Geotechnical
Environmental and
Water Resources
Engineering

Alternatives Analysis/Remedial Action Work Plan

Troy (Liberty Street) Non-Owned Former MGP Site

City of Troy
Rensselaer County
New York
AOC Index No. A2-0552-0606
Site No. V00482

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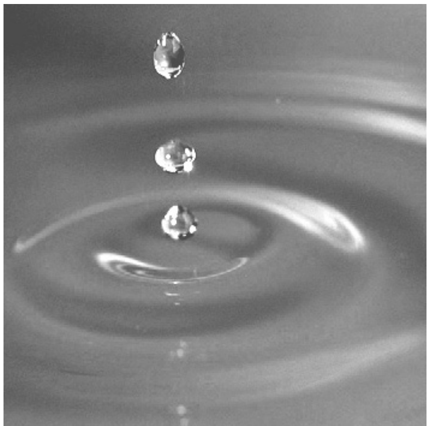

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Abbreviations and Acronyms

AA	Alternatives Analysis
ASTM	American Society for Testing and Materials
AWQS	Ambient Groundwater Quality Standards
bgs	Below ground surface
CAMP	Community Air Monitoring Plan
CFR	Code of Federal Regulations
DER	Department of Environmental Remediation
EA	EA Engineering
EPA	United States Environmental Protection Agency
FER	Final Engineering Report
Frac	Fractionation
GEI	GEI Consultants, Inc.
HASP	Health and Safety Plan
mg/kg	milligrams per kilograms
mg/L	milligrams per liter
MGP	Manufactured Gas Plant
NAPL	Non-Aqueous Phase Liquid
NAVD88	North American Vertical Datum of 1988
NYCRR	New York Codes, Rules, and Regulations
NYS	New York State
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PAH	Polycyclic Aromatic Hydrocarbon
PCBs	Polychlorinated biphenyls
PDI	Pre-Design Investigation
PPE	Personal Protective Equipment
QAPP	Quality Assurance
RA	Remedial Action
RAO	Remedial Action Objective
RAWP	Remedial Action Work Plan
RI	Remedial Investigation
RIR	Remedial Investigation Report
ROW	Right of way
SC	Site Characterization
SCGs	Standards, Criteria, and Guidance
SCOs	Soil Cleanup Objective
SMP	Site Management Plan

Abbreviations and Acronyms (continued)

SVOCs	Semivolatile Organic Compounds
SWPP	Storm Water Pollution Prevention
TCLP	Toxicity Characteristic Leaching Procedure
VOCs	Volatile Organic Compounds
VCA	Voluntary Cleanup Agreement
VCO	Voluntary Cleanup Order

1. Introduction

National Grid has entered into a Voluntary Cleanup Agreement (VCA) with the New York State Department of Environmental Conservation (NYSDEC) to investigate and remediate contamination at the Troy(Liberty Street) Non-Owned former Manufactured Gas Plant (MGP) site (Site). Specifically, the Site is under a NYSDEC voluntary cleanup order (VCO) Index Number D0-0001-0011, dated July 3, 2001. The NYSDEC Site number is V000482. Per the VCO and subsequent to the NYSDEC-approved Remedial Investigation Report, National Grid agreed to:

- Evaluate likely remedial approaches (an Alternatives Analysis, or AA) and recommend the most appropriate one for the site conditions and environment.
- Develop a Remedial Action Work Plan (RAWP) to implement the recommended action.
- Follow the action with a Remedial Action (RA) Engineering Report.

This AA/RAWP combines the first two steps.

The Site is located on Liberty Street in the City of Troy, Rennselaer County, New York (Figure 1). It is currently owned by the City of Troy (herein referred to as the “owner”) and has been used in non-winter months as a farmer’s market and community gathering place. The Little Italy Association continues to use the bocce courts at the southern end of the Site.

Gas was manufactured at the Site for approximately 41 years between 1848 and 1889. During its time of operation, two gas holders and two tar wells were constructed and used. It is believed to have been shut down in 1889.

A Remedial Investigation Report (RIR) that summarized site characterization and remedial investigations activities at the Site was submitted in July 2012 and approved by the NYSDEC on August 31, 2012. This report concluded that little migration of tar and impacted groundwater has occurred. Commercial soil standards are generally met at the Site boundaries or just downgradient of them. There is little current risk to humans because access to impacted subsurface soil and groundwater requires deliberate and aggressive action to break through the pavement that covers the Site. There are no on-site buildings where potential soil vapor intrusion could occur and soil and groundwater sampling results indicate that potential off-site vapor intrusion is not a concern. Fish and wildlife impacts are absent because the Site does not provide habitat and the surrounding area is heavily developed.

