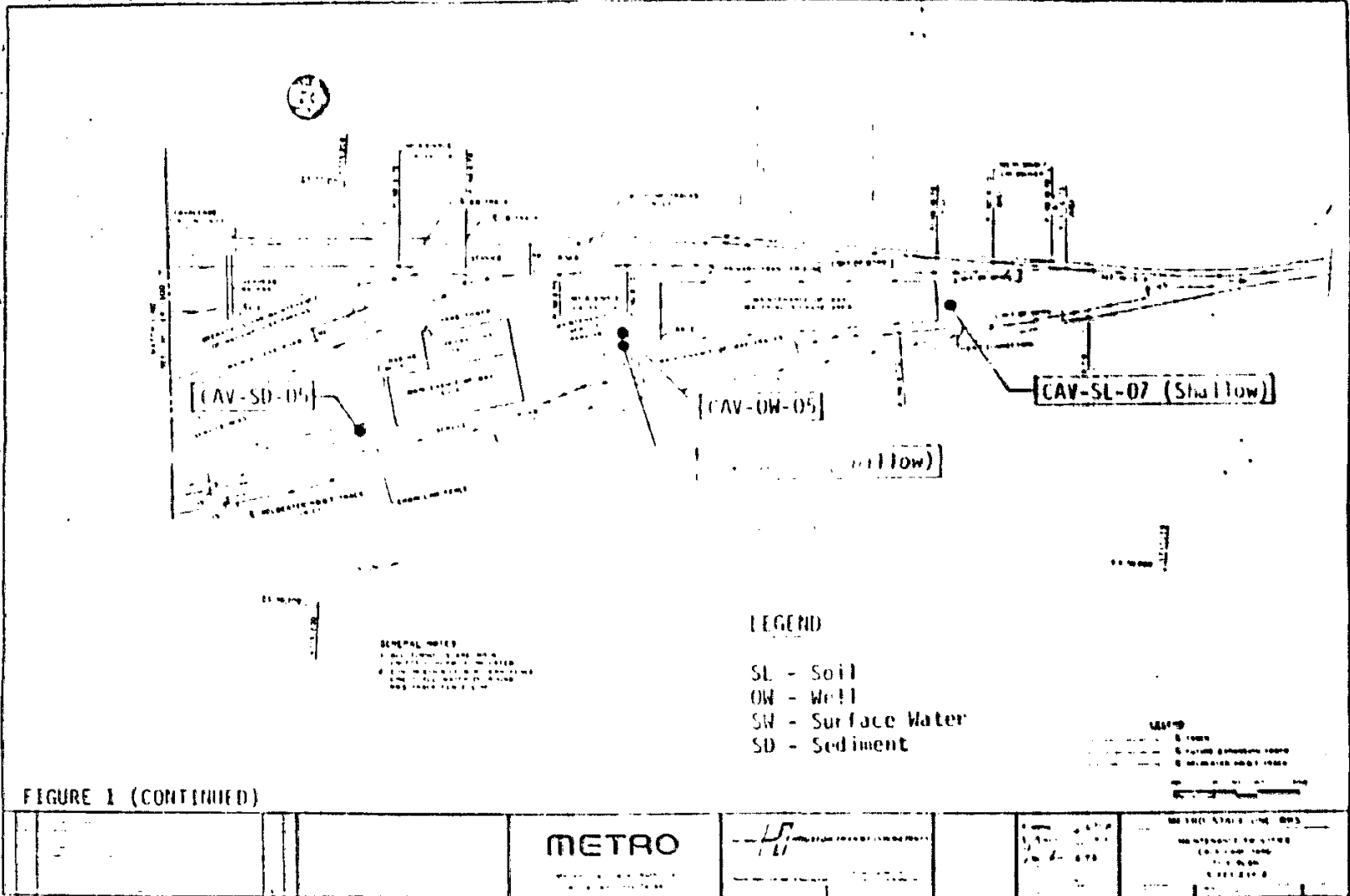


FIGURE 1 (CONTINUED)

METRO

CDM.

EXPENDABLE EQUIPMENT REQUEST FORM

TO: Name: J. Gram Office: CDM-Boston
 FROM: Name: _____ Title: Project Scientist
 DATE: JANUARY 11, 1984 SS# 007-60-6115

Please provide the following expendable items of equipment which are required for: Initial Site Characterizations

SITE: CAVALCADE NIS W.A.: 777-141-WP1-DELOE

Has Health & Safety Plan been approved? YES/NO (circle one)

ITEM	DESCRIPTION	REQUIRED	INTID #
1	Knapp Steel-toed Safety Boots	2 PAIR	SIZE 11 1/2
2	Over Boots, 9" Butyl	2 PAIR	
3	Viton Gloves		
4	Latex Gloves	2 PAIR	
5	PVC Gloves	2 PAIR	
6	Hooded Sytan-Coated Tyvek Suit	2 PAIR	
7***	MSA Ultratwin Cartridges (GMC-H)	2 PAIR	
8	Hard Hats		
9	REM II Baseball Caps		
10	Duct Tape, 25' Roll		
11	Industrial Coveralls (Acid Resistant)	2 PAIR	
12	Railers		
13			
14			
15			
16			
17			
18			
19			

*** Additional types of MSA chemical cartridges available on special request

APPENDIX III
TOXICOLOGY INFORMATION

quired an 8-hour exposure at about 6000 ppm (35° C) to kill four of six rats. Signs of gross overexposure were varying degrees of ataxia, prostration, and respiratory distress followed by narcosis. Those that survived appeared to recover without significant signs of exposure.⁽¹⁾

Shell Chemical Corporation⁽¹⁾ presents the following observations in respect to sensory responses reported by unconditioned personnel during or following 5-minute exposures to the vapor:

Threshold, odor	6 ppm
50% Threshold, eye irritation	50 ppm
50% Threshold, nose irritation	50 ppm

No incidents of illness caused by industrial handling of EAK have been reported. Workers may complain of odor

and transient eye irritation when handled in poorly ventilated areas when the concentration exceeds 25 ppm, but experience shows that transient responses do not lead to significant systemic effects.⁽¹⁾

Accordingly, the TLV of 25 ppm is recommended as a comfort level for unconditioned workers.⁽²⁾

References:

1. *Industrial Hygiene Bulletin* SC.57:59, Shell Chemical Corporation, NY (March 1958).
2. Communication from O.M. Banks, Ind. Hygienist, Shell Chemical Corporation, (May 29, 1965).

ETHYL BENZENE

Phenylethylene

C₈H₁₀

TLV, 100 ppm (≈ 435 mg/m³)

STEL, 125 ppm (≈ 545 mg/m³)

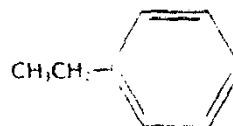
Ethyl benzene is a colorless, flammable liquid with an aromatic odor. It has a molecular weight of 106.16, a specific gravity of 0.86258 at 25° C and a vapor pressure of 7.1 mm Hg at 20° C. The vapor density is 3.7 times that of air. Saturated air with the vapor at 25° C and 760 mm is 1.32%. It boils at 136.2° C and freezes at -45.01° C. The closed cup flash point is 63° F, autoignition temperature is 810° F and is a fire risk.⁽¹⁾ Ethyl benzene is only slightly soluble in water at 15° C (14 mg/100 ml), but is miscible with alcohol and ether.

This compound is employed as a solvent and as an intermediate in the production of styrene.

Ethyl benzene toxicity is characterized by its irritancy to the skin and less markedly, to the mucous membranes. Repeated application of the liquid to the skin of rabbits causes reddening and some exfoliation and blistering.⁽²⁾ Oettel⁽³⁾ characterized ethyl benzene as the most severe irritant of the benzene series.

On the eyes and nose, the vapor at 5000 ppm causes intolerable irritation; at 2000 ppm, eye irritation and lacrimation are immediate and severe, and are accompanied by moderate nasal irritation, decreasing somewhat in several minutes, at 1000 ppm, irritation and tearing, but tolerance develops rapidly, and at 200 ppm, the vapor has a transient irritant on human eyes.⁽¹⁾

Like benzene, its acute toxicity is low, the dose fatal to guinea pigs in a few minutes was 10,000 ppm⁽⁴⁾ and 5000 ppm dangerous to life in 30 to 60 minutes; animals dying



from exposure had intense congestion and edema of the lungs, and generalized visceral hyperemia. The narcotic dose for animals was 10,000 ppm, reached in 18 minutes preceded by vertigo, unsteadiness and ataxia.

Chronic inhalation exposure of guinea pigs, monkeys, rabbits and rats at concentrations from 400 ppm to 2,200 ppm, seven to eight hours/day, five days/week for as long as six months, produced no effects in all species except the rat, which showed a slight increase in the weights of the kidneys and livers, on the average, for those exposed at 400 ppm for 186 days. The investigators concluded that 400 ppm was the beginning effect level for chronic inhalation of the vapor.⁽²⁾

It is apparent that, as no systemic effects can be expected at levels producing distinctly disagreeable skin and eye irritation, the TLV must be based on the latter effects. For the prevention of disagreeable irritation, a TLV of 100 ppm and a STEL of 125 ppm are recommended.

Other recommendations: Czechoslovakia (1976) 45 ppm, Poland (1975) 25 ppm.

References:

1. Gerarde, H.W.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol II, p. 1231, Interscience, NY (1963).
2. Wolf, M.A., et al. *Arch. Ind. Health* 14:387 (1956).
3. Oettel, H.: *Arch. Exp. Path. Pharmacol.* 18:641 (1936).
4. Yant, W.P., Schrenk, H.H., Waite, C.P., Pally, F.A.: *Pub. Health Rept.* 45:1241 (1930).

ski et al.¹⁰⁹ reported that 25% of 68 workers handling chloroform in a chemical plant had enlarged livers. The lengths of employment were between 1 and 4 years. Concentrations of chloroform in air ranged from 10 to 200 ppm.

In the view of recent reports on carcinogenicity and embryotoxicity of chloroform, the Committee recommendation for TLV chloroform is 10 ppm as TWA and classification as an Industrial Substance Suspect of Carcinogenic Potential for Man (A2). A concentration of 10 ppm is one fifth of the concentration at which organ injury was observed and is half of the concentration which would be derived comparing the toxicity of other organic solvents.¹¹⁰ NIOSH recommended in 1974 a TLV 10 ppm as TWA¹¹¹ and in 1976 lowered the value to 2 ppm because of suspected carcinogenic potential of chloroform.¹¹²

Foreign Industrial Air Standards (taken from Reference 12): Bulgaria, 10 ppm; Czechoslovakia, 10 ppm, for brief exposures, 50 ppm; Finland, 50 ppm; Hungary, 4 ppm, for brief exposures, 20 ppm; Japan, 50 ppm; Poland, 10 ppm; Rumania, 10 ppm; Yugoslavia, 50 ppm; West Germany, 10 ppm (1978).

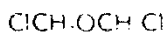
References:

1. Morris, L.E.: *Clinical Anesthesia Halogenated Anesthetics*, editor J.F. Artusio, p. 24-41, F.A. Davis Company, Philadelphia, PA (1963)

2. Ilett, K.F., Reid, W.D., Sipes, I.G., et al: *Exp. Mol. Pathol.* 19: 215-229 (1973)
3. Kylin, B., Reichard, H., Sumegi, I., et al: *Acta Pharmacol. et Toxicol.* 20:16-26 (1963).
4. Torkelson, T.R., Oyen, F., Rowe, V.K.: *Am. Ind. Hyg. Assoc. J.* 37:697-705 (1976)
5. Schwetz, B.A., Leong, B.K.J., Gehring, P.J.: *Tox. Appl. Pharm.* 28:442-451 (1974).
6. Eschenbrenner, A.B.: *J. Nat. Cancer Inst.* 5:251 (1945).
7. National Cancer Institute: *Report on Carcinogenesis Bioassay of Chloroform*, (March 1, 1976).
8. Roe, F.J.C.: *Prelim. Rept. of Long-Term Tests of Chloroform in Mice, Rats and Dogs*, Soc. of Tox. Ann. Meetings, Atlanta, GA (March 18, 1976).
9. Challen, P.I.R., Hickish, D.E., Bedford, J.: *Brit. J. Ind. Med.* 15: 243 (1958)
10. Bomski, H., Sobolewska, A., Strakowski, A.: *Arch. Gewerbe-path. u. Gewerbhyg.* 24:127 (1967)
11. von Oettingen, W.F.: *The Halogenated Hydrocarbons. Their Toxicity and Potential Dangers*, U.S. Public Health Serv. Bull. 314(212) 46-65 (1955)
12. Utidjian, H.M.D.: *J. Occup. Med.* 18:253 (1976)
13. NIOSH: *Criteria For a Recommended Standard — Occupational Exposure to Waste Anesthetic Gases and Vapors* (March 1977)

bis(CHLOROMETHYL) ETHER

bisCME



TLV, 0.001 ppm (\approx 0.005 mg/m³), Appendix A1a — Recognized Carcinogen

The chloromethyl ethers, bis(chloromethyl) and chloromethyl ether (CME), are highly reactive, colorless liquids with a suffocating odor and high vapor pressures. BisCME has a molecular weight of 114.96, a specific gravity of 1.315 at 20° C, a melting point of -41.5° C and a boiling point of 76° C. It is an inadvertent compound generated in the production and use of CME, which, in the presence of either hydrogen or hydroxyl ions and traces of water, disproportionates to aldehydes and methanal which in turn recombine to form bisCME. It is soluble in all proportions in alcohol and ether, but is decomposed by water into hydrogen chloride and formaldehyde.

BisCME is no longer used for chloromethylation in industry, but is used as the monitoring indicator for CME, because of its greater stability in workroom air, and as an intermediate in anionic exchange strong-base resins of the quaternary ammonium type.

The carcinogenic potency of bisCME is greater than CME. Attention was first called to the alpha-halo-ethers as alkylating carcinogens by Van Duuren et al.¹¹³ bisCME was found to be a potent alkylating carcinogen for mouse skin, more potent than either the beta-lactones (β -propiolactone) or epoxides (1-diepoxybutane). Subsequently, bisCME was reported to be a highly potent inducer of tumors in the respiratory tract in mice¹¹⁴ and rats.¹¹⁵ Increased num-

bers of pulmonary adenomas occurred in mice upon repeated daily exposures to bisCME at 1 ppm and squamous cell carcinomas of the lung and esophageal epitheliomas of the olfactory epithelium occurred in rats following similar conditions of inhalation exposure at a reported 0.1 ppm bisCME.

That bisCME could be carcinogenic for man was first observed in 1964 and 1965 following the deaths from lung cancer of two relatively young employees, aged 48 and 35 years respectively, who had worked in chloromethylation operations.¹¹⁶ Later, in 1967, a 39-year old male chemist who had worked in both the research laboratory and pilot plant during the period 1951 to 1965 died of lung cancer. A fourth lung cancer death occurred in 1971 in a 32-year old employee who was first employed two years earlier. This employee had, however, reportedly worked in the warehouse and tank farm and thus was relatively removed from direct contact with chloromethyl ether operations. Two additional employees are currently alive, but with lung cancer; one, age 60, had worked in the research and development laboratory, the other, had worked for 13 years in the warehouse and in the steam-tube drier operation in the ion-exchange department. Although five of the six lung cancer employees were considered tobacco smokers, this distribution of smokers is not too dissimilar from that of the general population. This fact, coupled with relatively high incidence of lung cancer, (6 of approximately 100 employees), the relatively youthful age when the cancers appeared, and the demonstrated potency of the chloromethyl ethers for animals¹¹⁵ make these ethers highly suspicious of being carcinogenic for man.

Further animal experimental evidence of the potent cancerigenicity of bisCME was provided in a report¹¹⁶ of the finding that 98 of 111 rats had gross or microscopic

exposure standard, insofar as the TLV can be defined as such a standard. There is little evidence that exposure to benzene at concentrations below 25 ppm causes blood dyscrasias of any kind. Setting the TLV at 10 ppm, as a time-weighted average, provides an added margin of safety.

If the standard is to be set at the lowest practicable detectable limit, it is the opinion of some members of the Committee that a value lower than 1 ppm should be selected. In the absence of interfering substances benzene vapor can be measured with reasonable accuracy in concentrations at least as low as 0.1 ppm; in the presence of certain interferences, it may be difficult to achieve the prescribed accuracy and reliability even at concentrations somewhat above 1 ppm.

Because the effects the TLV is designed to prevent are chronic in nature, a ceiling designation is not appropriate and a STEL of 25 ppm is recommended.

Other recommendations: ANSI (1969) 10 ppm; Czechoslovakia (1969) 16 ppm; USSR (1972) 1.6 ppm; DDR (1973) 16 ppm; Sweden (1975) 10 ppm; BRD (1974) 0 ppm (treats as carcinogen).

References:

1. Merck Index, 9th ed., p. 138, Merck & Co., Inc., Rahway, NJ (1976).
2. Gerarde, H.W.: *Toxicology & Biochemistry of Aromatic Hydrocarbons*, Elsevier Publishing Co., NY (1960).
3. Elkins, H.B.: *Chemistry of Industrial Toxicology*, p. 103, Wiley & Sons, NY (1959).
4. Vigilani, E.C. Saita, G.: *New Eng. J. Med.* 271:872 (1964).
5. Legge, T.M.: *J. Ind. Hyg.* 1:539 (1920).
6. Greenburg, L.: *U.S. Public Health Reports* 41:1357 (1926).
7. Bowditch, M., Elkins, H.: *J. Ind. Hyg. & Tox.* 21:321 (1939).
8. Hunter, F.T.: *Ibid.*, p. 331.
9. Mallory T.B. et al: *Ibid.*, p. 355.
10. Greenburg, L. et al: *Ibid.*, p. 395.
11. Helmer, K.J.: *Acta Med. Scand.* 77:354 (1944).
12. Savilahti, M.: *Arch. Gewerbepath. u. Gewerbehyg.* 15:147 (1956).
13. Koslova, T.A., Volkova, A.P.: *Gig. Sanit.* 25:29 (1960). Cited by NIOSH in ref. 31.
14. Juzwiak, I.: *Med. Przemylowa* 20:67 (1969) *Ibid.*
15. Aksoy, M. et al: *Brit. J. Ind. Med.* 29:56 (1972).
16. Aksoy, M. et al: *Blood* 44:837 (1974).
17. Ikeda, M.: *Poisoning Due to Benzene and its Substitutes in Japan*, *International Workshop on the Toxicology of Benzene*, Paris (1976).
18. Winslow, C.E.A.: *J. Ind. Hyg.* 9:69 (1927).
19. Heimann, H., Ford, C.B.: *NY Ind. Hyg. Bull.*, p. 124 (November 1940).
20. Wilson, R.H.: *J. Lab. Clin. Med.* 27:1517 (1942).
21. Hardy, H.L., Elkins, H.B.: *J. Ind. Hyg. & Tox.* 30:196 (1948).
22. Blaney, L.: *Ind. Med. & Surg.* 19:227 (1950).
23. Walkley, J.E. et al: *Am. Ind. Hyg. Assoc. J.* 22:362 (1961).
24. Pagnotto, L.D. et al: *Ibid.*, p. 417.
25. Pagnotto, L.D. et al: *Benzene Exposure in the Rubber Coating Industry: a Followup*. Presented at the *American Industrial Hygiene Conference*, New Orleans (May 1977).
26. Elkins, H.B.: *Significance of Benzene Exposure Among Workers in Rubber Spreading Operations*. Presented at the *International Workshop on the Toxicology of Benzene*, Paris (1976).
27. Fuchs, A.: in *Documentation of the MAC in Czechoslovakia*, Prague (1969).
28. Deichmann, V.B. et al: *Tox. Appl. Pharm.* 5:201 (1963).
29. Nau, C.A. et al: *Arch. Env. Health* 12:382 (1966).
30. National Academy of Sciences: *Health Effects of Benzene: a review* (1976).
31. NIOSH: *Criteria for a Recommended Standard for Occupational Exposure to Benzene* (1974).
32. NIOSH: *Revised Recommendation for an Occupational Exposure Standard for Benzene* (August 1975).
33. McMichael, A.J. et al: *J. Occup. Med.* 16:458 (1974).
34. Andjelkovic, D. et al: *Ibid.* 18:387 (1976).
35. Monson, R.R., Nakano, K.K.: *Am. J. Epidemiol.* 103:254 (1976).
36. OSHA: *Emergency Temporary Standard for Occupational Exposure to Benzene*. *Federal Register* 42:22516 (May 3, 1977).
37. Infante, P.F. et al: *Leukemia Among Workers Exposed to Benzene*. A manuscript (1977).
38. Young, R. et al: *Walk Through Survey of Goodyear Tire & Rubber Co.*, St. Mary's, OH. A manuscript (1977).
39. Harris, R.L. Jr.: *Testimony before OSHA hearings on the proposed standards for occupational exposure to benzene*, Washington, DC (August 1977).
40. Thorpe, J.J.: *J. Occup. Med.* 16:375 (1974).
41. Ott, M.G. et al: *Mortality Among Individuals Occupationally Exposed to Benzene*. A manuscript (1975).
42. Fishbeck, W.A.: *Testimony before OSHA hearings on the proposed standards for occupational exposure to benzene*, Washington, DC (August 1977).
43. Todaro, G.L., Huebner, R.J.: *Proc. Nat. Acad. Sci.* 69:1039 (1972). Cited by NIOSH in ref. 31.
44. Tough, I.M. et al: *Eur. J. Cancer* 6:49 (1970).
45. Formi, A.: *Report in the Proceedings of International Workshop on the Toxicology of Benzene*, Paris (1976).
46. Muzgeri, S., Pollini, G.: *Benzene Haemopathy: Cellular Damage and Chromosome Changes*. *Personal Researches* *Ibid.*
47. DeGowin, R.L.: *J.A.M.A.* 185:748 (1963).
48. Truhaut, R.: *Proceedings of the XI International Cancer Congress*, Florence, Italy (1974).

including leukemia, was found to be higher than in the general population among certain groups of rubber workers. Monson and Nakano¹⁵⁵ found 55 cases of leukemia, vs. 43 expected, among rubber workers. It was noted that benzene has been used extensively in the rubber industry, but is no longer employed, although it is a contaminant of extensively used naphtha solvents. The degree of exposure to benzene in the rubber industry during the first half of the 1940-1950 decade may well have been excessive. Wilson¹⁶¹ has noted deaths and blood abnormalities among workers in the rubber industry during the war years who were exposed, on the average, to concentrations of benzene vapor of 100 ppm. Neither Monson-Nakano or other authors of similar papers quoted in the NIOSH update mention whether or not aplastic anemia or other blood dyscrasias, apart from leukemia, occurred in the groups of workers that were studied.

Nevertheless OSHA, in 1977, issued an Emergency Temporary Standard (ETS)¹⁶¹ establishing a TWA limit of 1 ppm for benzene vapor. (Enforcement of this standard was voided by the courts). Much of the evidence substantiating this action was the same as that quoted in the NIOSH update. However, one additional paper was cited by Infante *et al.*¹⁷⁷ in which nine leukemia deaths were reported from two rubber film casting plants where benzene vapor concentrations allegedly ranged from 0 to 15 ppm. This report was critically examined in OSHA hearings on a permanent standard, with essentially the same provisions as the ETS, which were held during the summer of 1977. The data on benzene exposure in the two plants in question, especially during the first part of the ten year employment period (1940 to 1950) covered by the study, were found to be incomplete, unreliable and contradictory. Even in 1976 a NIOSH report of one of the plants involved, or its successor, showed concentrations in excess of 15 ppm at several locations.¹⁸¹ A study by Harris *et al.*¹⁹¹ in 1973 and 1974 revealed similar findings, although the overall average of all sample results was slightly above 1 ppm. During the period 1940 to 1945 or so, when many of the involved workers were employed, the permissible concentration for benzene exposure (ASA standard) was 100 ppm. In common with the papers cited by the NIOSH update, no information on other blood abnormalities was given in the Infante report.

Epidemiologic studies of workers exposed to measured low concentrations of benzene vapor have yielded negative or inconclusive results. Thorpe¹⁹¹ after studying the occurrence of leukemia in a population of 38,000 workers in a variety of European petroleum and petrochemical operations, some of whom were exposed at levels of benzene that occasionally reached 20 ppm, over a period of ten years, found that deaths from leukemia "were not abnormal" for the countries involved (18 vs. 23-23 expected).

Retrospective studies of employees of a large chemical company, exposed for many years to benzene, mostly at low levels, revealed no excess mortality.^{141, 142} A cohort of 594 workmen were divided into four exposure groups: very low exposures, less than 2 ppm as time weighted average (TWA); low exposures, 2-9 ppm; moderate exposures, 9-24 ppm; and high exposures, above 25 ppm. In many areas there was exposure to other chemicals as well as to benzene. The duration of exposure was also divided into four groups, with 186 workers having in excess of 20 years.

Of 102 deaths, two were due to anemia, two to leukemia, and one had leukemia as a complication. Of these five cases, only one, an autopsy-confirmed pernicious anemia, involved a previous exposure to benzene of significance, 5520 ppm months. The other anemia death, diagnosed as being of the aplastic type, was of a worker with 453 ppm months of benzene exposure. Two of the leukemia cases involved exposures of 545 and 305 ppm months, respectively, while the third was of a worker with only 18 ppm months benzene exposure.

To put these exposure data in perspective, three of the deceased workers had had exposures to benzene equivalent to 40 years' employment in concentrations slightly above or below 1 ppm; the exposure of the fourth, if spread over 30 years, would have been at a concentration of 0.05 ppm.

The predicted deaths from anemia and leukemia were 0.2 and 1 respectively. The fact that, apart from the pernicious anemia death, there appeared to have been no dose response relationship, apparently led to the conclusion of the authors that "no mortality findings directly attributable to benzene exposure were observed".

The NIOSH update mentions the consistent observations of chromosomal aberrations associated with benzene exposure, but further comments that the implications of these findings with respect to benzene leukemia are still not clear. The possibility of a chromosomal instability acting as a stimulus for a latent leukemogenic virus has been speculated upon.¹⁴³ This question was discussed at some length at the International Workshop on the Toxicology of Benzene, held in Paris in November 1976. Tough¹⁴⁴ had previously reported that marked aberrations were found only in plants where concentrations of benzene vapor were believed to be between 25 and 250 ppm, and that no significant changes were observed at 12 ppm. Forni¹⁴⁵ however, stated that there had been a few positive, as well as negative, reports at levels between 5 and 25 ppm. The consensus of opinion was that the significance of the finding of increased chromosome aberrations for the occurrence of benzene leukemia was still not clear. Maugeri and Pollini¹⁴⁶ reported that among Italian shoe workers "almost all the cases of haemopathy due to benzol which lead to death show features of terminal leukemia... and (the leukemias) were always preceded by aplastic conditions".

Opinions of the workshop participants relative to the appropriate TLV for benzene were varied. The final recommendation was to retain 10 ppm as a permissible TWA, which must not be exceeded, but it was also specified that benzene should not be employed when substitute materials were available.

DeGowin's report¹⁴⁷ of a case of leukemia following an apparent benzene-induced aplastic anemia contains a discussion which implies that there is evidence that aplastic anemia *per se* may lead to leukemia, and that delayed cases of this disease are not confined to aplastic anemia due to benzene.

It is the opinion of the Committee that the characterization of benzene as a leukemogen, by NIOSH, is, in essence, valid, although benzene may be what Truhaut has described as a "secondary carcinogen".¹⁴⁸ An A2 notation should be applied to benzene in the TLV listings.

On the other hand, the Committee does not agree with the NIOSH recommendation of 1 ppm as an occupational

numerous organic chemicals. It is found in gasoline from trace amounts to as much as 30% concentration in some countries.

As an acute poison benzene produces narcotic effects comparable to those of toluene; it is a more potent narcotic than the alkanes or naphthenes of similar boiling points. But the effect of chronic exposure to this compound is by far the most serious disease caused by any of the common hydrocarbon solvents. Its action on the bone marrow may result in detectable alterations, and, in some instances, aplastic anemia. The reported LD₅₀ orally in young adult rats is 3.8 mL/kg.⁽¹⁾

It is unique among hydrocarbons as a myelotoxicant.⁽²⁾ More than 140 fatal cases of benzene poisoning had been recorded prior to 1959.⁽³⁾ Vigliani and Saita⁽⁴⁾ listed 26 deaths from chronic benzene poisoning in two provinces in Italy between 1960 and 1963. Eleven of these were diagnosed as leukemia, which may develop several years after cessation of exposure to benzene.

Most deaths from benzene have resulted from exposures of the order of 200 ppm or more. In a few instances concentrations of 1000 or even 2000 ppm have been recorded in workplaces where deaths occurred. Some of these are: Legge⁽⁵⁾ 210 to 1050 ppm; Greenburg,⁽⁶⁾ 70 to 1800 ppm, with over half above 200; Bowditch,⁽⁷⁾ 100 to 200+ measured, one leukemia case described by Hunter⁽⁸⁾ and Mallory⁽⁹⁾ six years after exposure at over 200 ppm; Greenburg,⁽⁶⁾ 25 to 1000 ppm in four rooms; Helmer,⁽¹⁰⁾ 140 to 200 ppm after improvements; Savilahti,⁽¹¹⁾ 318, 433 and 470 ppm; Koziova,⁽¹²⁾ 47 to 310 ppm; Vigliani,⁽⁴⁾ 190 to 660 ppm after four years death from leukemia; Juzwiak,⁽¹³⁾ 31 to 156 ppm; Aksoy,⁽¹⁴⁾ 150 to 650 ppm, and 210 to 650 ppm;⁽¹⁵⁾ 26 patients with acute leukemia or preleukemia; Ikeda,⁽¹⁶⁾ 100 to 800 ppm, 7 deaths, all females, none from leukemia.

Winslow⁽¹⁷⁾ however, reported blood changes in workers where concentrations of benzene vapor below 100 ppm were found. Heimann and Ford⁽¹⁸⁾ found one death and three cases with blood changes where air analysis for benzene showed a concentration of 105 ppm. Wilson⁽¹⁹⁾ reported three fatal cases in a plant where the average concentration of benzene vapor was 100 ppm. In a fifth room associated with benzene poisoning, Greenburg⁽⁶⁾ found 11 to 57 ppm. So far as can be determined the lowest measured concentration of benzene vapor associated with a fatal case of benzene intoxication (due to aplastic anemia) was the 60 ppm reported by Hardy and Elkins in 1948,⁽²⁰⁾ in a plant where repeated air analyses were made, and a number of other workers showed some blood abnormalities.

Blaney⁽²¹⁾ found little evidence of benzene intoxication in a group of 90 workers regularly exposed to benzene for about 13 years. Concentrations were generally low, but urinary phenols measurements indicated some exposures of the order of 25 ppm.⁽²²⁾ A followup several years later showed no evidence of persisting blood dyscrasias. No cases of leukemia are known to have occurred in this group of workers. Pagnotto *et al.*⁽²³⁾ found workers in rubber spreading operations involving naphtha with a relatively high benzene content exposed to benzene in concentrations which were for the most part between 6 and 25 ppm. A number of blood studies showed a few abnormalities but only two were serious to warrant special consideration. In one case the possibility of leukemia was raised, and the worker being removed from his job and given iron therapy

the worker recovered. Because of several job changes his benzene exposure could not be reliably estimated.

The other worker was in a group studied intensively over a period of several years by Pagnotto.⁽²³⁾ He had a red count below four million, a hemoglobin below twelve grams and suffered from nose bleeds. His benzene exposure, as estimated from several urinary phenol determinations, was to about 40 ppm. After his exposure to benzene was terminated, his blood picture gradually returned to normal. The 38 workers in this plant were followed up for 15 years after the use of naphtha containing benzene was discontinued. None showed any signs of permanent blood abnormalities. There were three deaths, none being from leukemia. It was concluded that 25 ppm of benzene vapor is safe for most workers, but that since the margin of safety is small, a TLV of 10 ppm was recommended.⁽²⁴⁾ Elkins⁽²⁰⁾ in a summary of the findings in the rubber spreading industry, came to a similar conclusion.

These conclusions were consistent with those of Fuchs⁽²⁵⁾ in 1969, who found variations in the blood pictures of three workers but did not consider that the changes were proved to result from their benzene exposures of 19, 28 and 43 ppm, respectively. He also stated that he could find no data in the literature on proved benzene poisoning in concentrations below 16 ppm, nor could he find any Soviet report which cited reasons for decreasing the Russian MAC to 6 ppm.

Two investigators have studied the effects on rats of exposures at relatively low levels of benzene vapor extended periods. Deichmann *et al.*⁽²⁶⁾ found that after 5 to 8 weeks of 5 hour/day, 5 days/week exposure at 44 and 47 ppm, rats developed a moderate degree of leukopenia, but that none resulted from 15 to 31 ppm. Nau *et al.*⁽²⁷⁾ found a decrease in the white blood cell counts of rats following 756 hours of exposure at 50 ppm of benzene on a schedule of 8 hours/day, 5 days/week. Reduced amounts of DNA in the white cells, a depression in myelocytic activity, and an increase in the relative numbers of red cell precursors in the bone marrow were also observed.

There have been numerous reviews of the literature of benzene intoxication. Noteworthy are those of the National Academy of Sciences in 1976⁽²⁸⁾ and the NIOSH criteria document on benzene, published in 1974.⁽²⁹⁾ As a result of this extremely thorough review, NIOSH recommended a workplace time-weighted average standard of 10 ppm with a ceiling of 25 ppm.

In 1976 however, NIOSH issued a revised recommendation for an occupational exposure standard for benzene.⁽³⁰⁾ The key to this recommendation is the statement in the introduction that "because it is not at present possible to establish a safe exposure level for a carcinogen, the NIOSH recommendation is to restrict exposure to very low levels which can still be reliably measured in the workplace." A number of references are given, primarily to support the characterization of benzene as a carcinogen (leukemogen). Thus most relate to leukemia cases associated with heavy benzene exposures, either measured or inferred from association with numerous cases of aplastic anemia or other blood dyscrasias. Others are epidemiologic studies on cancer in which no evidence of the degree, or even fact, of benzene exposure is cited. Thus in at least two of these papers,^(31,32) the word "benzene" does not appear. In these and other papers the incidence of various types of cancer,

BENOMYL

Methyl 1-(butylcarbamoyl)-2-benzimidazolecarbamate;
Benlate

$C_{17}H_{23}N_3O_3$

TLV, 10 mg/m³

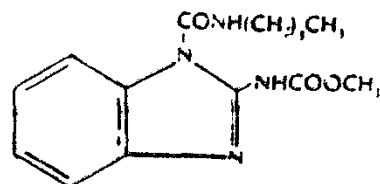
STEL, 15 mg/m³

Benomyl is a white crystalline solid, which has a molecular weight of 290.32. It decomposes without melting and has a negligible vapor pressure, indicating exposure would be in particulate form. Very slightly soluble in water, it is soluble in xylene, acetone, dimethylformamide and chloroform.¹¹ Fluorometric and colorimetric¹² and liquid chromatographic¹³ procedures for determining residues of benomyl have been published.