This Alternatives Analysis/Remedial Action Work Plan (AA/RAWP) presents an analysis of three remedial alternatives to address the MGP-related impacts at the Site. Based on the analysis, National Grid has selected one remedial alternative. The selected remedial action (RA) consists of the excavation and off-site disposal of MGP-related source material within and surrounding the two former tar wells. The Site will be repaved and the bocce courts will be replaced in kind.

This report has been developed in accordance with the VCA, Title 6 of the New York Code of Rules and Regulations Part 375 (6 New York Codes, Rules, and Regulations [NYCRR] Part 375), and NYSDEC [Department of Environmental Remediation] *DER-10 Technical Guidance for Site Investigation and Remediation*. This AA/RAWP describes the remedial action goals and objectives, evaluates potential remedial alternatives, and recommends an appropriate remedy. It also describes the implementation of the selected remedy.

1.1 Work Plan Organization

This AA/RAWP is organized as follows.

- Section 1 - Introduction
- Section 2 - Remedial Action Goals and Objectives
- Section 3 - Remedial Alternatives
- Section 4 - Recommended Remedy
- Section 5 - Scope of Work
- Section 6 - Vapor/Odor Management
- Section 7 - Erosion and Sediment Control Plan
- Section 8 - Site Security Plan
- Section 9 - Decontamination Plan
- Section 10 - Waste Management Plan
- Section 11 - Sample Collection and Analysis Plan
- Section 12 - Groundwater Management Plan
- Section 13 - Traffic Control Plan
- Section 14 - Schedule of Remedial Activities
- Section 15 - Final Engineering Report
- Section 16 - References

1.2 Site Description and History

The Site is located in Troy, New York (Figure 1). It consists of paved and unoccupied land in an urban residential/light commercial setting in Troy's "Little Italy" neighborhood (Figure 2). The Site is bordered on all sides by city streets and a former railroad right of way (ROW): Liberty Street to the north, Fifth Avenue to the east, the former railroad to the southeast, Washington Street to the south, and Hill Street to the west (Figure 2). The Site lies, roughly, at the western base of Mount Ida (Prospect Park). The highest point at Prospect Park is more than 300 feet above the North American Vertical Datum of 1988 (NAVD88). The Site is at approximately 35 feet NAVD88.

The Site is approximately 1.02 acres and is generally flat, with a slight dip in elevation from southeast to northwest. It is bordered by a metal fence with brick pillars on the western side and a chain link fence on the northern side. It can be accessed through gated entrances from either Hill Street (west) or Liberty Street (north). At the eastern boundary is a concrete retaining wall that increases in height from approximately 6 to 20-feet (north to south). At the top of the wall, maintained grass and a sidewalk is located along Fifth Avenue. Near the southern end of the Site a concrete and chain link fence separates the paved area from a recreation area with elevated bocce courts. Immediately south of the bocce courts is a brick wall at the Site boundary.

The Site is zoned for commercial use by the City of Troy Zoning and Planning Department. There are no private wells at the Site and no potable water is supplied to the Site. The residential and commercial properties in the vicinity of the Site are supplied with potable water from the Tomhannock Reservoir, a man-made reservoir 6½ miles northeast of the city.

The closest known well is on Campbell Avenue over 6,000 feet southeast of the Site, according to the NYSDEC Water Well Information Search Wizard. The well is 382 feet deep; depth to bedrock was reported as 45 feet. No information regarding well ownership or purpose was available.

The gas works on Liberty Street in Troy were constructed in 1848 by the Troy Gas Light Company. Soon after the plant was built, a railroad was constructed across the southeastern corner of the Site. The tracks were eventually removed. The bocce courts are parallel to the former railroad.

The gas plant consisted of coal storage sheds, a retort house, a purification house, a condenser room, and offices. The plant had two subsurface gas holders approximately 55-feet in diameter, with aboveground iron guide frames. In 1874, a gas holder was built by the Troy Gas Light Company three blocks south, on Jefferson Street. Gas from Liberty Street was likely sent to that holder for storage. The boiler room with attendant exhauster at Liberty Street was likely used to push the gas to Jefferson Street.

The configuration of the Liberty Street plant apparently did not change between 1848 and 1889, when it was shut down. The Liberty Street plant was replaced by a newer gas works on Smith Avenue in Troy in the late 1880s, concurrent with the merger of Troy Gas Light Company with two other gas companies (Troy Citizen’s Gas Co. and Troy Fuel Gas Co.) to form the Troy Gas Company.

By 1899, the Liberty Street gas plant buildings had been demolished and the City of Troy took possession in July 1899, using the property as an open-air market. In November 1975, the Troy News Company purchased the property. In 2003, the city foreclosed and regained ownership. The Site continues to be used as an open-air farmer's market and for community activities organized by the Little Italy Association.