Benomyl is the common name for this fungicide and ascaricide.

The acute oral LD₅₀ for the rat is $\geq 10,000$ mg/kg. The acute skin absorption LD₅₀ for the rabbit is $\geq 10,000$ mg/kg. Application to the shaved intact skin of ten male guinea pigs, at each level as aqueous suspensions containing 5, 12.5 and 25% benomyl as the active ingredient in a 50% wettable powder, resulted in negligible irritation. One of ten guinea pigs had mild erythema two days after application at the high rate. All guinea pigs at the two lower rates and in a control showed no irritation after two days.¹⁴ Instillation into the eyes of rabbits of 10 mg of dry 50% powder or 0.1 ml of 10% suspension in mineral oil caused only temporary mild conjunctival irritation.¹⁵ The acute inhalation LC₅₀ is ≥ 2000 mg/m³ (≥ 2 mg/L) for rats¹¹ and is equivalent to ≥ 825 mg/m³ (≥ 0.825 mg/L) for dogs¹¹ for four-hour exposures. Histoologically, there was reduction of spermatogenic activity in some animals. With regard to this activity, no-effect levels for benomyl for four-hour exposures are equivalent to $\geq 100 \leq 410$ mg/m³ ($\geq 0.1 \leq 0.41$ mg/L) for the rat and $\geq 325 \leq 825$ mg/m³ ($\geq 0.325 \leq 0.825$ mg/L) for the dog. Additionally fifteen four-hour inhalation exposures at the equivalent of 100 mg/m³ (0.1 mg/L) of benomyl over a period of three weeks produced no clinical or histopathologic indication of accumulative effects in the rat.¹⁴

A low order of toxicity has been found in chronic studies. In two-year feeding studies no-effect levels in the diet are 2500 ppm (0.25%) for rats (highest level fed) and 500



ppm (0.05%) for dogs. Pesticide residue tolerances have been established in many food crops. They are as high as 15 ppm for stone fruits and food additive tolerances are as high as 50 ppm for raisins.¹⁶ In a three-generation rat reproduction study no compound-related reproduction or lactation differences were observed among control and test groups even at 2500 ppm (0.25%), the highest dietary level fed. In a teratogenic study in rat neither the outcome of pregnancy nor embryonal development was affected even at 5000 ppm (0.50%), the highest dietary level fed. In a dominant lethal mutagenic study in the rat, benomyl was not mutagenic at 2500 ppm (0.25%), the highest dietary level fed.¹⁷

Gardiner *et al.*¹⁸ showed that rat and dog eliminated $\geq 99\%$ of single, oral doses of 2-¹⁴C benomyl via the urine and feces within 72 hours. The major metabolite was methyl 5-hydroxy-2-benzimidazole-carbamate which was present in the urine as glucuronide and/or sulfate conjugates. Residue data on dog and rat tissues from two-year chronic feeding studies demonstrated that benomyl and its metabolites do not accumulate in animal tissues.

In view of the low order of acute and chronic toxicity the TLV of 10 mg/m³ and the STEL of 15 mg/m³ appear appropriate.

References:

1. E.I. du Pont de Nemours & Co., Inc.: Technical data sheet (June 1974).
2. Pease, H.L., Holt, R.F.: *J. Assoc. Offic. Anal. Chem.* 54(6): 1359-1402 (1971).
3. Kirkland, J.L., Holt, R.F., Pease, H.L.: *J. Agr. Food Chem.* 21(3): 368-371 (1973).
4. E.I. du Pont de Nemours & Co., Inc.: Unpublished data.
5. Sherman, H., Culik, R., Jackson, R.A.: *Tox. Appl. Pharm.* 32: 305-315 (1975).
6. Gardiner, J.A., Kirkland, J.L., Klopping H.L.: *J. Agr. Food Chem.* 22(3): 419-427 (1974).

BENZENE

C_6H_6

TLV, 10 ppm (≈ 30 mg/m³), Appendix A2 — Suspected Carcinogen

STEL, 25 ppm (≈ 75 mg/m³), Appendix A2

Benzene is a colorless, non-polar liquid, with an odor characteristic of aromatic hydrocarbons. It has a molecular weight of 78.11, a boiling point of 80.1° C, a melting point of 5.5° C, a vapor pressure of 75 mm Hg at 20° C and a

specific gravity of 0.87865 at the same temperature. Benzene has a flash point of -11.1° C (closed cup, 12° F), making it a dangerous fire hazard. It was formerly derived almost exclusively by distillation of coal tar, but now comes primarily from petroleum, either by extraction or by dealkylation of toluene. Benzene is slightly soluble in water, but soluble in all proportions in alcohol, acetone and ether.

At one time benzene was an important solvent, especially for rubber, as a diluent in lacquers, and in paint removers. At present such uses are minimal; most benzene is consumed in the chemical industry, as a raw material for

4. Aver, H.E., Fitzpatrick, M.S., Scheel, L.D.: *Rept. of Survey of Air-borne Dithiocyanate during Spray Application of Polyurethane Foam*. Div. of Occup. Health (NIOSH), Cincinnati, OH (March 1963).

5. Konzen, R.B., Craft, B.F., Scheel, L.D., Gorski, C.H.: *Am Ind Hyg Assoc J* 27:121 (1966)

6. Bruckner, H.C., Avery, S.B., Stetson, D.M., Dodson, V.N., Rowayne, J.J.: *Arch. Env. Health* 16:619 (1968)

METHYLENE CHLORIDE

Dichloromethane



TLV, 100 ppm ($\approx 360 \text{ mg/m}^3$)

STEL, 500 ppm ($\approx 1700 \text{ mg/m}^3$)

Methylene chloride is a colorless volatile liquid, soluble in water to only 1% by weight, but completely miscible with most organic solvents. It has a sweetish odor, like most chlorinated hydrocarbons. The molecular weight is 84.94, a specific gravity is 1.335, boiling point is 40° C and it solidifies at -95° C. With its high vapor pressure (315 mm Hg at room temperature, 23.5° C) substantial concentrations of vapor are readily achieved whenever methylene chloride is spilled or spread out over a large surface, even in a space that is not closely confined. It is non-flammable by standard tests, but will burn in extreme conditions.

Methylene chloride is widely used in paint removers as a solvent for plastics as a degreasing agent, in propellant mixtures for aerosol sprays and as a blowing agent in foams. The odor is not a good indication of exposure since concentrations of 100 ppm reportedly are not highly perceptible.

Liquid methylene chloride is painful and irritating if splashed in the eyes or if confined on the skin by gloves, clothing or paint remover formulations. A burn can result if it is not promptly removed from the eyes and skin. The acute oral LD₅₀ for rats is about 2000 mg/kg.

According to Lehmann and Flury,¹¹ slight narcosis occurs at 4000 to 6100 ppm in several species of animals. The fatal concentration for seven hours' exposure is given by many authorities as about 15,000 ppm.¹² Rats exposed 75 days (8 hours a day) at 1,800 ppm showed slight liver changes which were not found at 50 days. Cats exposed four to eight days at 7,200 ppm for four weeks were found to have kidney and liver changes. Heppel and associates¹³ found that daily seven-hour exposures at 3000 ppm for six months had no discernible effect on dogs and rabbits, and only reduction in the rate of growth of guinea pigs. At 10,000 ppm, four hours a day, for seven and one-half weeks dogs and guinea pigs, but not monkeys, rabbits or rats developed liver injury. Moskowitz and Shapiro¹⁴ reported four cases of poisoning with one fatality apparently due to narcotic action. Collier¹⁵ reported two cases of poisoning in painters who suffered from headache, giddiness, stupor, irritability, numbness and tingling in the limbs. Kuzelova and Vlasak¹⁶ noted complaints of headache, fatigue and irritation of the eyes and respiratory passages by workers exposed at concentrations up to 5000 ppm. Neurasthenic disorders were found in 50%, and digestive disturbances in 70% of the persons exposed. Three acute poisonings, one involving loss of consciousness, were recorded without serious after-effects.

Weiss¹⁷ stated that a chemist after a year's exposure developed toxic encephalosis with acoustical and optical delusions and hallucinations. Concentrations frequently exceeded 500 ppm; values of 660 ppm, 800 ppm, and near the floor, 3600 ppm were noted.

Golubovski and Kamchatnova¹⁸ found liver disease in workers exposed to methylene chloride and methanol which they attributed to the former. Exposure concentrations were not reported.

In the early 1940's methylene chloride was considered the least toxic of the chlorinated hydrocarbon solvents when a safe industrial air limit of 500 ppm was proposed by Heppel et al.¹⁹ and later adopted by the TLV Committee as protective enough to prevent any significant narcotic effects or liver injury.

Subsequently, Stewart et al.¹⁰ reported that significant quantities of carbon monoxide and carboxyhemoglobin were produced in humans receiving single exposures at 500-1000 ppm of methylene chloride. The carboxyhemoglobin concentrations reported by Stewart approximated those considered objectionable if due to inhalation of carbon monoxide.

More extensive examination of CO products from methylene chloride was later reported by the same investigators.¹⁰ Human volunteers exposed to methylene chloride at 1000 ppm for two hours (2000 ppm-hours) one half of the TLV permitted for an 8-hour exposure at 500 ppm resulted in carboxyhemoglobin levels in excess of those permitted in industry from exposure to CO alone.

This finding of the body's capacity to metabolize methylene chloride to CO was confirmed by Rainey, Wegman and Ekins²⁰ in a small group of workers exposed to 180 to 200 ppm methylene chloride. Such daily repeated exposures resulted in equilibrium blood concentrations of carboxyhemoglobin of 4% that decreased to half that value by next day's start of work. The differential increment in percent carboxyhemoglobin of 4.5% from a day's exposure at 180 to 200 ppm of methylene chloride is approximately the same as that developed from a daily exposure to CO at its TLV of 50 ppm.

DiVincenzo²¹ found that humans exposed to 100 ppm methylene chloride for 8 hours had a carboxyhemoglobin (COHb) value of 3.22% \pm 0.22%, whereas an 8-hour exposure at 150 ppm produced 5.39% \pm 0.06% level and an 8-hour exposure at 200 ppm resulted in COHb level of 6.8% \pm 0.65%.

In an extensive study several healthy adults of both sexes were exposed from 2-10 times to methylene chloride vapor concentrations of 0.50, 100, 250 or 500 ppm for periods of 1, 3 and 7.5 hours in a controlled environment chamber. These studies were designed to simulate the type of exposures encountered in the industrial setting and consisted of both steady, non-fluctuating vapor concentrations. Exposure resulted in a prompt elevation of carboxyhemoglobin. The elevation persisted longer than COHb from CO alone since metabolism of the absorbed methy-

lene chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for 2 weeks, or in the case of the male subjects to 500 ppm on two consecutive days.¹⁴ Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinalysis (Combitix) urinary urobilinogen, neurological tests, EEG, visual evoked response, pulmonary function and cognitive, alertness, time estimation, coordination, arithmetic and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations as low as 100 ppm for 5 days resulted in COHb elevations about 5 percent in nonsmokers. The odor was not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

Since the toxic effects of methylene chloride are due in part to its conversion to carbon monoxide, they would presumably be augmented by the presence of carbon monoxide in the air. Foder et al.¹⁵ found the effects of CO and the COHb from methylene chloride to be additive in 3-hour exposure tests with rats. Therefore, whenever there is a combined exposure to the vapors of methylene chloride and carbon monoxide, the appropriate equation for mixtures should be used in determining whether or not the exposure is acceptable.

A time-weighted average TLV of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. This recommendation is based upon experimental data obtained from non-smoking males at rest, and should keep COHb levels well below 5 percent. A STEL of 500 ppm is recommended since data indicate that neither undesirable CNS responses nor COHb values are likely to occur with such exposures to methylene chloride.^{16,17} Concurrent exposure to other source of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Ekins (1959) 200 ppm; ANSI (1959) 500 ppm; USSR (1970) 15 ppm; East Germany (1973) Romania (1975) Yugoslavia (1971) and Czechoslovakia (1976) 140 ppm; Sweden (1974) 100 ppm; others 200 or 250 ppm.

References:

1. Lehmann, K.B., Flury, F.: *Toxicology & Hygiene of Industrial Solvents*, pp. 13-158. Williams & Wilkins, Baltimore, MD (1941).
2. von Oettingen, W.F.: *Halogenated Hydrocarbons: Toxicity & Potential Dangers*. Pub. Health Service Publication # 414, pp. 35-41 (1955).
3. Svirbel, J.L., Highman, B., Alford, W.C., von Oettingen, W.F.: *J. Ind. Hyg. & Tox.* 29:182 (1947).
4. Heffel, L.A., Neal, P.A., Perrin, T.L., Orr, N.L., Porterfield, V.T.: *Ibid.* 26:8 (1944).
5. Moskowitz, S., Shapiro, H.: *Arch. Ind. Hyg. & Occup. Med.* 6:116 (1952).
6. Collier, H.: *Lancet* 1:594 (1916).
7. Kuzelova, M., Vlasak, R.: *Pracovní Lékařství* 18:147 (1966), abstr. in *Scientific Reports on Industrial Hygiene and Occupational Diseases in Czechoslovakia*, p. 69, Prague (1966).
8. Weiss, G.: *Zentralblatt Arbeitsmed. u. Arbeitsschutz* 17:282 (1967).
9. Golubovskii, I.E., Kamchatnova, V.P.: *Hygiene & Sanitation* 29:145, USSR (1964).
10. Stewart, R.D., Fisher, T.N., Hosko, J.J., Peterson, J.E., Baretta, E.D., Dodd, H.C.: *Science* 176:295 (1972).
11. Stewart, R.D., Fisher, T.N., Haska, M.I., Peterson, J.E., Baretta, E.D., Dodd, H.C.: *Arch. Env. Health* 25:342 (1972).
12. Ratnev, R.S., Wegman, D.H., Elkins, H.B.: *Ibid.* 28:223 (1974).
13. Raleigh, Robert L., M.D.: Letter report from Dir. of Health & Safety Laboratory, Eastman Kodak Company, Rochester, NY (April 3, 1975).
14. Stewart, R.D., Hake, C.L., Forster, H.V., Lebrun, A.J., Peterson, J.E., Wu, A.: *Methylene Chloride: Development of a Biologic Standard for the Industrial Worker by Breath Analysis*.
15. Foder, G.G., Prajsnar, D., Schliokoter, H.W.: *Endogenous CO Formation by Incorporated Halogenated Hydrocarbons of the Methane Series*. *Graub-Kernhalt Luft* 33:260-261 (1973).
16. NIOSH: *Criteria for a Recommended Standard—Occupational Exposure to Methylene Chloride*. U.W. HEW Publication No. (NIOSH) 75-138 (March 1976).
17. Stewart, R.D., Forster, H.V., Hake, C.L., Lebrun, A.J., Peterson, J.E.: *Human Responses to Controlled Exposures of Methylene Chloride Vapor*. Report No. NIOSH-MCOW-ENVM-MC-73-7. The Medical College of Wisconsin, Dept. of Environmental Medicine, Milwaukee, WI (December 1973).
18. Winneke, G.: *Behavioral Effects of Methylene Chloride and Carbon Monoxide as Assessed by Sensory and Psychomotor Performance*. C. Vintaras, B.L. Johnson, J. de Groot, J.S. Behavioral Toxicology—Early Detection of Occupational Hazards. HEW Pub. No. (NIOSH) 74-126, pp. 110-144. U.S. DHEW Center for Disease Control, NIOSH (1974).
19. Hake, C.L., Stewart, R.D., Forster, H.V., Lebrun, A.J., Peterson, J.E., Wu, A.: *Results of Controlled Exposure of Human Females to Vapor of Methylene Chloride*. Report No. NIOSH-MCOW-ENVM-MC-74-3. The Medical College of Wisconsin, Dept. of Environmental Medicine, Milwaukee, WI (March 1974).
20. Gamborale, F., Annwall, B.A., Hultengren, M.: *Exposure to Methylene Chloride—II. Psychological Functions*. *Scand. J. Work. Env. Health* 1:95-103 (1975).

3. Grandjean, E. et al. *Arch. Ind. Health* 114:426-441 (1956).
4. Dale, K.: *Scand. J. Resp. Dis.* 54(3):168-184 (1973).

5. National Cancer Institute: *Bioassay of Titanium Dioxide for Possible Carcinogenicity*, DHEW Pub. No. (NIH) 78-1347, Bethesda, MD (1978).

TOLUENE

Toluol

$C_6H_5CH_3$

Skin

TLV, 100 ppm (\approx 375 mg/m³)

STEL, 150 ppm (\approx 560 mg/m³)

Toluene is a colorless liquid with a typical aromatic hydrocarbon odor. Its molecular weight and specific gravity are 92.13 and 0.866, respectively. The boiling point is 110.7° C and solidifies at -95° C. At 25° C, the vapor pressure is 28 mm Hg. The closed cup flash point is 40° F. It is insoluble in water, but miscible with most organic solvents.