1.3 Summary of Site Characterization

EA Engineering (EA), on behalf of National Grid, conducted Site Characterization (SC) activities at the Site in 2005 and 2006. EA drilled ten soil borings, installed seven monitoring wells, and excavated six test pits.

Eleven subsurface samples were collected from eight borings and two test pits. Black "oily liquid" and "odors" were documented in subsurface soil at a boring near the tar well in the bocce court area. Oily liquid was also described in a boring located inside the northeast gas holder.

Analytical soil samples contained polycyclic aromatic hydrocarbon (PAH) concentrations above the 6 NYCRR Part 375 Restricted Use Commercial Soil Cleanup Objectives (Commercial SCOs). PAH concentrations were also above the Commercial SCOs in a composite sample collected from a test pit within the southern tar well footprint; though no physical impacts were apparent. Off-site, a petroleum sheen was noted in the subsurface between 15 and 18 feet below ground surface (bgs) downgradient on Hill Street. EA did not collect an analytical sample from this interval.

EA collected groundwater samples from wells in December 2005 and December 2006. Samples collected from on-site wells and one off-site well on Hill Street contained concentrations of organic compounds in excess of the NYSDEC Groundwater Standards and Guidance Values.

Soil and groundwater analytical results generated during 2005 and 2006 SC demonstrated a general lack of metals, total cyanide, pesticides, and polychlorinated biphenyls (PCBs).

1.4 Summary of Remedial Investigation

In 2010 and 2011, GEI Consultants, Inc. (GEI) conducted a remedial investigation (RI) at the Site on behalf of National Grid, in accordance with NYSDEC-approved work plans for remedial and supplemental remedial investigation (GEI, 2008, 2010, 2011), to determine the nature, extent, and migration potential for contaminants present on the Site. The goal of the investigation was to provide the necessary data to assess the potential risk posed by contaminants to human health and the environment, and to determine appropriate risk management actions. The results of the investigations are summarized below.

1.4.1 Utilities

A private utility survey was conducted to determine the presence and location of any subsurface utilities located at the Site. There are no known active subsurface utilities at the Site; however, one subsurface feature was detected roughly half-way between the two tar wells that may be an abandoned water line. It enters the site between the former southern gas holder and the 16 HP engine room (Figure 2), but is not in an area that requires excavation.

There are overhead electric lines supported by a wood pole at the northeast corner of the on-site parking lot. Electric lines span from this pole across the parking lot to a steel pole at the lot entrance and then across to another steel pole beyond a retaining wall at the southeast corner of the lot (Figure 2). These lines appear to feed overhead spot lights only.

A municipal water main runs underground through the center of Hill Street, though City Water Department representatives explained that the exact location is unknown. A fire hydrant on the northwest corner of Hill and Washington Street is connected to the water main.

Other utilities were recently identified in Hill Street during a Pre-Design Investigation, including a low pressure gas main. The locations were surveyed and the utilities are depicted in Figure 2.

1.4.2 Site Geology

Site geology was investigated by excavating test pits and installing soil borings. The data from these explorations can be found in Appendix A.

Five primary soil units were identified, as follows:

- Fill – Fill was observed in all borings; ranging in thickness from 5 to 20 feet. The fill consisted of sand, silt, clay, gravel, brick, concrete rubble, and other debris.
- Alluvial Deposits – An alluvial unit comprised of various amounts of sand, gravel, silt and clay is present at some locations on the Site. The materials were not deposited in an organized manner and consist of one or all of these soil types.
- Alluvial Sand and Gravel – An alluvial unit comprised of sand and gravel was observed in all borings drilled deeper than 15 feet bgs (outside of the holders and tar wells). It is the predominant native soil type and the top of the unit was encountered at depths between 11.4 and 20.5 feet bgs. The thickness of this unit ranged from 6 to 25 feet.
- Sand – A sand unit was observed in sixteen borings, the top of which was observed at

depths that ranged from 25.5 to 42.0 feet bgs. The thickness of this unit ranged from 3.75 to 7.50 feet.

- Silt – A dense silt unit was observed in six borings in the bocce court area. The top of the silt unit was encountered at approximately 44 feet bgs and borings were terminated at 45 feet bgs. Accordingly, the total maximum thickness of this unit is not known.

1.4.3 Groundwater and Hydrogeology

The depth to groundwater at the Site is approximately 15 feet bgs. The groundwater surface is uncommonly flat, an observation made by EA in their 2006 data report. The average overburden flow gradient in May 2011 was 0.002 feet per foot. Well B/MW-303(10) does not appear to be hydraulically connected to the aquifer at the Site. It seems to be within a cavity or vault and the data acquired from water in this well does not reflect site conditions.

A relatively flat water table surface is not generally expected at a site that lies at the base of a hill. Developments at the Site since 1837 may have an effect – the former railroad tunnel behind the Site and the sheer concrete wall on the eastern boundary may be influencing groundwater behavior.

1.4.4 Historic Structures

GEI excavated a number of test pits to uncover the purifier house, gas holders, and the southern tar well and survey their locations. EA had previously excavated test pits at the retorts and compressor building. Test pits at the purifier house location did not uncover any recognizable structure.

Each gas holder foundation was found and the walls were exposed at a minimum of two locations. The walls were surveyed to determine their specific locations and diameters. Some crumbling of the top edge of the foundation walls was apparent, but the overall condition of both gas holders was intact, solid, and resistant to damage from the backhoe.

A test pit was installed to examine the southern tar well near the bocce courts. It became apparent that the southern tar well was damaged, and apparently had leaked tar into the surrounding subsurface.

A previously unknown tar well was discovered between the gas holder foundations. This is shown as the northern tar well on Figure 3-1 showing Alternative 2. This northern tar well structure appears to be generally intact.

1.4.5 RI Findings

1.4.5.1 Subsurface Soil

In general, soil borings were advanced deep enough to recover soil that was apparently clean. In test pits, depth was limited by the reach of the backhoe, or by groundwater intrusion or caving of the test pit walls. If deeper observations were required at a test pit location, a soil boring was installed at or adjacent to the test pit location.

Analytical samples were biased toward the heaviest physical impacts to quantify MGP related chemical impacts, and toward soil expected to be “clean”, to demonstrate the limits of these impacts.

The subsurface soils at the Site are impacted by typical MGP constituents such as PAHs and coal tar-related odors and sheens. This is consistent with sites used as a gas manufacturing facility for so many years.

There was evidence of a small amount of coal tar DNAPL (in one boring) within the northeast gas holder foundation, but the primary impacts in the foundation are PAHs and odors. The small amount of tar is not likely to be mobile, either within the foundation, or outside of it, as the foundation is intact and holding water above the natural groundwater table, and no tar was observed in surrounding borings or test pits.

No evidence of coal tar was found inside the southwest gas holder foundation, though tar odors were noted. The foundation is intact, holding water above the natural groundwater table, and is not a potential source of impacts to surrounding soils.

Viscous coal tar was found in the northern tar well, which appears to be intact and not leaking.

The southern tar well has apparently been damaged (to a depth of approximately 4.5 feet bgs), but water did gather and stand in the test pit performed at the well. This suggests that the tar well may be at least partially intact. The soil borings installed around this tar well revealed the presence of small amounts of tar, blebs, sheens, and odors. As such, the well either leaked over time, or incident spills of tar occurred there in the past. The horizontal and vertical extents of physical and chemical impacts have, nonetheless, been defined and they are confined to the Site.

1.4.5.2 Groundwater

Twelve monitoring wells were installed at the Site since 2005. Depending on the monitoring well, between two to four rounds of groundwater samples were collected. The results were compared to the New York State Ambient Water Quality Standards (AWQS).

Groundwater impacts at the Site are well defined, and apparently confined to the Site. Wells B/MW-201(06), B/MW-302(10), B/MW-101(05), B/MW-301(10), and B/MW-102(05) provide a “clean” up-gradient/cross-gradient groundwater boundary. Wells screened across impacted subsurface soil, such as B/MW-103(05) and B/MW-324(10), generated groundwater samples with elevated levels of organic compounds. Downgradient and off-site wells such as B/MW-404(11), B/MW-202(06), and B/MW-203(06) serve as a “clean” downgradient boundary.

Several of the wells installed and sampled in 2005 and 2006 contained organic impacts at concentrations above the New York State (NYS) AWQS. However, in the last two sampling rounds (November 2010 and May 2011) the organic concentrations were less than the NYS AWQS or were not detected. These changes may reflect the combined effects of attenuation and improved sample quality (due to United States Environmental Protection Agency (EPA) low flow groundwater sampling methods).

1.5 Summary of Pre-Design Investigation

GEI, on behalf of National Grid, performed a Pre-Design Investigation (PDI) in March and April 2013. The PDI was performed to obtain necessary data for the creation of this AA/RAWP. PDI activities and conclusions are summarized in the *Pre-Design Investigation Data Report* dated May 2013.

The activities performed during PDI included the location and evaluation of utilities in Hill Street to determine their sensitivity to remedial activities; acquire geotechnical data (standard penetration tests, grain size, and Atterberg Limits); and to acquire physical and analytical data to confirm excavation limits, determine whether non-aqueous phase liquid (NAPL) may exhibit hazardous characteristics, and pre-characterize waste soil for disposal. Also, eleven piezometers/monitoring wells were decommissioned.