Formerly derived solely from coal tar, toluene is now obtained chiefly from petroleum, and is present in gasoline and many petroleum solvents. It is used as a solvent in paints and coatings, for rubber, oils, resins, etc.; as a raw material for the manufacture of benzene and a host of other chemicals, including TNT, TDI, and ingredients of detergents, dyes and drugs.

Because of its wide industrial use and chemical similarity to benzene, the literature of industrial toxicology and industrial medicine, particularly the latter, record numerous investigations of the toxic effects of toluene. According to Patty⁽¹⁾ the concentrations of toluene and benzene required to cause prostration of mice are apparently 3000 ppm and 4700 ppm, respectively. Death from acute poisoning results from 10,000 ppm toluene compared with 14,000 ppm of benzene. Several incidents of workers being overcome by toluene vapor, usually in confined spaces, have been reported. Longley and co-workers⁽²⁾ describe such an event aboard ship where 26 men were overcome. There were no deaths or serious aftereffects. No irritation of eyes or respiratory passages was observed.

From the standpoint of chronic poisoning, toluene does not cause the severe injury to the bone marrow characteristic of benzene poisoning. Gerarde⁽³⁾ stated that the myelotoxicity of benzene was completely absent in toluene and other alkyl derivatives of benzene. Von Oettingen *et al.*⁽⁴⁾ found that exposure of rats at 2500 to 5000 ppm of toluene caused a temporary decrease in the white-cell count, but no evidence of injury to blood-forming organs or liver. Greenburg and co-workers⁽⁵⁾ studied a group of painters exposed to toluene in concentrations ranging from 100 to 1100 ppm. Their findings included enlargement of the liver, macrocytosis, moderate decrease in erythrocyte count and absolute lymphocytosis, but no leukopenia.

Wilson⁽⁶⁾ found that among workers exposed at less than 200 ppm of toluene there were some complaints of headache, lassitude and nausea, but physical findings were essentially negative. At concentrations between 200 and 500 ppm impairment of coordination, momentary loss of memory and anorexia were also present. Between 500 and 1500 ppm palpitation, extreme weakness, pronounced loss

of coordination and impairment of reaction time were noted. The red cell count fell in many instances, and there were two cases of aplastic anemia, in which recovery followed intensive hospital treatment. A later comment by Wilson⁽⁷⁾ however, suggests that he did not rule out the possibility that some of the above effects were due to a benzene impurity in the toluene used.

According to Fairhall,⁽⁸⁾ severe exposure to toluene may result in a pronounced drop in the red count and partial destruction of the blood-forming elements of the bone marrow. However, Gerarde⁽⁹⁾ stated that extensive animal studies clearly indicate that toluene is not a bone marrow poison. While there have been occasional reports of aplastic anemia attributed to toluene,⁽¹⁰⁾ in some instances the presence of benzene was not precluded, and there have been no "epidemics" of this disease among toluene workers comparable to those which have resulted from benzene. Powars⁽¹¹⁾ reported six cases of aplastic anemia, one of them fatal, among glue sniffers. Although toluene was the solvent chiefly used, no analysis was given of the glue involved in the fatal case. Exposures in these cases are much greater than would normally arise from occupational use of toluene. Thus Knox and Nelson⁽¹²⁾ described an instance of permanent encephalopathy involving a man who inhaled toluene regularly for over 14 years.

Von Oettingen and co-workers⁽⁴⁾ found that human subjects exposed at 200 ppm suffered slight but definite changes in muscular coordination. They concluded that such concentrations were unlikely to have any discernible untoward effects on health. Gerarde⁽⁹⁾ however, believed that von Oettingen's work did not justify the 200 ppm limit. Ogata *et al.*⁽¹³⁾ found that experimental human subjects exposed at 200 ppm for seven hours showed prolongation of reaction time, decrease in pulse rate and in systolic blood pressure. They consider 200 ppm too high as the MAC. Takeuchi⁽¹⁴⁾ exposed rats at 200 ppm and higher concentrations of toluene for 32 weeks and then to benzene for 39 days. On the basis of differences found between the toluene-exposed animals and controls, e.g. changes in weight of adrenal glands, he suggested that the MAC of 200 ppm for toluene should be reconsidered.

Smyth *et al.* reported an oral LD₅₀ administered to rats, to be 7.53 mL/kg.⁽¹⁵⁾

On the basis of the above data, a reduction in the TLV for toluene from 200 ppm to 100 ppm is recommended, with a STEL of 150 ppm.

Other recommendations: Cook (1945) 200 ppm; Smyth (1956) comments that this limit may permit early signs of narcosis; Elkins (1959) 200 ppm; ANSI (1967) 200 ppm; USSR (1967) 14 ppm; Czechoslovakia (1969) 50 ppm; West Germany (1974) 200 ppm; Sweden (1975) 100 ppm; East Germany (1973) 50 ppm; NIOSH (1973) 100 ppm.

References:

1. Patty, F.S.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, p. 1226, Interscience, NY (1963).
2. Longley, E.Q., Jones, A.T., Lomaev, O.: *Arch. Env. Health* 14:481 (1967).

lene chloride continued after exposure ceased. This solvent-induced COHb is apparently added to the body burden of carbon monoxide derived from other sources.

This study corroborated previous single exposure studies in that no deleterious effects upon the health or performance of healthy adults could be detected when they were repeatedly exposed to 250 ppm or less for 7.5 hours per day, five days per week for 2 weeks, or in the case of the male subjects, to 500 ppm on two consecutive days.¹¹⁹ Among the parameters studied were complete blood count, clinical chemistry (SMA 12), EKG, serum triglycerides, blood pressure, subjective signs and symptoms, urinalysis (Combitox), urinary urobilinogen, neurological tests, EEG, visual evoked response, pulmonary function and cognitive, alertness, time estimation, coordination, arithmetic and inspection tests.

The increase in COHb was related to the magnitude of the vapor exposure. Both duration of exposure and vapor concentration were factors. Seven and one-half hour exposures to concentrations as low as 100 ppm for 5 days resulted in COHb elevations about 5 percent in nonsmokers. The odor was not objectionable at 250 ppm and many subjects could not detect it at 50 or 100 ppm.

Since the toxic effects of methylene chloride are due in part to its conversion to carbon monoxide, they would presumably be augmented by the presence of carbon monoxide in the air. Puder *et al*¹²⁰ found the effects of CO and the COHb from methylene chloride to be additive in 3-hour exposure tests with rats. Therefore, whenever there is a combined exposure to the vapors of methylene chloride and carbon monoxide, the appropriate equation for mixtures should be used, in determining whether or not the exposure is acceptable.

A time-weighted average TLV of 100 ppm is recommended for methylene chloride in the absence of occupational exposure to carbon monoxide. This recommendation is based upon experimental data obtained from non-smoking males at rest, and should keep COHb levels well below 5 percent. A STEL of 500 ppm is recommended since data indicate that neither undesirable CNS responses nor COHb values are likely to occur with such exposures to methylene chloride.^{117, 120} Concurrent exposure to other source of carbon monoxide or physical activity will require assessment of the overall exposure and adjustment for the combined effect.

Other recommendations: NIOSH (1976) 75 ppm; West Germany (1979) and Elkins (1959) 200 ppm; ANSI (1969) 500 ppm; USSR (1970) 15 ppm; East Germany (1973), Romania (1975), Yugoslavia (1971) and Czechoslovakia (1976) 140 ppm; Sweden (1974) 100 ppm, others 200 or 250 ppm.

References:

1. Lehmann, K.R., Flury, F.: *Toxicology & Hygiene of Industrial Solvents*, no. 13-1:8, Williams & Wilkins, Baltimore, MD (1943).

2. von Oettingen, W.F.: *Halogenated Hydrocarbons, Toxicity & Potential Dangers*, Pub. Health Service Publication # 474, pp 35-41 (1955).
3. Svirbely, J.L., Highman, B., Alford, W.C., von Oettingen, W.F.: *J. Ind. Hyg. & Tox.* 29:382 (1947).
4. Heppel, L.A., Neal, P.A., Pettin, T.L., Orr, N.L., Porterfield, V.T.: *Ibid.* 26:8 (1944).
5. Moskowitz, S., Shapiro, H.: *Arch. Ind. Hyg. & Occup. Med.* 6:116 (1952).
6. Collier, H.: *Lancet* 1:594 (1936).
7. Kuzelova, M., Vlasak, R.: *Pracovní lékařství* 18:167 (1966); *abstr. in Scientific Reports on Industrial Hygiene and Occupational Diseases in Czechoslovakia*, p. 69, Prague (1966).
8. Weiss, G.: *Zentralblatt Arbeitsmed. u. Arbeitsschutz* 17:282 (1967).
9. Golubovskii, I.E., Kamchatnova, V.P.: *Hygiene & Sanitation* 29:145, USSR (1964).
10. Stewart, R.D., Fisher, T.N., Hosko, J.J., Peterson, J.E., Baretta, E.D., Dodd, H.C.: *Science* 176:295 (1972).
11. Stewart, R.D., Fisher, T.N., Haska, M.J., Peterson, J.E., Baretta, E.D., Dodd, H.C.: *Arch. Env. Health* 25:342 (1972).
12. Ratney, R.S., Wegman, D.H., Elkins, H.B.: *Ibid.* 28:223 (1974).
13. Raleigh, Robert L., M.D.: Letter report from Director, Health & Safety Laboratory, Eastman Kodak Company, Rochester, NY (April 3, 1975).
14. Stewart, R.D., Hake, C.L., Forster, H.V., Lebrun, A.J., Peterson, J.E., Wu, A.: *Methylene Chloride. Development of a Biologic Standard for the Industrial Worker by Breath Analysis*.
15. Foder, G.G., Prajsnar, D., Schlipkoter, H.W.: *Endogenous CO Formation by Incorporated Halogenated Hydrocarbons of the Methane Series. Staub-Reinhalte Luft* 33:260-261 (1973).
16. NIOSH: *Criteria for a Recommended Standard—Occupational Exposure to Methylene Chloride*, U.W. HEW Publication No. (NIOSH) 76-138 (March 1976).
17. Stewart, R.D., Forster, H.V., Hake, C.L., Lebrun, A.J., Peterson, J.E.: *Human Responses to Controlled Exposures of Methylene Chloride Vapor* Report No. NIOSH-MCOW-ENVM-MC-73-1, The Medical College of Wisconsin, Dept. of Environmental Medicine, Milwaukee, WI (December 1973).
18. Winneke, G.: *Behavioral Effects of Methylene Chloride and Carbon Monoxide as Assessed by Sensory and Psychomotor Performance*, C. Xintaras, B.L. Johnson, I. de Groot, Eds. *Behavioral Toxicology—Early Detection of Occupational Hazards* HEW Pub. No. (NIOSH) 74-126, pp. 130-144, U.S. DHEW, Center for Disease Control, NIOSH (1974).
19. Hake, C.L., Stewart, R.D., Forster, H.V., Lebrun, A.J., Peterson, J.E., Wu, A.: *Results of Controlled Exposure of Human Females to Vapor of Methylene Chloride* Report No. NIOSH-MCOW-ENVM-MC-74-3, The Medical College of Wisconsin, Dept. of Environmental Medicine, Milwaukee, WI (March 1974).
20. Gamborale, F., Annwall, B.A., Hultengren, M.: *Exposure to Methylene Chloride—II. Psychological Functions. Scand. J. Work Env. Health* 1:95-103 (1975).

XYLENE

 $C_6H_4(CH_3)_2$

o-, m-, p-isomers

TLV, 100 ppm (\approx 435 mg/m³)STEL, 150 ppm (\approx 635 mg/m³)

Xylene is a clear, flammable liquid with an aromatic hydrocarbon odor and a molecular weight of 106.16. Commercial xylene is a mixture of three isomers, ortho, meta and para, with the meta form usually the principal component. According to Gerarde,⁽¹⁾ 6 to 15% of ethyl benzene may also be present. The physicochemical properties of the three isomers, meta, ortho, para, respectively, are: specific gravity, 0.8684, 0.8697 and 0.86104; boiling point, 138.8, 144 and 138.5° C; melting point, -47.4, -25 and -13 to -14° C. The vapor pressure at 25° C is between 7 and 9 mm Hg. The boiling ranges and flash points of the commercial product depends on its grade; the 10% grade boils between 135 and 145° C; closed cup flash points are from 81 to over 100° F. Xylene is insoluble in water, but miscible with absolute alcohol, ether and other organic solvents.

Xylene is present in gasoline and many petroleum solvents. It is used extensively as a solvent in paints and other coatings, especially the alkyl resin type, and in rubber cements. Meta-xylene is an intermediate in the preparation of isophthalic acid; ortho-xylene in the manufacture of phthalic anhydride; para-xylene in the synthesis of terephthalic acid. All isomers are used in making drugs, dyes and insecticides.

Fairhall⁽²⁾ considered the effects of xylene similar to those of toluene, but Gerarde⁽¹⁾ stated that the acute toxicity of the xylenes was higher.

Fabre and Truhaut⁽³⁾ exposed rats and rabbits to a mixture of xylene isomers at a concentration of about 690 ppm for eight hours a day, six days a week. After 130 days no significant deviations from normal in the peripheral blood were found. A decrease in red and white cell counts and an increase in the platelet count in the blood of rabbits followed similar exposures at 1150 ppm for 55 days. Reversible lesions in the cornea of cats exposed to xylene were observed.

Gerarde⁽¹⁾ listed headache, fatigue, lassitude, irritability and gastrointestinal disturbances such as nausea, anorexia and flatulence as the most frequent symptoms among workers exposed to xylene. A report which suggested that xylene might affect the heart and vascular system was cited.

Browning⁽⁵⁾ also recorded reports of gastrointestinal as well as neurological disturbances, and injury to heart, liver, kidneys and the nervous system among workers with xylene exposure. In addition, she noted a number of reports of blood dyscrasias, some of them fatal, associated with exposure to xylene. De Oliveira⁽⁶⁾ described the death from aplastic anemia of a lithographer who used xylene for several years; and Goldie⁽⁷⁾ reported a patient who had an

apparent epileptiform seizure following relatively brief exposure to xylene vapor.

Gerarde,⁽¹⁾ however, considered that industrial experience confirmed the animal experimentation evidence that xylene is not a myelotoxicant. Goldwater⁽⁸⁾ was of the opinion that xylene was probably less toxic than toluene to the bone marrow. In most of the cases of blood disease associated with xylene, the presence of benzene as an impurity was not ruled out.

Nelson and associates⁽⁹⁾ found 200 ppm of xylene definitely irritating to the eyes, nose and throat of experimental human subjects. Greenburg and Moskowitz⁽¹⁰⁾ suggested a maximum allowable concentration of 200 ppm. Cook,⁽¹¹⁾ Smyth,⁽¹²⁾ Elkins⁽¹³⁾ and Gerarde⁽¹⁾ all considered this value too high, and Gerarde suggested 100 ppm as more acceptable limit.

The NIOSH criteria document on xylene, published in 1975,⁽¹⁴⁾ refers to a report by Morley *et al.*⁽¹⁵⁾ in which renal impairment and some evidence of disturbance of liver function were noted in three workers who were overcome by a gross overexposure to xylene (estimated concentration, 10,000 ppm); one worker died, the others suffered from amnesia and did recover, slowly however. A paper by Matthaus describes corneal changes in furniture polishers exposed to xylene in unknown concentrations.⁽¹⁶⁾

In a study of various hydrocarbon solvents, Croenter *et al.*⁽¹⁷⁾ found the 4-hour LC₅₀ for rats to be 6700 ppm. The no-ill-effect concentration for rats and dogs, following 6 days (6 hours/day, 5 days/week) was 800 ppm. Sensory response experiments with human subjects indicated a hygienic standard of around 200 ppm.

The TLV of 100 ppm, first adopted in 1967, is retained with a STEL of 150 ppm. It is believed that irritant effects will be minimal, and that no significant degree of narcosis or chronic injuries will result from continued occupational exposure at that level.

NIOSH⁽¹⁴⁾ also recommended a workplace environmental standard of 100 ppm, as a TWA, with a ten minute ceiling of 200 ppm.

Other recommendations: ANSI (1970) 100 ppm; West Germany (1974) 200 ppm; Sweden (1975) 100 ppm; Czechoslovakia (1969) and East Germany (1973) 45 ppm; USSR (1972) 11 ppm.

References:

1. Gerarde, H.W.: *Toxicology & Biochemistry of Aromatic Hydrocarbons*, pp. 171-180, Elsevier, Amsterdam (1960).
2. Fairhall, L.T.: *Industrial Toxicology*, 2nd ed., p. 358, Williams Wilkins, Baltimore, MD (1957).
3. Patty, F.A.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, 1234, Interscience, NY (1963).
4. Fabre, R., Truhaut, R.: *Congresso Internazionale de Medicina del Lavoro*, Napoli (1954). Cited by Gerarde in ref. 1.
5. Browning, E.: *Toxicity & Metabolism of Organic Solvents*, p. 77-89, Elsevier, Amsterdam (1965).

001383

TRICHLOROACETIC ACID

TCA

CCl₃COOH

TLV, 1 ppm (≈ 5 mg/m³)

TCA forms deliquescent crystals with a molecular weight of 163.40 and a specific gravity of 1.6298. It is a relatively strong acid, which melts at 57.5° C, boils at 197.5° C and is nonflammable. TCA is soluble in water, alcohol and ether.

It is used in medicine, pharmacy, as a reagent for albumin detection and in making herbicides.

Trichloroacetic acid was first placed on the Notice of Intended Change in 1978 at 1 mg/m³. This value had been carried for 1979 and transferred to the adopted list in 1980. This value was in error. The TLV 0.75 ppm (≈ 5 mg/m³), which appeared on page 476 of the 1978 Supplemental Documentation V, was the value initially given TCA, and was to have been rounded off to 1 ppm, by analogy with 2,2-dichloropropionic acid (TLV 1 ppm). The numeral one was then inadvertently placed in the (mg/m³) column in-

stead of the ppm column, and this error was not discovered until now. The correct adopted TLV is 1 ppm (≈ 5 mg/m³) and this correction will be made in the second printing of the 1980 TLV booklet. The following documentation reflects this value.

The oral LD₅₀ has been reported as 3.3 g/kg for rats,⁽¹⁾ for mice, 5.64 g/kg.⁽¹⁾ By intraperitoneal administration, 500 mg/kg was fatal to mice.⁽¹⁾

TCA is corrosive to the skin and eye, but not readily absorbed through the skin. Medical reports of acute exposure effects showed mild to moderate skin and eye burns.

A time-weighted TLV of 1 ppm is suggested, based largely on analogy to 2,2-dichloropropionic acid, and the above meager data.

Other recommendations: USSR (1976) 0.75 ppm

References:

1. Merck Index, 9th ed., p. 1236, Merck & Co., Inc., Rahway, NJ (1976)
2. Dow Chemical Company: Communication to Committee (1977)
3. NIOSH: Registry of Toxic Effects of Chemical Substances (1977)

1,2,4-TRICHLOROBENZENE

C₆H₃Cl₃

CEILING LIMIT, 5 ppm (≈ 40 mg/m³)

A colorless, stable liquid at room temperature, with an odor similar to that of o-dichlorobenzene, 1,2,4-trichlorobenzene has a molecular weight of 181.46 and a specific gravity of 1.4634 at 25° C. It melts at 17° C, boils at 213° C and has a reported flash point of 224.6° F. It is combustible and soluble in most organic solvents, but insoluble in water.

It is used as a dielectric fluid, heat transfer medium in lubricants, insecticides and organic synthesis.

A study of the acute and subacute inhalation toxicity of trichlorobenzene (92% the 1,2,4-isomer) by Treoni⁽¹⁾ indicated that the target organs from non-lethal exposures of cats, dogs, rats, rabbits and guinea pigs included the liver, kidney, ganglion cells at all brain levels, and mucous membranes. Local irritation of the lungs and functional changes in respiration, e.g., dyspnea, were noted in animals later dying from inhalation exposure.

Brown et al⁽²⁾ reported 1,2,4-trichlorobenzene to have a single dose acute oral LD₅₀ of 756 mg/kg for rats and 766 mg/kg for mice. The acute percutaneous LD₅₀ for rats was 6139 mg/kg. Sublethal doses administered repeatedly to guinea pigs caused liver damage. Acute and short term (15 x 6 exposures, 70-200 ppm) inhalation studies failed to kill animals, and produced lethargy and retarded weight gain with no organ pathology.⁽¹⁾ Cameron et al⁽³⁾ reported that the trichlorobenzenes are less toxic to rats than the mono- and dichlorobenzenes.

The aforementioned studies are short term ones and information needed to recommend an airborne concentra-

tion to which workers may be repeatedly exposed during a working lifetime without adverse effects is limited. Cutaneous exposure to 1,2,4-trichlorobenzene does not cause chloracne or acneiform dermatitis but can cause dermal irritation which is probably attributable to its degreasing action.⁽¹⁾ Industrial data report an odor threshold of approximately 3 ppm and minimal eye and throat irritation at 3-5 ppm in certain people.⁽⁶⁾ Twenty male rats, 4 rabbits and 2 male dogs were exposed at either 30 or 100 ppm 1,2,4-trichlorobenzene (98.4% purity, 1.4% 1,2,3-trichlorobenzene) 7 hours/day 5 days/week for 30 exposures in 44 days. No adverse effects were detectable at 30 ppm with the exception of an elevation of urinary uroporphyrin and coproporphyrin in the rats only at 15 and 30 exposure days. No pathologic lesions could be attributed to the exposure in roughly 30 different specimens examined for each species.⁽⁶⁾ A second inhalation study was performed with 99.07% pure 1,2,4-trichlorobenzene 7 hours/day, 5 days/week for 26 consecutive weeks.⁽⁷⁾ Thirty rats, 16 rabbits, and 9 monkeys, all males, were exposed at zero, 25, 50 and 100 ppm. Pulmonary function and operant behavior in monkeys, ophthalmoscopic examination in rabbits and monkeys and body weight measurements, hematology and serum biochemical determinations in all species were conducted prior to and during the exposure period; no differences were noted among the four exposure groups. Microscopic changes were seen in the parenchymal cells of livers and kidneys from all groups of rats after 4 and 13 weeks of exposure to 1,2,4-TCB, but no exposure-related abnormalities were seen after 26 weeks of exposure in any of the three species understudy.

The above data do not indicate a high systemic toxicity. The recommended ceiling limit of 5 ppm, based on the irritating properties of TCB, seems low in comparison with

the limits for the dichlorobenzenes. For the present, this limit is retained.

Other recommendations for trichlorobenzene: Bulgaria, Poland, U.S.S.R., Yugoslavia, 1.4 ppm.

References:

1. Treon, J.: Unpublished report from the Kettering Laboratory, University of Cincinnati, OH (1950).
2. Brown, V.K.H., Muir, C., Thorpe, J.: *Ann. Occup. Hyg.* 12:209 (1969).
3. Gage, J.C.: *Brit. J. Ind. Med.* 27:1 (1970).
4. Cameron, G.R., Thomas, J.C., Ashmore, A.S., Buchan, J.L., Warren, E.H., Hughes, A.W.N.: *J. Path. Bact.*, Vol. 281 (1937).
5. Powers, M.B., Coate, W.B., Lewis, T.R.: *Arch. Env. Health* 30:1 965 (1975).
6. Rowe, V.K.: Private communication (1975).
7. Coate, W.B., Schoenfish, W.H., Busey, W.M., Lewis, T.R.: *Chronic Inhalation Exposure of Rats, Rabbits and Monkeys to 1,2,4-Trichlorobenzene.*

1,1,1-TRICHLOROETHANE

See. METHYL CHLOROFORM

1,1,2-TRICHLOROETHANE

Vinyl trichloride



Skin

TLV, 10 ppm ($\approx 45 \text{ mg/m}^3$)

STEL, 20 ppm ($\approx 90 \text{ mg/m}^3$)

A colorless, non-flammable liquid with a sweet odor, 1,1,2-trichloroethane has a molecular weight of 133.42 and a specific gravity of 1.4416 at 20° C. It boils at 113.7° C, freezes at -36.4° C and has a vapor pressure of 19 mm Hg at 20° C. Insoluble in water, it is miscible with alcohol, ether and other organic solvents.

It is used as a solvent for fats, resins, etc., and in organic synthesis.

1,1,2-trichloroethane depresses the central nervous system causing narcosis, in which respect it is considerably more potent than chloroform.^(1,2) By inhalation its acute toxicity is somewhat greater for certain laboratory animals (cats) than that of chloroform. Narcotic concentrations of 1,1,2-trichloroethane result in irritation to the eyes and nose and infection of the conjunctiva. Death occurs from respiratory arrest. Concentrations producing deep narcosis and death are of the order of 13,600 ppm for a two-hour exposure. The corresponding concentration for chloroform is 30,000 to 40,000 ppm. 1,1,2-trichloroethane is lethal by oral and subcutaneous administration; 0.75 g/kg was lethal to dogs by mouth, compared with 2.25 g/kg for chloro-

form.⁽³⁾ Fatty degeneration of the liver was observed in dogs dying two or more days following administration of trichloroethane, which is also absorbed through the intact skin.⁽⁴⁾

More recent data include the following⁽⁵⁾: oral LD₅₀, rat - 1140 mg/kg; intraperitoneal LD₅₀, mouse - 994, dog - 450 mg/kg; subcutaneous LD₅₀, mouse - 227 mg/kg. Exposure at 500 ppm for 8 hours was fatal to rats.

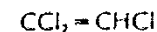
The current TLV of 10 ppm was based on the toxicological resemblance to symmetric tetrachloroethane, and by analogy with the TLV for chloroform, which at that time was 50 ppm. In view of the above comparisons of the toxicity of 1,1,2-trichloroethane with that of chloroform, a limit somewhat lower than 10 ppm, the TLV for the latter compound, might be in order for 1,1,2-trichloroethane. For the present, the TLV of 10 ppm and STEL of 20 ppm are retained.

Other recommendations: Several western European nations and Japan had adopted the 10 ppm TLV, as of 1977; Poland, with 22 ppm, was the only exception. West Germany (1979) considers it a potential carcinogen.

References:

1. Lazarew, N.W.: *Arch. Exptl. Path. Pharmacol.* 14:19 (1929).
2. Von Oettingen, W.F.: *The Halogenated Hydrocarbons, Their Toxicity & Potential Dangers.* USPHS Pub No 414, pp 155-156, US Gov. Printing Office, Washington, DC (1955).
3. Barsoum, G.S., Saad, K.: *Q J Pharm & Pharmacol.* 7:205 (1934).
4. Burgi, E.: *Bruxelles Med.* 16:1481 (1936).
5. NIOSH: *Registry of the Toxic Effects of Chemical Substances* (1977).

TRICHLOROETHYLENE



TLV, 50 ppm ($\approx 270 \text{ mg/m}^3$)

STEL, 150 ppm ($\approx 805 \text{ mg/m}^3$)

Trichloroethylene is a nonflammable, colorless liquid of sweetish odor. It has a molecular weight of 131.4 and a specific gravity of 1.4649. The boiling point is 87° C and solidifies at -84.8° C. The vapor pressure at 20° C equals 58 mm Hg. It is practically insoluble in water, but highly solu-

ble in lipids. (Partition coefficient at 37° C: blood-air 9, oil-air 943). In the presence of oxygen and short ultraviolet wavelength, trichloroethylene is decomposed to phosgene and hydrochloric acid.

Trichloroethylene is used for degreasing, dry cleaning, and as a solvent. In the past, trichloroethylene was used as an extractant in food-processing (FDA had approved residue below 25 ppm in decaffeinated ground coffee and 10 ppm for instant coffee). This was discontinued in 1975, when NCI issued an alert, warning that trichloroethylene may be a carcinogen. Its use as an anesthetic was aban-

NAPHTHA

See. RUBBER SOLVENT

NAPHTHALENE

 $C_{10}H_8$ TLV, 10 ppm ($\approx 50 \text{ mg/m}^3$)STEL, 15 ppm ($\approx 75 \text{ mg/m}^3$)

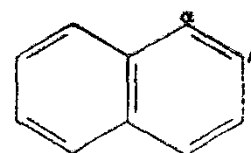
Naphthalene occurs commonly as white, crystalline flakes which have a strong coal tar odor. It has a molecular weight of 128.16 and a specific gravity of 1.145. It melts at 80.2°C , boils at 217.96°C and has a vapor pressure at 25°C of approximately 0.087 mm Hg. The open cup flash point is 176°F and closed cup is 190°F . Insoluble in water, it dissolves in most organic solvents.

Crystalline naphthalene finds household use as a moth repellent, scientific use in scintillation counters. It is an important raw material for the manufacture of phthalic anhydride, naphthol, hydrogenated naphthalenes and halogenated naphthalenes; it or its derivatives are employed in dyes, explosives, lubricants, tanning agents and emulsion breakers.

According to Flury and Zernik⁽¹⁾ and Patty,⁽²⁾ the inhalation of naphthalene vapor may cause headache, loss of appetite and nausea. Optical neuritis and injuries to the cornea and, in addition, kidney damage have also been reported. Ghetti and Mariani⁽³⁾ reported opacities of the lens in 8 of 21 workers who had been exposed to naphthalene for about five years. Ingestion of naphthalene in relatively large amounts has reportedly caused severe hemolytic anemia and hemoglobinuria.⁽⁴⁾ A hypersusceptibility, probably genetically based, is recognized.⁽⁵⁾

The oral LD_{50} for rats is 1760 mg/kg.⁽⁶⁾ It was used as an anthelmintic for many years at dose levels, for adults, of 0.1 to 0.5 gram three times a day,⁽⁷⁾ several times higher than the lowest reported lethal dose for man of 50 mg/kg.⁽⁸⁾ An incident in which blankets containing naphthalene caused acute hemolytic effects in infants, in some cases fatal, has been described.⁽⁹⁾

Patty suggested 25 ppm as a tentative limit for naphthalene vapor in air. He noted that this corresponds to a saturation pressure of approximately 25% at 25°C . This value has been used at the Los Alamos Laboratories, according to



Hyatt and Milligan⁽¹⁰⁾ Robbins,⁽¹⁰⁾ however, reported that concentrations in excess of about 15 ppm resulted noticeable irritation of the eyes.

Gerardo⁽¹¹⁾ also suggested 25 ppm as a tentative limit, noting that it represents 25% of the concentration of naphthalene vapor in air saturated at 25°C .

In view of the fact that irritation is experienced at 15 ppm and that continued exposure may result in fairly serious eye effects, a limit lower than 25 ppm would seem in order. The value of 10 ppm TLV and 15 ppm STEL are recommended to prevent ocular effects, but possibly not blood changes in hypersusceptibles.

Other recommendations: West Germany, 10 ppm; East Germany and USSR, 4 ppm.

References:

1. Flury, F., Zernik, E.: *Schadliche Gase*, p. 290. J. Springer, Berlin (1931).
2. Patty, F.A.: *Industrial Hygiene & Toxicology*, Vol. II, p. 770. Interscience, NY (1949).
3. Ghetti, G., Mariani, L.: *Med. d. Lavoro* 47:533 (1956).
4. Zuelzer, W.W., Apt, L.: *J. A.M.A.* 141:185 (1949).
5. Stokinger, H.E., Mountain, J.T.: *Arch. Env. Health* 6:495 (1963).
6. NIOSH: *Registry of Toxic Effects of Chemical Substances* (1977).
7. Am. Ind. Hyg. Assoc.: *Hygienic Guide Series-Naphthalene* (1967).
8. Valoes, T., Doxiadis, S.A., Fassas, P.: *J. Ped.* 63:904 (1963). Cited in ref. 7.
9. Hyatt, E.C., Milligan, M.F.: *Am. Ind. Hyg. Assoc. Q.* 14:289 (1953).
10. Robbins, M.C.: *Arch. Ind. Hyg. & Occup. Med.* 4:85 (1951).
11. Gerardo, H.W.: *Toxicology & Biochemistry of Aromatic Hydrocarbons*, p. 230. Elsevier Pub. Co., NY (1960).

The TLV of 0.5 mg/m³ is believed low enough to minimize the incidence of chloracne and prevent serious injury to the liver. However, in view of the fact that hepatic changes in rats resulted from 143 eight-hour exposures at 1.44 mg/m³ of a mixture of penta- and hexachloronaphthalenes,⁽⁵⁾ the margin of safety of the 0.5 mg/m³ limit for pentachloronaphthalene may be rather small. At this time, a STEL of 2 mg/m³ is suggested.

References:

1. von Oettingen, W.F.: *The Halogenated Hydrocarbons, Their Toxicity & Potential Dangers*, Public Health Service Pub. #414, p. 313 (1955).

2. Cotter, L.H.: *J.A.M.A.* 125:273 (1944)
3. *Annual Report of the Chief Inspector of Factories for 1938*, p. 67, H.M.S.O., London (1939).
4. Drinker, C.K., Warren, M.F., Bennett, G.A.: *J. Ind. Hyg. & Tox.* 19:283 (1937).
5. Bennett, G.A., Drinker, C.K., Warren, M.F.: *Ibid.* 20:97 (1938).
6. Drinker, C.K. *Ibid.* 2:155 (1939).
7. Bell, W.B.: *Vet. Med.* 48:135 (1953).

PENTACHLOROPHENOL

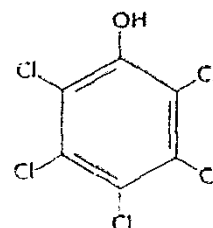
PCP; Chem-Tol; Permicide; Penta; Santophen 20;
Dowicide 7

C₆HCl₅O

Skin

TLV, 0.5 mg/m³

STEL, 1.5 mg/m³



Pentachlorophenol is a colorless, noncombustible solid with a phenolic odor and a pungent taste. The molecular weight is 266.35, specific gravity is 1.978 at 20° C and, at the same temperature, the reported vapor pressure of 0.00017 mm Hg. It is volatile with steam and noncorrosive to metals. Its melting point is 190° C with a boiling point of 310° C. The compound is soluble in water to the extent of 14 ppm at 20° C. Its solubility in organic solvents depends greatly on the nature of the solvent. Barely soluble in alkanes, pentachlorophenol is most soluble in methyl alcohol.

It is a contact herbicide, fungicide, wood preservative and molluscicide.