1.5.1 PDI Findings

1.5.1.1 Northern Tar Well Area

Outside of the northern tar well, there are limited NAPL impacts. Three borings drilled to 20 feet bgs within the northern tar well did not encounter a hard bottom. However, wood chunks and bricks were encountered at 16.9 and 18.5 feet bgs, respectively. Therefore, the depth of the northern tar well floor is unknown. Two angle borings were advanced beneath the tar well (vertical depth of 28 feet). The soil was free of tar impacts and total PAHs were less than 500 milligrams per kilograms(mg/kg).

The horizontal limit of MGP impacts at the northern tar well was defined during the PDI, based on the absence of tar and total PAHs less that 500 mg/kg. The vertical limit of the excavation will be approximately 20 feet bgs inside this area.

1.5.1.2 Southern Tar Well Area

Thin layers of NAPL-impacted soil were encountered in the southern tar well area in borings drilled a few feet south of the well. The NAPL does not appear to be mobile and is confined to an area immediately outside the well. The proposed excavation limits for the southern tar well area extend to the locations of “clean” borings and is conservative. The vertical limit of the excavation will be approximately 20 feet bgs.

An active low pressure gas main is located in Hill Street approximately 20 feet west of the southern tar well. This gas main is outside the limits of the proposed excavation. A test pit was installed in an attempt to locate a 24-by 36-inch brick sewer reported by the City of Troy. The results of the test pit indicate the brick sewer is not located within the limits of the proposed southern tar well excavation, and the brick sewer is believed to be located somewhere outside of the proposed excavation.

1.5.1.3 Waste Pre-characterization

Soil samples were collected to generate analytical data to evaluate off-site disposal of excavated soil. The samples were analyzed for a large suite of compounds (detailed in Section 10.3) typically required for acceptance by a waste disposal facility.

NAPL inside the northern tar well is characteristic of a hazardous waste due to the presence of benzene. The toxicity characteristic leaching procedure (TCLP) benzene concentration was 8.5 milligrams per liter (mg/L). The regulatory limit is 0.5 mg/L.

1.6 Project Organizational Structure and Responsibility

National Grid the NYSDEC, New York State Department of Health (NYSDOH), and City of Troy will participate jointly in the implementation of the RAWP described in this document.

National Grid will have the ultimate responsibility and authority for implementing all aspects of this RAWP including the site-specific CAMP. It is anticipated that NYSDEC and/or NYSDOH will have representatives on site periodically to observe work activities during the RA.

National Grid will be responsible for coordinating with the Contractor and Engineer (as necessary) to implement the required work activities in conformance with the RAWP. The construction activities will be observed by National Grid’s representative (the Engineer) for general compliance with this RAWP.

The Contractor, under contract to National Grid, will be responsible for all on-site construction activities including, but not limited to, compliance with all applicable Occupational Safety and Health Administration health and safety regulations, construction personnel health and safety, implementation of odor control measures (as necessary), traffic control, site security, excavation, material handling, transport and disposal activities associated with the RAWP, and any other specified tasks outlined in this Work Plan or the Contract Documents.

The Engineer (GEI), under contract to National Grid, will serve as the Engineer of Record for the RAWP and act as National Grid's representative on site. As such, the Engineer will be responsible for engineering design, oversight of contractor to ensure compliance with Contract Documents, implementation of the Community Air Monitoring Plan (CAMP), maintenance of site sampling logs, meteorological logs, and contractor invoice and change order review on behalf of National Grid.

Representatives of NYSDEC, NYSDOH, and the owner will be invited to attend all regular job progress meetings, including pre-construction meetings.

The following are the key personnel or agencies involved with RA activities at the Troy (Liberty Street) Non-Owned Former MGP Site:

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2. Remedial Action Goal and Objectives

2.1 Remedial Action Goal

Following approval of the Remedial Investigation Report, NYSDEC indicated in discussions that removal of potential tar sources at the site, to achieve a soil cleanup level of 500 mg/kg for total PAHs, is an appropriate Remedial Action Goal. This cleanup level is in lieu of achieving all of the PAH-specific SCOs in 6 NYCRR 375-6, and it is consistent with NYSDEC CP-51.

The goal for the remedial action is to remove the former tar well structures and adjacent soils that contain MGP-related source material, to the extent practicable and soils in the top 20 feet that exceed the criteria listed above. MGP-related source material is defined as materials containing or saturated with NAPL or product related to the former MGP operations.

2.2 Remedial Action Objectives

Remedial Action Objectives (RAOs) are medium-specific or operable-unit-specific objectives for the protection of human health and the environment. The RAOs that will be applied for this remedy are presented below.

Soil

- Prevent, to the extent practicable, ingestion/direct contact with MGP-related soil contamination.

Groundwater

- Restore, groundwater to pre-disposal/pre-release conditions to the extent practicable.
- Prevent, to the extent practicable, contact with, or ingestion of groundwater with MGP-related contaminant levels exceeding class GA standards.

2.3 Standards, Criteria, and Guidance

Standards Criteria, and Guidance (SCGs) are New York State regulations or statutes, which dictate the cleanup standards, standards of control and other substantive environmental protection requirements, criteria, or limitations which are generally applicable, consistently applied, officially promulgated and are directly applicable to a remedial action. Guidance are non-promulgated criteria and are not legal requirements; however, those responsible for investigation and/or remediation of the Site should consider guidance that, based on professional judgment, are determined to be applicable.

3. Remedial Alternatives

3.1 Remedial Alternatives Descriptions

3.1.1 Alternative 1: No Further Action

Alternative 1 is the “No Further Action” alternative. This alternative assumes that the site will be allowed to remain in its existing condition. The existing cover (asphalt, grass/ vegetation) and fencing on the property will be maintained. This Alternative does not include any additional activities to address MGP impacts through remedial actions. The RI has noted that off-site migration of impacted groundwater does not appear to be occurring. However, MGP-related impacts do exist below ground surface in the vicinity of each tar well. This alternative does not address the soil and groundwater related RAOs. Under the “No Further Action” alternative, neither National Grid nor NYSDEC personnel would monitor this process.

3.1.2 Alternative 2: Excavation of MGP-Source Material and Adjacent MGP-Impacted Materials

Alternative 2 consists of the excavation and off-site disposal of MGP-related source materials, MGP-impacted material adjacent to the former tar wells, and construction debris, as illustrated in Figure 3-1. Specifically, the following actions are proposed:

The excavations under this alternative will extend to approximately 20 feet bgs in the area of the former tar wells. MGP-related source material within the former tar wells and adjacent MGP-impacted soils will be excavated. Excavated materials will be properly disposed of off-site at a properly permitted, National Grid-approved facility.

This alternative will remove approximately 1,393 cubic yards of impacted soil and debris. The excavation will be backfilled to restoration grades. Backfill materials will include imported clean soil. Per the owner’s restoration requirements, the parking lot will be re-paved and the Site will be restored to existing conditions.

Removal of the impacted soil will require the installation of a temporary subsurface earth support structure (e.g. sheet pile), due to the depth and location. This will allow excavation to proceed to the planned depths without jeopardizing stability of the adjacent streets or surroundings. Upon completion of the excavation, the temporary earth support system will be removed from the ground.

In accordance with NYSDEC and NYSDOH requirements, a CAMP will be implemented as part of this alternative. The objective of the CAMP is to provide a measure of protection for the downwind community (i.e., off-site receptors, including residences and businesses and on-site workers not involved with site remedial activities) from airborne contaminants that are potentially released during intrusive remedial activities. The CAMP will include upwind and downwind air monitoring stations at the perimeter of the work area, as well as monitoring within the work zone. If, during excavations, the emission levels approach regulatory levels or a nuisance odor is detected, then appropriate additional controls will be implemented to control/manage emissions (cover excavations, odor suppressing foam, etc.).

The approximate depth to water in the excavation areas is 15 feet bgs. A temporary, localized, dewatering system(s) may be required to maintain the groundwater level to allow for excavation and backfill to be performed. Groundwater effluent from the dewatering system will be pumped to a covered fractionation (frac) tank(s). The frac tank(s) will be sufficiently sized to contain the groundwater and provide some measure of primary treatment (settling) through the use of weirs, baffles or other appropriate technology, and flow equalization, if needed. The effluent within the frac tank(s) will then be removed from the Site by a properly licensed liquid waste hauler and disposed of at a properly permitted National Grid-approved disposal facility. Following the completion of the removal, groundwater monitoring will be conducted to confirm the effectiveness of the remedy, and identify any potential residual effects.

This excavation may be conducted as a direct load operation, but there is also room for stockpiling of excavated materials on the Site.

Institutional controls will be required to control potential exposure to remaining contamination following completion of the RA. The proposed institutional controls may include the following:

- An environmental easement or deed restriction on the property dictating future use and development constraints for the Site.
- Worker notification if utility or other excavation work is planned on the Site or adjacent to the Site on Hill Street.
- Notification to the NYSDEC of a potential change in use or prior to any action that could jeopardize the integrity of the remedy.
- Development and approval of a Site Management Plan (SMP) (including a health and safety plan [HASP]) for management of any future MGP-impacted residual soil excavated or removed from the Site.
- A prohibition on the development of water supply or irrigation wells on the Site.
- Annual inspection and certification to confirm appropriate use of the Site, and to confirm that institutional controls included in this remedy are in place and remain

effective to control the identified potential exposures.