The most important effect of PCP inhalation is acute poisoning centering in the circulatory system with accompanying heart failure. Kehoe *et al.*⁽¹⁾ found no evidence of chronic poisoning in rabbits. The smallest lethal intravenous dose was 22 mg/kg. The compound penetrates the skin readily. Physiologic injury is mainly vascular with heart failure. Industrial hygiene experience shows that PCP and its sodium salt are capable of inducing discomfort and local as well as systemic effects. Dusts are particularly irritating to the eyes and nose in concentrations greater than 1 mg/m³.⁽²⁾ Some irritation of the nose may occur at 0.3 mg/m³.⁽³⁾ Hardened workers can tolerate up to 2.4 mg/m³.⁽²⁾ PCP is highly poisonous with a wide range of acute action but no pronounced cumulative properties. It has been demonstrated⁽⁴⁾ that dermal penetration is the most dangerous pathway of PCP exposure. The acute gastric LD₅₀'s for mice and rats are 130 and 184 mg/kg, respectively.⁽¹⁾ The dermal LD₅₀ in rats is 96 mg/kg. The inha-

lation LD₅₀ for rats is 335 mg/m³ and for mice 225 mg/m³.⁽¹⁾ The rat embryo was shown to be most susceptible to the toxic effects of PCP during the early phases of organogenesis.⁽⁴⁾ The world literature reveals about 51 cases of PCP poisoning from its use as a herbicide, molluscicide or wood preservative of which 30 out of 51 resulted in death.⁽⁵⁾ The survivors of PCP intoxication suffer with impairments in autonomic function, circulation, visual damage and an acute type of scotoma.⁽⁶⁾ Other damage included acute inflammation of the conjunctiva and characteristically shaped corneal opacity, corneal numbness and slight mydriasis.⁽⁶⁾ Other symptoms involve excessive sweating, tachycardia, tachypnea, respiratory distress, hepatic enlargement and metabolic acidosis.

The 0.5 mg/m³ TLV and the STEL of 1.5 mg/m³ are derived by analogy with other compounds of similar action and toxicity in addition to the specific available information. They are believed low enough to prevent vascular injury.

References:

1. Kehoe, R.A., Deichmann-Gruetler, W., Kitzmiller, K.V.: *J. Ind. Hyg. & Tox.* 21:160 (1939).
2. Patty, F.A.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, p. 1401 Interscience, NY (1963).
3. Demidenko, N.M.: *Gigiena Truda i Prof. Zabolevaniya* 13(9):58 (1969).
4. Schwetz, B.A., Gehring, P.J.: *Tox. Appl. Pharm.* 24(3):455 (1973).
5. Anonymous: *Calif. Health* 27(12):13 (1970).
6. Imaizumi, K.: *Atsumi, N. Gankai* 3(7):717 (1971).

References:

1. NIOSH: *Toxic Substances List*, HEW Pub. No. (NIOSH) 74-134 (1974)

2. Dow Chemical Company: Communication to TLV Committee (1977).

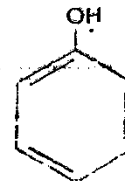
PHENOL



Skin

TLV, 5 ppm (\approx 19 mg/m³)

STEL, 10 ppm (\approx 38 mg/m³)



Pure phenol is a solid at room temperature and is liquified by mixing with about 8% water. The molecular weight is 94.11 and the specific gravity is 1.071. It is white but often has a pinkish hue resulting from impurities or exposure to light and has a characteristic sweet, tarry odor. The solid has a boiling point of 182° C and, when free from water and cresols, it congeals at 41° C and melts at 43° C. At 25° C it has a vapor pressure of 0.35 mm Hg. It is soluble in water and most organic solvents and is combustible, having a closed cup flash point of 172° F.

Its chief use is as a starting point in the manufacture of phenolic resins, bis-phenol-A, caprolactam and many other chemicals and drugs. It is employed as a disinfectant in germicidal paints and as a fumigant.

Deichmann¹ reported results of animal experimentation in which guinea pigs were severely injured by inhalation for 20 days of phenol vapor at concentrations of from 25 to 50 ppm. Post mortem evidence of acute toxicity to the lungs, heart, liver and kidney was found.

Intermittent industrial exposure (five to ten minutes per hour) inside a conditioning room for phenol-impregnated asbestos resulted in marked irritation of the nose, throat and eyes. The average phenol concentration in the room was 48 ppm, although formaldehyde (8 ppm) also was found. Urine sulfate ratios were 79.4 and 86.7 percent. Workers at the same plant, continuously exposed during winding operations, experienced no respiratory irritation, although the odor of phenol was noticeable. The average concentration in the room was 4 ppm. Urine sulfate ratios averaged 74 percent.

Due in part to its low volatility, phenol does not frequently constitute a serious respiratory hazard in industry.² Formerly its use as an antiseptic in surgery resulted in numerous cases of sub-acute or chronic poisoning among surgeons and their assistants.³ Urinary excretions of 2 grams per day, by patients, have been reported.⁴ Absorption of 2 grams of phenol could result from eight hours inhalation at about 4) ppm.

According to Thomas and Back⁵ the TLV of 5 ppm provides a sufficiently large factor of safety to prevent systemic poisoning if skin absorption is avoided.

In 1976 NIOSH published a criteria document in which the toxicology of phenol was reviewed.⁶ The serious local and systemic effects of contact of the skin with phenol and its concentrated solutions were properly emphasized. Relatively little additional information on the effects of inhalation, bearing on the TLV, however, turned up. A report by Petrov⁷ of poisonings among workers in Russia, who quenched coke with waste water containing 0.3 to 0.8 me of phenol per liter is discussed. Air samples indicated phenol vapor concentrations of the order of 2 to 3 ppm and the author believed that phenol might have been implicated in the intoxications, which were not described.

The NIOSH recommendation of 20 mg/m³ as a time-weighted average standard is essentially the same as the TLV of 5 ppm established in 1952. The NIOSH ceiling of 100 mg/m³ for any 5 minute period is higher than the STEL of 10 ppm (38 mg/m³).

Except for the USSR, which has set an MAC of 1.3 ppm, most of the published hygienic standards (East and West Germany, Sweden, Czechoslovakia) are either 19 or 20 mg/m³ or, for practical purposes, 5 ppm.

References:

1. Deichmann, W.B., Kitzmiller, K.V., Witherup, S.: *Am J Clin Path*, 14:273 (1944).
2. Connecticut Bur. of Ind. Hygiene: Unpublished data.
3. Elkins, H.B.: *The Chemistry of Industrial Toxicology*, 2nd ed., p. 116. Wiley & Sons, NY (1959).
4. Patty, F.A.: *Industrial Hygiene & Toxicology*, 2nd ed., Vol. II, p. 1170. Interscience, NY (1963).
5. Thomas, A.A., Back, K.C.: *A Symposium on Toxicity in the Closed Ecosystem*, p. 135. Hanna & Crosby Ed., Lockheed Missiles & Space Co., Palo Alto, CA (1964).
6. NIOSH: *Criteria for a Recommended Standard-Occupational Exposure to Phenol*, HEW Publication No. (NIOSH) 76-196 (1976).
7. Petrov, V.I.: *Cases of Phenol Vapor Poisoning During Coke Slaking with Phenol Water in Levine, B.S.* (trans): *USSR Literature on Air Pollution and Related Occupational Diseases-A Survey*, U.S. Dept. of Commerce, National Technical Information Service 8-219 (1963) (NTIS 63-11370), Springfield, VA. Cited by NIOSH in ref. 6.

CCT


CREOSOTE, COAL TAR

<p>Change of State of</p> <p>Liquid</p> <p>Yellow to black</p> <p>Tarry odor</p> <p>May float on top of water.</p>	<p>From the surface if possible Lead to the bottom Remove the product and transfer to another container Wear hand gloves and protective clothing</p>
<p>Fire</p> <p>Combustible.</p> <p>Extinguish with dry chemical, foam or carbon dioxide. Water may be ineffective on fire.</p>	
<p>Exposure</p> <p>Avoid the medical end.</p> <p>LIQUID Irritates to skin and eyes. Harmful if swallowed.</p> <p>1. Avoid contact with skin and eyes. 2. Avoid contact with clothing. 3. Avoid contact with food and drink. 4. Avoid contact with water. 5. Avoid contact with water. 6. Avoid contact with water. 7. Avoid contact with water. 8. Avoid contact with water. 9. Avoid contact with water. 10. Avoid contact with water.</p>	
<p>Water Pollution</p> <p>Effect of low concentrations on aquatic life is unknown. Fouling to shoreline. May be dangerous if it enters water bodies. Do not discharge into water bodies.</p>	
<p>1. RESPONSE TO DISCHARGE (See Response Materials Handbook, CO 604-1) Issue warning—water containing Mechanical contaminants Should be removed. Chemical and physical treatment.</p>	<p>2. LABELS No label required by Code of Federal Regulations.</p>
<p>3. CHEMICAL DESIGNATIONS</p> <p>3.1 Synonyms: Lignite oil Dead oil</p> <p>3.2 Coast Guard Compatibility Classification: Crosol</p> <p>3.3 Chemical Formula: Mixture</p> <p>3.4 HMCO/United Nations Numerical Designation: 9.2022</p>	<p>4. OBSERVABLE CHARACTERISTICS</p> <p>4.1 Physical State (as shipped): Liquid</p> <p>4.2 Color: Yellow to brown to black</p> <p>4.3 Odor: Lignite or tarry aromatic</p>
<p>5. HEALTH HAZARDS</p> <p>5.1 Personal Protective Equipment: All-serve canvas mask, rubber gloves, chemical safety goggles and/or face shield, overalls or a neoprene apron, barrier cream.</p> <p>5.2 Symptoms Following Exposure: Vapor cause moderate irritation of nose and throat. Liquid causes severe burns on eyes and reddening and itching of skin. Prolonged contact with skin can cause blisters. Ingestion causes irritation, vomiting, respiratory difficulties, itchy throat, vertigo, headache, loss of pulmonary reflexes, hypothermia, cyanosis, and convulsions.</p> <p>5.3 Treatment for Exposure: INHALATION: Remove victim to fresh air. If he is not breathing, give artificial respiration; preferably mouth-to-mouth. If breathing is difficult, give oxygen. Call a physician. EYES: Flush immediately with plenty of water for at least 15 min. and call a physician. SKIN: Wipe with vegetable oil or margarine, then wash with soap and water. INGESTION: Have victim drink water or milk; do NOT induce vomiting.</p> <p>5.4 Toxicity by Inhalation (Threshold Limit Value): Data not available</p> <p>5.5 Short-Term Inhalation Limit: Data not available</p> <p>5.6 Toxicity by Ingestion: Grade 2 LD₅₀ 5 to 5 g/kg</p> <p>5.7 Late Toxicity: Repeated exposures may cause cancer of skin</p> <p>5.8 Vapor (Gas) Irritant Characteristics: Vapors cause moderate irritation such that rebound will find high concentrations unbearable. The effect is temporary.</p> <p>5.9 Liquid or Solid Irritant Characteristics: Fairly severe skin irritant. May cause pain and second-degree burns after a few minutes contact.</p> <p>5.10 Odor Threshold: Data not available</p>	

<p>6. FIRE HAZARDS</p> <p>6.1 Flash Point: $> 100^{\circ}\text{F } (38^{\circ}\text{C})$</p> <p>6.2 Flammability Limits in Air: Not pertinent</p> <p>6.3 Fire Extinguishing Agents: Dry chemical, carbon dioxide or foam</p> <p>6.4 Fire Extinguishing Agents Not to be Used: Water may be ineffective</p> <p>6.5 Special Hazards of Combustion Products: Data not available</p> <p>6.6 Behavior in Fire: Heavy irritating black smoke is formed</p> <p>6.7 Ignition Temperature: 631°F</p> <p>6.8 Electrical Hazards: Not pertinent</p> <p>6.9 Burning Rate: Data not available</p>	<p>8. WATER POLLUTION</p> <p>8.1 Akzo's Toxicity: Data not available</p> <p>8.2 Water's Toxicity: Data not available</p> <p>8.3 Biological Oxygen Demand (BOD): Data not available</p> <p>8.4 Total Organic Carbon (TOC) Parameter: None</p>																																		
<p>7. CHEMICAL REACTIVITY</p> <p>7.1 Reactivity with Water: No reaction</p> <p>7.2 Reactivity with Common Materials: No reaction</p> <p>7.3 Stability During Transport: Stable</p> <p>7.4 Neutralizing Agents for Acids and Bases: Not pertinent</p> <p>7.5 Polymerization: Not pertinent</p> <p>7.6 Inhibitor of Polymerization: Not pertinent</p>	<p>9. SELECTED MANUFACTURERS</p> <p>1. Waco Chemical Corporation Pioneer Division 277 Park Avenue New York, N.Y. 10017</p> <p>2. Koppers Company, Inc. Organic Materials Division Koppers Building Pittsburgh, Pa. 15219</p> <p>3. Allied Chemical Corporation Semi-Solvent Division Trenton Tar Plant 3330 South Third Street Trenton, Ohio 45416</p>																																		
<p>11. HAZARD ASSESSMENT CODE (See Hazard Assessment Handbook, CO 604-1) A T L X Y</p>	<p>10. SHIPPING INFORMATION</p> <p>10.1 Grades or Purity: Where exposure to various fractions depending on boiling points. All have similar properties.</p> <p>10.2 Storage Temperature: Ambient</p> <p>10.3 Inert Atmosphere: No requirement</p> <p>10.4 Venting: Use flame arresters</p>																																		
<p>12. HAZARD CLASSIFICATIONS</p> <p>12.1 Code of Federal Regulations: Combustible Liquid</p> <p>12.2 NA & Hazard Rating for Bulk Water Transportation:</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr> <td>Fire</td> <td>1</td> </tr> <tr> <td>Health</td> <td>1</td> </tr> <tr> <td>Vapor Irritant</td> <td>2</td> </tr> <tr> <td>Liquid or Solid Irritant</td> <td>3</td> </tr> <tr> <td>Poison</td> <td>2</td> </tr> <tr> <td>Water Pollution</td> <td>2</td> </tr> <tr> <td>Human Toxicity</td> <td>3</td> </tr> <tr> <td>Aquatic Toxicity</td> <td>4</td> </tr> <tr> <td>Respiratory</td> <td>1</td> </tr> <tr> <td>Other Chemicals</td> <td>0</td> </tr> <tr> <td>Water</td> <td>0</td> </tr> <tr> <td>Self Reaction</td> <td>0</td> </tr> </tbody> </table> <p>12.3 NFPA Hazard Classifications:</p> <table border="1"> <thead> <tr> <th>Category</th> <th>Classification</th> </tr> </thead> <tbody> <tr> <td>Health Hazard (H) Class</td> <td>1</td> </tr> <tr> <td>Flammability (F) Class</td> <td>2</td> </tr> <tr> <td>Reactivity (R) Class</td> <td>0</td> </tr> </tbody> </table>	Category	Rating	Fire	1	Health	1	Vapor Irritant	2	Liquid or Solid Irritant	3	Poison	2	Water Pollution	2	Human Toxicity	3	Aquatic Toxicity	4	Respiratory	1	Other Chemicals	0	Water	0	Self Reaction	0	Category	Classification	Health Hazard (H) Class	1	Flammability (F) Class	2	Reactivity (R) Class	0	<p>13. PHYSICAL AND CHEMICAL PROPERTIES</p> <p>13.1 Physical State at 68°F and 5 atm.: Liquid</p> <p>13.2 Molecular Weight: Mixture</p> <p>13.3 Boiling Point at 1 atm.: $> 356^{\circ}\text{F}$ or $> 180^{\circ}\text{C}$ or $> 355^{\circ}\text{K}$</p> <p>13.4 Freezing Point: Not pertinent</p> <p>13.5 Critical Temperature: Not pertinent</p> <p>13.6 Critical Pressure: Not pertinent</p> <p>13.7 Specific Gravity (0.9818 at 15°C): 1.05 (OR at 15°C): 1.05</p> <p>13.8 Liquid Surface Tension (mN/m): 20 dyne/cm = 0.020 N/m at 20°C</p> <p>13.9 Liquid Water Interfacial Tension (mN/m): 20 dyne/cm = 0.020 N/m at 20°C</p> <p>13.10 Vapor (Gas) Specific Gravity: Not pertinent</p> <p>13.11 Ratio of Specific Heats of Vapor (Gas): Not pertinent</p> <p>13.12 Latent Heat of Vaporization: Not pertinent</p> <p>13.13 Heat of Combustion: (eq. 1) 12,400 Btu/lb or 56,200 kJ/kg = 12.4 x 10³ kJ/kg</p> <p>13.14 Heat of Detonation: Not pertinent</p> <p>13.15 Heat of Polymerization: Not pertinent</p> <p>13.16 Heat of Polymerization: Not pertinent</p>
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CRS

CRESOLS

General Information Chemical Name: Cresols Synonyms: Cresylic acids Trade Name: Cresolene Description: Water liquid, or solid crystals depending on yield. Sweet olive odor.	
Physical State Solid, liquid, or solid crystals depending on yield. Sweet olive odor.	
Fire POISONOUS GASES MAY BE PRODUCED IN FIRE. Dry, orange and red-browned burning residues.	
Exposure IRRITANT TO SKIN AND EYES. May cause dermatitis, conjunctivitis, and other eye irritation.	
Water Pollution HARMFUL TO AQUATIC LIFE IN VERY LOW CONCENTRATIONS.	
1. RESPONSE TO DISCHARGE Do not discharge into waterways.	2. LABEL 
3. CHEMICAL DESIGNATIONS 3.1 Synonyms: Cresylic acids, Hydroxytoluenes, Methylphenols, Oxymetolene, Tar acids. 3.2 Coast Guard Compatibility Classification: Critical. 3.3 Chemical Formula: C ₇ H ₈ O 3.4 HCSO United Nations Numerical Designation: 200	4. OBSERVABLE CHARACTERISTICS 4.1 Physical State (as shipped): Liquid or solid. 4.2 Color: Lustrous to dark yellow. 4.3 Odor: Sweet, tart.
5. HEALTH HAZARDS 5.1 Personal Protective Equipment: Organic vapor respirator with U.S. BME Type B approved by U.S. Bureau of Mines; rubber gloves; chemical safety goggles; face shield; forearm and/or rubber apron; rubber shoes or boots. 5.2 Symptoms Following Exposure: VAPORS cause irritation of eyes, nose, and throat. Contact with skin or eyes causes severe burns. Chemical vapors absorbed through skin. 5.3 Treatment for Exposure: Call a physician. INHALATION: Remove to fresh air. INGESTION: Have victim drink water or milk. DO NOT induce vomiting. SKIN OR EYES: Flush with copious amounts of water for at least 15 min. Remove contaminated clothing immediately and wash before reuse. Avoid contaminated linens. 5.4 Toxicity by Inhalation (Threshold Limit Value): 3 ppm. 5.5 Short-Term Inhalation Limit: Data not available. 5.6 Toxicity by Ingestion: Grade 2, LD ₅₀ 1.145 g/kg rat, rabbit. 5.7 Lethal Toxicity: Data not available. 5.8 Vapor (Gas) Irritant Characteristics: Vapors cause moderate irritation such that personnel will find high concentrations unpleasant. The effect is temporary. 5.9 Liquid or Solid Irritant Characteristics: Fluids cause severe irritation; may cause pain and second-degree burns after a few minutes contact. 5.10 Odor Threshold: 3 ppm.	