The institutional controls will be memorialized to remain in place via an agreement between the owner and National Grid, with the approval of the NYSDEC and NYSDOH. The institutional controls will only apply to the area within the Site boundary of the former MGP.

With respect to the preliminary screening guidance in DER-10, the alternative is evaluated as follows:

Size and Configuration: During excavation and remedial activities, the majority of the Site will be disturbed, and require restricted access. Excavation support will be necessary to allow for the excavation of the former tar wells and adjacent MGP-impacted soils. Dewatering is necessary to facilitate the excavation of source material below the water table.

Time for Remediation: The expected duration of the project is approximately fifty days of continuous on-site activities.

The maintenance of necessary institutional controls will continue for an indefinite period of time for material left in place below or outside of the planned redevelopment.

Spatial Requirements: The alternative will require access to a substantial portion of the property for equipment and material storage, access, logistics, and operation. If necessary, a minimal area will be required for the frac tanks for particulate settling. Access restrictions will be required on Hill Street during remedial activity. Access to residential roads and highways will be necessary to mobilize equipment and materials to the Site. MGP-impacted soil and debris will also need to be transported from the site to the disposal facility.

Options for Disposal: Options for disposal of MGP-source materials, MGP-impacted materials, and construction debris are readily available off-site at properly permitted, National Grid-approved disposal facilities.

Permit Requirements: Since this remedy will be conducted under NYSDEC oversight under the VCA, National Grid is exempt from applying for state permits. However, they are required to meet all substantive requirements of those permits. National Grid or the contractor will be required to obtain all local permits required for performing the remediation. This will include, but is not limited to, City of Troy Building Permit, Road Closing Permit, Demolition Permit, and Storm Water Pollution Prevention(SWPP) permit. As noted above, National Grid will meet NYSDEC SWPP permit requirements.

Limitations: The ability to perform the remedial activities may be limited to current construction methods, safety constraints, and Site access concerns. These concerns include, but are not limited to, Site access due to normal function of the Site and accessibility for traffic to adjacent businesses. Further geotechnical, structural, and excavation evaluation will be required in the design phase to confirm safe setbacks, excavation supports, machine limitations and construction schedules.

The brick wall located near the northern tar well and the mural located near the southern tar well will need to be protected and monitored during construction activities.

Ecological Impacts: This alternative is not anticipated to have any impacts on fish and wildlife resources.

3.1.3 Alternative 3: Unrestricted Land Use Excavation

Alternative 3 consists of the excavation and off-site disposal of MGP-related source materials and soils that exceed the Unrestricted Use criteria. The excavation area is illustrated in Figure 3-2.

This alternative would remove all historic MGP structures and soil that exceeds the Unrestricted Use SCO. The depth of excavation under this alternative will extend to approximately 30 feet bgs. Excavated soil will be disposed of off site at a properly permitted National Grid-approved facility. This alternative will remove approximately 17,990 cubic yards of soil and debris. The excavation will be backfilled to restoration grades. Backfill materials will include imported clean soil. Per the owner’s restoration requirements, the parking lot will be re-paved and the Site will be restored to existing conditions.

Excavation activities will require the installation of a temporary subsurface earth support structure (e.g. sheet pile). This will allow excavation to proceed to the planned depths without jeopardizing stability of the adjacent streets or structures. Upon completion of the excavation, the temporary earth support system will be removed from the ground.

In accordance with NYSDEC and NYSDOH requirements, a CAMP will be implemented as part of this alternative. The objective of the CAMP will be to provide a measure of protection for the downwind community (i.e., off-site receptors, including residences and businesses and on-site workers not involved with Site remedial activities) from potential airborne contaminant releases as a direct result of intrusive remedial activities. The CAMP will include several air monitoring stations at the perimeter of the work area to monitor potential emissions from the Site. If, during excavations, the emission levels approach regulatory levels or a nuisance odor is detected, then appropriate additional controls will be implemented to control/manage emissions (cover excavations, odor suppressing foam, etc.). The approximate depth to groundwater in the excavation area is 15 feet bgs. A temporary, localized, dewatering system(s) will be required to maintain the groundwater level to allow for excavation and backfill to be performed. Groundwater effluent from the dewatering system will be pumped to a covered frac tank(s). The frac tank(s) will be sufficiently sized to contain the groundwater and provide some measure of primary treatment (settling) through the use of weirs, baffles or other appropriate technology, and flow equalization, if needed. The effluent within the frac tank(s) will then be removed from the Site by a properly licensed liquid waste hauler and disposed of at a properly-permitted, National Grid-approved disposal facility or treated and discharged at the Site depending upon which is more cost effective. Following the completion of the removal, groundwater monitoring will be conducted to confirm the effectiveness of the remedy, and identify any potential residual effects.

This excavation may be conducted as a direct load operation, but there is also room for stockpiling of excavated materials on the Site.