6. FIRE HAZARDS 6.1 Flash Point: 115-118°F (40-48°C). 6.2 Flammable Limits in Air: LEL: 1.4% (Vol); UEL: 11% (Vol) or 10% (Vol). 6.3 Fire Extinguishing Agents: Water, dry chemical, carbon dioxide, and foam. 6.4 Fire Extinguishing Agents Not to be Used: Not pertinent. 6.5 Special Hazards of Combustion Products: Forms the toxic carbon monoxide. 6.6 Behavior in Fire: Heated liquid can splatter and burn on fire if exposed to air in fire. 6.7 Ignition Temperature: 1110°F (600°C). 6.8 Electrical Hazard: Data not available. 6.9 Burning Rate: Data not available.	8. WATER POLLUTION 8.1 Aquatic Toxicity: Data not available. (100 mg/l water). 8.2 Waterways Toxicity: Data not available. 8.3 Biological Oxygen Demand (BOD): 400 mg/l (1 day), 600 mg/l (5 days), 600 mg/l (5 days). 8.4 Feed Chain Concentration Factor: None.																				
7. CHEMICAL REACTIVITY 7.1 Reactivity with Water: No reaction. 7.2 Reactivity with Common Materials: No reaction. 7.3 Stability During Transport: Stable. 7.4 Neutralizing Agents for Acids and Gases: Not pertinent. 7.5 Polymerization: Not pertinent. 7.6 Inhibitor of Polymerization: Not pertinent.	9. SELECTED MANUFACTURERS 1. Allied Chemical Corp. 2. Continental Oil Co. 3. Koppers Co. Inc.																				
11. HAZARD ASSESSMENT CODE A-P-O-T-U-X-Y	10. SHIPPING INFORMATION 10.1 Grades of Purity: USP (United States Pharmacopeia) mixture. 10.2 Molecular Weight: 108.13. 10.3 Boiling Point at 5 mm Hg: 177°C (350°F). 10.4 Freezing Point: Not pertinent. 10.5 Critical Temperature: Not pertinent. 10.6 Critical Pressure: Not pertinent. 10.7 Specific Gravity: 1.03 (at 20°C liquid). 10.8 Liquid Surface Tension: 37 dyne/cm (at 20°C). 10.9 Liquid-Water Interfacial Tension: Data not available. 10.10 Vapor (Gas) Specific Gravity: Not pertinent. 10.11 Ratio of Specific Heats of Vapor (Gas): 1.03. 10.12 Latent Heat of Vaporization: 10.120 Btu/lb (11.4 cal/g) at 4.4 x 10 ³ J/kg. 10.13 Heat of Combustion: 44,100 Btu/lb (10.4 cal/g) at 4.4 x 10 ³ J/kg. 10.14 Heat of Decomposition: Not pertinent. 10.15 Heat of Solution: Not pertinent. 10.16 Heat of Polymerization: Not pertinent.																				
12. HAZARD CLASSIFICATIONS 12.1 Code of Federal Regulations: Part 1910.106 (h) (2) (ii) Class B. 12.2 HMB Hazard Rating for Bulk Water Transportation: <table border="1"> <thead> <tr> <th>Category</th> <th>Rating</th> </tr> </thead> <tbody> <tr><td>Fire</td><td>1</td></tr> <tr><td>Health</td><td>1</td></tr> <tr><td>Vapor Irritant</td><td>2</td></tr> <tr><td>Liquid or Solid Irritant</td><td>3</td></tr> <tr><td>Poisons</td><td>2</td></tr> <tr><td>Water Pollution</td><td>1</td></tr> <tr><td>Human Toxicity</td><td>1</td></tr> <tr><td>Aquatic Toxicity</td><td>3</td></tr> <tr><td>Aesthetic Effect</td><td>4</td></tr> </tbody> </table>	Category	Rating	Fire	1	Health	1	Vapor Irritant	2	Liquid or Solid Irritant	3	Poisons	2	Water Pollution	1	Human Toxicity	1	Aquatic Toxicity	3	Aesthetic Effect	4	13. PHYSICAL AND CHEMICAL PROPERTIES 13.1 Physical State at 15°C and 1 atm: Liquid. 13.2 Molecular Weight: 108.13. 13.3 Boiling Point at 5 mm Hg: 177°C (350°F). 13.4 Freezing Point: Not pertinent. 13.5 Critical Temperature: Not pertinent. 13.6 Critical Pressure: Not pertinent. 13.7 Specific Gravity: 1.03 (at 20°C liquid). 13.8 Liquid Surface Tension: 37 dyne/cm (at 20°C). 13.9 Liquid-Water Interfacial Tension: Data not available. 13.10 Vapor (Gas) Specific Gravity: Not pertinent. 13.11 Ratio of Specific Heats of Vapor (Gas): 1.03. 13.12 Latent Heat of Vaporization: 10.120 Btu/lb (11.4 cal/g) at 4.4 x 10 ³ J/kg. 13.13 Heat of Combustion: 44,100 Btu/lb (10.4 cal/g) at 4.4 x 10 ³ J/kg. 13.14 Heat of Decomposition: Not pertinent. 13.15 Heat of Solution: Not pertinent. 13.16 Heat of Polymerization: Not pertinent.
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Health Hazard (Hurt)	3	3																			
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REVISED 1978

Occupational Health Guideline for Phenol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_6H_5OH
- Synonyms: Carboic acid; monohydroxybenzene
- Appearance and odor: Colorless to pink solid or thick liquid with a characteristic, sweet, tar odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for phenol is 5 parts of phenol per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 19 milligrams of phenol per cubic meter of air (mg/m^3). NIOSH has recommended that the permissible exposure limit be changed to 20 mg/m^3 averaged over a work shift of up to 10 hours per day, 40 hours per week, with a ceiling of 60 mg/m^3 averaged over a 15-minute period. The NIOSH Criteria Document for Phenol should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- Routes of exposure
Phenol can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed. It may enter the body through the skin.
- Effects of overexposure
1. Short-term Exposure: Phenol has a marked corrosive effect on any tissue. When it comes in contact with the eyes, it may cause severe damage and blindness. On contact with the skin, it does not cause pain but causes a whitening of the exposed area. If the chemical is not removed promptly, it may cause a severe burn or

systemic poisoning. Systemic effects may occur from any route of exposure, especially after skin contact.

2. Long-term Exposure: Repeated or prolonged exposure to phenol may cause chronic phenol poisoning. The symptoms of chronic poisoning include vomiting, difficulty in swallowing, diarrhea, lack of appetite, headache, fainting, dizziness, dark urine, mental disturbances, and possibly a skin rash. Liver damage and discoloration of the skin may occur.

3. Reporting Signs and Symptoms: A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to phenol.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to phenol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Persons with a history of convulsive disorders or abnormalities of the skin, respiratory tract, liver, or kidneys would be expected to be at increased risk from exposure. Examination of the liver, kidneys, and respiratory tract should be stressed. The skin should be examined for evidence of chronic disorders.

—Urinalysis: Darkening of the urine has occurred in persons exposed to phenol after accidental ingestion or skin contact. A urinalysis should be performed, including a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment. Urinary phenol is useful if good individual background levels are available.

—Liver function tests: Since liver damage has been observed in humans exposed to phenol, a profile of liver function should be performed by using a medically acceptable array of biochemical tests.

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

September 1978

2. **Periodic Medical Examination:** The aforementioned medical examinations should be repeated on an annual basis.

• **Summary of toxicology**

Phenol in the vapor form or in solution is an irritant to the eyes, mucous membranes, and skin; systemic absorption causes central nervous system effects as well as liver and kidney damage. Sudden collapse is characteristic of gross overexposure. In animals, prolonged inhalation of the vapor at 30 to 60 ppm induced respiratory difficulty, lung damage, and paralysis. Systemic absorption by animals caused muscle twitching and severe convulsions. There are no reports of human fatalities from inhalation of the vapor, although one case of severe poisoning has been reported. Ingestion of lethal amounts (as little as 1 g) cause severe burns of the mouth and throat, marked abdominal pain, cyanosis, muscular weakness, collapse, coma, and death; tremors, convulsions, or muscle twitching were occasionally observed but were not severe. A laboratory technician repeatedly exposed to unknown vapor concentrations and liquid spilled on the skin developed anorexia, weight loss, weakness, muscle aches and pain, and dark urine; during several months of nonexposure there was gradual improvement in his condition, but after brief reexposure he suffered an immediate worsening of symptoms with prompt darkening of the urine and tender enlargement of the liver. Brief intermittent industrial exposures to vapor concentrations of 48 ppm of phenol (accompanied by 8 ppm of formaldehyde) caused marked irritation of eyes, nose, and throat. Concentrated phenol solutions are severely irritating to the human eye and cause conjunctival swelling; the cornea becomes white and hypesthetic; loss of vision has occurred in some cases. Solutions of phenol have a marked corrosive action on any tissue on contact; on skin, there is local anesthesia and a white discoloration, and the area may subsequently become gangrenous; severe dermatitis will result from contact with dilute solutions, and prolonged exposure may result in ochronosis. In workers making phenol-formaldehyde plastic, the urinary level of total phenol, free plus conjugated, was proportional to the air concentration of phenol up to 12.5 mg/m³ of workroom air. Mice were treated twice weekly for 72 weeks by application of 1 drop of a 10% solution of phenol in benzene to the shaved dorsal skin; after 52 weeks of treatment there were papillomas in 5 of 14 mice, and 1 fibrosarcoma appeared at 58 weeks.

CHEMICAL AND PHYSICAL PROPERTIES

• **Physical data**

1. Molecular weight: 94.11
2. Boiling point (760 mm Hg): 182 C (359 F)
3. Specific gravity (water = 1): 1.07 (solid); 1.05 (liquid)
4. Vapor density (air = 1 at boiling point of phenol): 3.24

2 Phenol

5. Melting point: 41 C (106 F)
6. Vapor pressure at 20 C (68 F): 0.36 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 8.4
8. Evaporation rate (butyl acetate = 1): Less than 0.01

• **Reactivity**

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizers (especially calcium hypochlorite) may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving phenol.
4. Special precautions: Liquid phenol will attack some forms of plastics, rubber, and coatings. Hot liquid phenol will attack aluminum, magnesium, lead, and zinc metals.

• **Flammability**

1. Flash point: 79 C (174 F) (closed cup)
2. Autoignition temperature: 715 C (1319 F)
3. Flammable limits in air, % by volume: Lower: 1.7; Upper: 8.6
4. Extinguishant: Alcohol foam, carbon dioxide, dry chemical

• **Warning properties**

1. Odor Threshold: Summer reports that the odor threshold of phenol is 3 ppm; the Manufacturing Chemists Association reports 0.3 ppm; Thienes and Haley report 5 ppm.
2. Irritation Levels: The *Documentation of TLVs* reports that intermittent exposures to 48 ppm phenol have been observed to produce eye, nose, and throat irritation. Formaldehyde was also present in this atmosphere at a concentration of 8 ppm. The Respirator Review Committee considers the source of the eye irritation to be the 8 ppm formaldehyde rather than the phenol.
3. Evaluation of Warning Properties: Since the odor threshold of phenol is at or below the permissible exposure limit, phenol is treated as a material with good warning properties.

MONITORING AND MEASUREMENT PROCEDURES

• **Eight-Hour Exposure Evaluation**

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• **Ceiling Evaluation**

Measurements to determine employee ceiling exposure are best taken during periods of maximum expected airborne concentrations of phenol. Each measurement

should consist of a fifteen (15) minute sample or series of consecutive samples totalling fifteen (15) minutes in the employee's breathing zone (air that would most nearly represent that inhaled by the employee). A minimum of three (3) measurements should be taken on one work shift and the highest of all measurements taken is an estimate of the employee's exposure.

• **Method**

Sampling and analyses may be performed by collection of phenol in a bubbler containing sodium hydroxide, followed by treatment with sulfuric acid, and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure phenol may be used. An analytical method for phenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 6, 1980, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00369-6).

RESPIRATORS

- Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.
- In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

- Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with solid or liquid phenol or liquids containing phenol.
- If employees' clothing has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing which has had any possibility of being contaminated with solid or liquid phenol or liquids containing phenol should be placed in closed containers for storage until it can be discarded or until provision is

made for the removal of phenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the phenol, the person performing the operation should be informed of phenol's hazardous properties.

- Where there is any possibility of exposure of an employee's body to solid or liquid phenol or liquids containing phenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.
- Non-impervious clothing which becomes contaminated with phenol should be removed immediately and not reworn until the phenol is removed from the clothing.
- Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of solid or liquid phenol or liquids containing phenol contacting the eyes.
- Where there is any possibility that employees' eyes may be exposed to solid or liquid phenol or liquids containing phenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with phenol should be immediately washed or showered with soap or mild detergent and water to remove any phenol.
- Any clothing which becomes wet with liquid phenol or liquids containing phenol should be removed immediately and not reworn until the phenol is removed from the clothing.
- Eating and smoking should not be permitted in areas where solid or liquid phenol or liquids containing phenol are handled, processed, or stored.
- Employees who handle solid or liquid phenol or liquids containing phenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to phenol may occur and control methods which may be effective in each case:

Operation	Controls
Application and curing of bonding resin in plywood manufacture; application and curing of molding resins in manufacture of molded articles, such as	Process enclosure; local exhaust ventilation; personal protective equipment

electrical appliances, automotive parts, foundry sand molds, and utensil handles; manufacture of friction materials, bonded abrasives, coated abrasives, wood particle board, and insulation materials

Use in industrial coatings in drum and can linings, milk and beer-processing equipment, water tanks and air-conditioning equipment, decorative laminates, and textile coatings

Use in synthesis of thermosetting phenolic resins, epoxy, polycarbonate, phenoxy, and polysulfone; synthesis of apolactam for use in nylon 6 fibers, plastics, and films

Use in synthesis of agricultural chemicals and intermediates; synthesis of pharmaceuticals, rubber and plastic plasticizers, antioxidants, curing agents, and intermediates

Use in synthesis of stabilizers and preservatives for dyes, perfumes, and fungicides

Use during solvent refining of lubrication oil and wax; use in synthesis of additives for gasoline and lubricating fluids and intermediates

Process enclosure; local exhaust ventilation; personal protective equipment

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Use in synthesis of intermediates in polyester production; production of corrosion-resistant polyester and polyester polyols; use in synthesis of dye intermediates

Use in synthesis of surface-active agents and detergent intermediates; in synthesis of explosives

Use in manufacture of disinfectant agents and products for industrial and household use

Use in synthesis of synthetic cresols and xylenols

Process enclosure; local exhaust ventilation; personal protective equipment

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EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If solid or liquid phenol or liquids containing phenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If solid or liquid phenol or liquids containing phenol get on the skin, promptly wash the contaminated skin using soap or mild detergent and water. If solid or liquid phenol or liquids containing phenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. Get medical attention immediately.

• Breathing

If a person breathes in large amounts of phenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When solid or liquid phenol or liquids containing phenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

- **Rescue**

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL, LEAK, AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills or leaks until cleanup has been completed.

- If phenol is spilled or leaked, the following steps should be taken:

1. Ventilate area of spill.
2. If in the solid form, for small quantities, sweep onto paper or other suitable material, place in an appropriate container and burn in a safe place (such as a fume hood). Large quantities may be reclaimed; however, if this is not practical, dissolve in a flammable solvent (such as alcohol) and atomize in a suitable combustion chamber.
3. If in the liquid form, for small quantities, absorb on paper towels. Evaporate in a safe place (such as a fume hood). Allow sufficient time for evaporating vapors to completely clear the hood ductwork. Burn the paper in a suitable location away from combustible materials. Large quantities can be collected and atomized in a suitable combustion chamber.

- Waste disposal methods:

Phenol may be disposed of:

1. If in the solid form, by making packages of phenol in paper or other flammable material and burning in a suitable combustion chamber, or by dissolving phenol in a flammable solvent (such as alcohol) and atomizing in a suitable combustion chamber.
2. If in the liquid form, by absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill, or by atomizing the liquid in a suitable combustion chamber.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Phenol," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
- American Industrial Hygiene Association: "Phenol," *Hygienic Guide Series*, Detroit, Michigan, 1957.
- Baskin, A. D. (ed.): *Handling Guide for Potentially Hazardous Commodities*, Railway Systems and Management Association, Chicago, 1972.
- Boutwell, R. K., and Bosch, D. K.: "The Tumor-promoting Action of Phenol and Related Compounds for Mouse Skin," *Cancer Research*, 19:413-424, 1959.
- Christensen, H. E., and Luginbyhl, T. L. (eds.):

NIOSH Toxic Substances List, 1974 Edition, HEW Publication No. 74-134, 1974.

- Community Air Quality Guides: "Phenol and Cresol," *American Industrial Hygiene Association Journal*, 30:425-428, 1969.

- Deichmann, W. B., and Witherup, S.: "Phenol Studies VI: The Acute and Comparative Toxicity of Phenol and o-, m-, and p-Cresols for Experimental Animals," *Journal of Pharmacology and Experimental Therapy*, 80, 233, 1944.

- Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.

- Gleason, M. N., Gostelin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.

- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

- *Hygienic Information Guide No. 40 - Phenol*, Commonwealth of Pennsylvania, Department of Environmental Resources, Bureau of Occupational Health, 1958.

- Jacobs, M.: *The Analytical Chemistry of Industrial Poisons, Hazards, and Solvents*, Interscience, New York, 1956.

- Manufacturing Chemists Association, Inc.: *Chemical Safety Data Sheet SD-4, Phenol*, Washington, D.C., 1964.

- Merliss, R. R.: "Phenol Marasmus," *Journal of Occupational Medicine*, 14:55-56, 1972.

- National Institute for Occupational Safety and Health, U.S. Department of Health, Education, and Welfare: *Criteria for a Recommended Standard . . . Occupational Exposure to Phenol*, HEW Publication No. (NIOSH) 76-196, GPO No. 017-033-00184-7, U.S. Government Printing Office, Washington, D.C., 1976.

- Ohtsuji, H., and Ikeda, M.: "Quantitative Relationship between Atmospheric Phenol Vapour and Phenol in the Urine of Workers in Bakelite Factories," *British Journal of Industrial Medicine*, 29:70-73, 1972.

- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.

- Summer, W.: *Odor Pollution of Air: Causes and Control*, I. Hill, London, 1975.

- Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

- Union Carbide Corporation, Industrial Medicine and Toxicology Department: *Toxicology Studies - Phenol*, New York, 1966.

RESPIRATORY PROTECTION FOR PHENOL

Condition	Minimum Respiratory Protection* Required Above 5 ppm
Vapor or Particulate Concentration 50 ppm or less	Any chemical cartridge respirator with an organic vapor cartridge(s) and dust and mist filter(s). Any supplied-air respirator. Any self-contained breathing apparatus.
100 ppm or less	A chemical cartridge respirator with a full facepiece, organic vapor cartridge(s), and dust and mist filter(s). A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust and mist filter. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
Greater than 100 ppm** or entry and escape from unknown concentrations	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode. A combination respirator which includes a Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure or continuous-flow mode and an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.
Fire Fighting	Self-contained breathing apparatus with a full facepiece operated in pressure-demand or other positive pressure mode.
Escape	Any gas mask providing protection against organic vapors and particulates. Any escape self-contained breathing apparatus.

*Only NIOSH-approved or MSHA-approved equipment should be used.

**Use of supplied-air suits may be necessary to prevent skin contact while providing respiratory protection from airborne concentrations of phenol; however, this equipment should be selected, used, and maintained under the immediate supervision of trained personnel. Where supplied-air suits are used above a concentration of 100 ppm, an auxiliary self-contained breathing apparatus operated in positive pressure mode should also be worn.

Occupational Health Guideline for Pentachlorophenol

INTRODUCTION

This guideline is intended as a source of information for employees, employers, physicians, industrial hygienists, and other occupational health professionals who may have a need for such information. It does not attempt to present all data; rather, it presents pertinent information and data in summary form.

SUBSTANCE IDENTIFICATION

- Formula: C_5Cl_5OH
- Synonyms: PCP; penta
- Appearance and odor: Light brown solid with a pungent odor when hot.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for pentachlorophenol is 0.5 milligram of pentachlorophenol per cubic meter of air (mg/m^3) averaged over an eight-hour work shift.

HEALTH HAZARD INFORMATION

- Routes of exposure
Pentachlorophenol can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. It may enter the body through the skin.
- Effects of overexposure
Exposure to pentachlorophenol may cause irritation of the eyes and respiratory tract. Bronchitis has been reported to occur. Systemic effects from either a large exposure or repeated smaller exposures include weakness, loss of appetite, nausea, vomiting, shortness of breath, chest pain, excessive sweating, headache, and dizziness. In fatal cases the temperature is often very high and death may occur as early as three hours after the onset of symptoms. The risk of serious intoxication is greater in hot weather. Persons with decreased liver or kidney functions are more susceptible to poisoning from this chemical. Repeated exposure to pentachlorophenol may cause an acne-like skin rash and liver

damage. Commercial pentachlorophenol may be contaminated with dioxin compounds which are much more toxic than pentachlorophenol.

• Reporting signs and symptoms:

A physician should be contacted if anyone develops any signs or symptoms and suspects that they are caused by exposure to pentachlorophenol.

• Recommended medical surveillance

The following medical procedures should be made available to each employee who is exposed to pentachlorophenol at potentially hazardous levels:

1. Initial Medical Examination:

—A complete history and physical examination: The purpose is to detect pre-existing conditions that might place the exposed employee at increased risk, and to establish a baseline for future health monitoring. Examination of the cardiovascular system, eyes, upper respiratory tract, liver, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders. Analysis of the urine for pentachlorophenol may be helpful in estimating the extent of absorption.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis.

• Summary of toxicology

Pentachlorophenol dust and mist cause irritation of the eyes and upper respiratory tract; absorption results in an increase in metabolic rate and hyperpyrexia; prolonged skin exposure causes an acneform dermatitis. Human exposure to dust or mist concentrations greater than $1 mg/m^3$ causes pain in the nose and throat, violent sneezing, and cough; $0.3 mg/m^3$ may cause some nose irritation; persons acclimated to pentachlorophenol can tolerate concentrations up to $2.4 mg/m^3$. Pentachlorophenol readily penetrates the skin; systemic intoxication is cumulative and has been fatal. Intoxication is characterized by weakness, anorexia, weight loss, and profuse sweating; there also may be headache, dizziness, nausea, vomiting, dyspnea, and chest pain. In fatal cases, the body temperature is frequently extremely high and

These recommendations reflect good industrial hygiene and medical surveillance practices and their implementation will assist in achieving an effective occupational health program. However, they may not be sufficient to achieve compliance with all requirements of OSHA regulations.

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

U.S. DEPARTMENT OF LABOR
Occupational Safety and Health Administration

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death has occurred as early as 3 hours after the onset of symptoms. The risk of serious intoxication is increased during hot weather; persons with impaired liver or kidney function are more susceptible to the effects of pentachlorophenol. The dust, mist, and vapor cause eye irritation. Prolonged exposure of workers has caused an acneform dermatitis; 10 workers engaged in production of pentachlorophenol for 5 to 10 months developed a widely disseminated skin eruption characterized by small and large furuncles, brown pigmentation, and some cicatrization; 7 workers also developed severe bronchitis; all but 1 worker still showed signs of extensive acne more than a year after cessation of exposure, and 4 still complained of bronchitis. On the skin, solutions of pentachlorophenol as dilute as 1% may cause irritation if contact is repeated or prolonged.

CHEMICAL AND PHYSICAL PROPERTIES

• Physical data

1. Molecular weight: 266.3
2. Boiling point (760 mm Hg): 311 C (592 F) (decomposes)
3. Specific gravity (water = 1): 2.0
4. Vapor density (air = 1 at boiling point of pentachlorophenol): Not applicable
5. Melting point: 182 - 190 C (360 - 374 F)
6. Vapor pressure at 20 C (68 F): 0.00017 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): 0.002
8. Evaporation rate (butyl acetate = 1): Not applicable

• Reactivity

1. Conditions contributing to instability: None.
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen chloride, chlorinated phenols, and carbon monoxide) may be released when pentachlorophenol decomposes.
4. Special precautions: None.

• Flammability

1. Not combustible

• Warning properties

1. Odor Threshold: The AIHA *Hygienic Guide* states that pentachlorophenol has a characteristic odor. No quantitative information is available, however, concerning the odor threshold of this substance.
2. Irritation Levels: The *Documentation of TLV's* states that "dusts are particularly irritating to the eyes and nose, in concentrations appreciably greater than 1 mg/m³, but some irritation of the nose may occur at 0.3 mg/m³. Hardened workers can tolerate up to 2.4 mg/m³."
3. Evaluation of Warning Properties: Through its irritant effects, pentachlorophenol can be detected within three times of the permissible exposure limit. For the purposes of this guideline, therefore, pentachlorophenol is treated as a material with good warning

properties.

MONITORING AND MEASUREMENT PROCEDURES

• General

Measurements to determine employee exposure are best taken so that the average eight-hour exposure is based on a single eight-hour sample or on two four-hour samples. Several short-time interval samples (up to 30 minutes) may also be used to determine the average exposure level. Air samples should be taken in the employee's breathing zone (air that would most nearly represent that inhaled by the employee).

• Method

An analytical method for pentachlorophenol is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 4, 1978, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00317-3).

• Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969.

RESPIRATORS

• Good industrial hygiene practices recommend that engineering controls be used to reduce environmental concentrations to the permissible exposure level. However, there are some exceptions where respirators may be used to control exposure. Respirators may be used when engineering and work practice controls are not technically feasible, when such controls are in the process of being installed, or when they fail and need to be supplemented. Respirators may also be used for operations which require entry into tanks or closed vessels, and in emergency situations. If the use of respirators is necessary, the only respirators permitted are those that have been approved by the Mine Safety and Health Administration (formerly Mining Enforcement and Safety Administration) or by the National Institute for Occupational Safety and Health.

• In addition to respirator selection, a complete respiratory protection program should be instituted which includes regular training, maintenance, inspection, cleaning, and evaluation.

PERSONAL PROTECTIVE EQUIPMENT

• Employees should be provided with and required to use impervious clothing, gloves, face shields (eight-inch minimum), and other appropriate protective clothing necessary to prevent any possibility of skin contact with pentachlorophenol or liquids containing pentachlorophenol.

• If employees' clothing has had any possibility of being contaminated with pentachlorophenol or liquids containing pentachlorophenol, employees should change into uncontaminated clothing before leaving the work premises.

- Clothing which has had any possibility of being contaminated with pentachlorophenol should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of pentachlorophenol from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the pentachlorophenol, the person performing the operation should be informed of pentachlorophenol's hazardous properties.

- Where there is any possibility of exposure of an employee's body to pentachlorophenol or liquids containing pentachlorophenol, facilities for quick drenching of the body should be provided within the immediate work area for emergency use.

- Non-impervious clothing which becomes contaminated with pentachlorophenol should be removed immediately and not reworn until the pentachlorophenol is removed from the clothing.

- Employees should be provided with and required to use dust- and splash-proof safety goggles where there is any possibility of pentachlorophenol or liquids containing pentachlorophenol contacting the eyes.

- Where there is any possibility that employees' eyes may be exposed to pentachlorophenol or liquids containing pentachlorophenol, an eye-wash fountain should be provided within the immediate work area for emergency use.

SANITATION

- Skin that becomes contaminated with pentachlorophenol should be immediately washed or showered with soap or mild detergent and water to remove any pentachlorophenol.

- Workers subject to skin contact with pentachlorophenol or liquids containing pentachlorophenol should wash with soap or mild detergent and water any areas of the body which may have contacted pentachlorophenol at the end of each work day.

- Eating and smoking should not be permitted in areas where pentachlorophenol or liquids containing pentachlorophenol are handled, processed, or stored.

- Employees who handle pentachlorophenol or liquids containing pentachlorophenol should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.

COMMON OPERATIONS AND CONTROLS

The following list includes some common operations in which exposure to pentachlorophenol may occur and control methods which may be effective in each case:

Operation

Formulation of preservatives, pesticides, and fungicides

Application as a preservative for wood, starch, paint, adhesives, leather, latex, and oils; use in slime-algae control; use as a pesticide, herbicide, and soil control agent

Manufacture of pentachlorophenol

Controls

Process enclosure; local exhaust ventilation; personal protective equipment

Personal protective equipment

Process enclosure; local exhaust ventilation; personal protective equipment

EMERGENCY FIRST AID PROCEDURES

In the event of an emergency, institute first aid procedures and send for first aid or medical assistance.

• Eye Exposure

If pentachlorophenol or liquids containing pentachlorophenol get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. Get medical attention immediately. Contact lenses should not be worn when working with this chemical.

• Skin Exposure

If pentachlorophenol or liquids containing pentachlorophenol get on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If pentachlorophenol or liquids containing pentachlorophenol penetrate through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent and water. If irritation is present after washing, get medical attention.

• Breathing

If a person breathes in large amounts of pentachlorophenol, move the exposed person to fresh air at once. If breathing has stopped, perform artificial respiration. Keep the affected person warm and at rest. Get medical attention as soon as possible.

• Swallowing

When pentachlorophenol or liquids containing pentachlorophenol have been swallowed and the person is conscious, give the person large quantities of water immediately. After the water has been swallowed, try to get the person to vomit by having him touch the back of his throat with his finger. Do not make an unconscious person vomit. Get medical attention immediately.

• Rescue

Move the affected person from the hazardous exposure. If the exposed person has been overcome, notify someone else and put into effect the established emergency

rescue procedures. Do not become a casualty. Understand the facility's emergency rescue procedures and know the locations of rescue equipment before the need arises.

SPILL AND DISPOSAL PROCEDURES

- Persons not wearing protective equipment and clothing should be restricted from areas of spills until cleanup has been completed.

- If pentachlorophenol is spilled, the following steps should be taken:

1. Ventilate area of spill.

2. Collect spilled material in the most convenient and safe manner and deposit in sealed containers for reclamation or for disposal in a secured sanitary landfill. Liquid containing pentachlorophenol should be absorbed in vermiculite, dry sand, earth, or a similar material.

- Waste disposal method:

Pentachlorophenol may be disposed of in sealed containers in a secured sanitary landfill.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Pentachlorophenol," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1971.

- American Industrial Hygiene Association: "Pentachlorophenol and Sodium Pentachlorophenate," *Hygienic Guide Series*, Detroit, Michigan, 1970.

- Baader, E. W., and Bauer, H. J.: "Industrial Intoxication Due to Pentachlorophenol," *Industrial Medicine and Surgery*, 20:286-290, 1951.

- Bergner, H., et al.: "Industrial Pentachlorophenol Poisoning in Winnipeg," *Canadian Medical Association Journal*, 92:443-451, 1965.

- Christensen, H. E., and Luginbyhl, T. L. (eds.): *NIOSH Toxic Substances List*, 1974 Edition, HEW Publication No. 74-134, 1974.

- Fairhall, L. T.: *Industrial Toxicology* (2nd ed.), Williams and Wilkins, Baltimore, 1957.

- Gleason, M. N., Gosselin, R. E., Hodge, H. C., and Smith, R. P.: *Clinical Toxicology of Commercial Products* (3rd ed.), Williams and Wilkins, Baltimore, 1969, 1969.

- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.

- Hayes, W. J., Jr.: *Clinical Handbook on Economic Poisons, Emergency Information for Treating Poisoning*, U.S. Public Health Service Publication No. 476, U.S. Government Printing Office, Washington, D.C., 1963.

- Hunter, D.: *Diseases of Occupations* (4th ed.), Little, Brown, Boston, 1969.

- International Labour Office: *Encyclopedia of Occupational Health and Safety*, McGraw-Hill, New York, 1971.

- Johnstone, R. T., and Miller, S. E.: *Occupational Disease and Industrial Medicine*, Saunders, Philadelphia, 1960.

- Patty, F. A. (ed.): *Toxicology*, Vol. II of *Industrial Hygiene and Toxicology* (2nd ed. rev.), Interscience, New York, 1963.

- Spector, W. S. (Vols. I, II), Negherbon, W. O. (Vol. III), Grebe, R. M. (Vol. IV), and Dittmer, D. S. (Vol. V) (eds.): *Handbook of Toxicology*, Saunders, Philadelphia, 1956-1959.

- Thienes, C. H., and Haley, T. J.: *Clinical Toxicology* (5th ed.), Lea and Febiger, Philadelphia, 1972.

RESPIRATORY PROTECTION FOR PENTACHLOROPHENOL

Condition	Minimum Respiratory Protection* Required Above 0.5 mg/m ³
Particulate or Vapor Concentration	
2.5 mg/m ³ or less	Any chemical cartridge respirator with an organic vapor cartridge(s) and dust, fume, and mist filter(s), including pesticide respirators which meet the requirements of this class.** Any supplied-air respirator.** Any self-contained breathing apparatus.**
25 mg/m ³ or less	Any chemical cartridge respirator with a full facepiece, an organic vapor cartridge(s), and dust, fume, and mist filter(s), including pesticide respirators which meet the requirements of this class. A gas mask with a chin-style or a front- or back-mounted organic vapor canister and dust, fume, and mist filter, including pesticide respirators which meet the requirements of this class. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
150 mg/m ³ or less	**If eye irritation occurs, full-facepiece respiratory protective equipment should be used.