With respect to the preliminary screening guidance in DER-10, the alternative is described as follows:

Size and Configuration: A significant portion of the Site will be disturbed, and require restricted access during excavation.

Sheeting will be used and dewatering will be necessary to facilitate the excavation of source material below the water table. Staging and possible sequencing of excavations will also be necessary.

Time for Remediation: The expected duration of the project would be approximately 2 years and 4 months of continuous on-site activities. This accounts for the time necessary to drive and remove sheeting, as well as the sequencing of the excavations necessary due to the size constraints of the Site.

No institutional controls will be required for the Site as all impacted materials will be removed.

Spatial Requirements: The alternative will require access to the entire property for equipment and material storage, access, logistics, and operations. A minimal area will be required for the 20,000 gallon frac tanks for particulate settling. Access restrictions will be required on Hill Street during the remedial action. Access to residential roads and highways will be necessary in order to dispose of contaminated materials. MGP-impacted soil and debris will also need to be transported to the disposal facility.

Options for Disposal: Options for disposal of MGP-source materials, MGP-impacted materials, and construction debris are readily available off-site at properly permitted, National Grid-approved facilities.

Permit Requirements: Since this remedy is being conducted under NYSDEC oversight under a VCA, National Grid is exempt from applying for state permits. However, they are required to meet all substantive requirements of those permits. National Grid or the contractor will be required to obtain all local permits required for performing the remediation. This will include, but is not limited to, City of Troy Building Permit, Street Closing Permit, Demolition Permit, and SWPP permit. As noted above, National Grid will meet NYSDEC SWPP permit requirements.

Limitations: The ability to perform remedial activities may be limited to current construction methods, safety constraints, and site access and spatial concerns. These concerns include, but are not limited to, site access due to normal function of the Site and accessibility for traffic to adjacent businesses. Further geotechnical, structural, and excavation evaluation will be required in the design phase to confirm safe setbacks, excavation supports, machine limitations and construction schedules.

The brick wall located near the northern tar well and the mural located near the southern tar well will need to be protected and monitored during construction activities.

Ecological Impacts: This alternative is not anticipated to have any impacts on fish and wildlife resources.

3.2 Remedial Alternatives Analysis Evaluation Criteria

6 NYCRR Part 375 requires a detailed analysis of remedial alternatives against nine criteria and specifies particular factors to consider for each criterion. The nine criteria are:

Overall Protection of Public Health and the Environment: This criterion is an evaluation of the remedy’s ability to protect public health and the environment. It assesses how risks posed through each existing or potential pathway of exposure are eliminated, reduced or controlled through removal, treatment, engineering controls or institutional controls. The remedy’s ability to achieve each of the RAOs is evaluated.

Compliance with Standards, Criteria, and Guidance (SCGs): Compliance with SCGs addresses whether or not a remedy will meet applicable environmental laws, regulations, standards, and guidance. All SCGs for the Site are listed, along with a discussion of whether or not the remedy will achieve compliance. For those SCGs that will not be met, a discussion and evaluation of the impacts of each is provided, and whether waivers are necessary.

Short-term Effectiveness: The potential short-term adverse impacts and risks of the remedy upon the community, the workers, and the environment during the construction and/or implementation are evaluated. A discussion of how the identified adverse impacts and health risks to the community or workers at the Site will be controlled, and the effectiveness of the controls, is presented. A discussion of engineering controls that will be used to mitigate short-term impacts (i.e., dust control measures) is provided. The length of time needed to achieve the remedial objectives is also estimated.

Long-term Effectiveness and Permanence: This criterion evaluates the long-term effectiveness of the remedy after implementation. If wastes or treated residuals remain on-site after the selected remedy has been implemented, the following items are evaluated:

- The magnitude of the remaining risks (i.e., will there be any significant threats, exposure pathways, or risks to the community and environment from the remaining wastes or treated residuals?).
- The adequacy of the engineering and institutional controls intended to limit the risk.
- The reliability of these controls.
- The ability of the remedy to continue to meet RAOs in the future.

Reduction of Toxicity, Mobility or Volume with Treatment: The remedy’s ability to reduce the toxicity, mobility or volume of site contamination is evaluated. Preference should be given to remedies that permanently and significantly reduce the toxicity, mobility, or volume of the wastes at the Site.

Implementability: The technical and administrative feasibility of implementing the remedy is evaluated. Technical feasibility includes the difficulties associated with the construction and the ability to monitor the effectiveness of the remedy. For administrative feasibility, the availability of the necessary personnel and material is evaluated along with potential difficulties in obtaining specific operating approvals, access for construction, etc.

Cost: Capital, operation, maintenance, and monitoring costs are estimated for the remedy and presented on a present worth basis.

Community Acceptance: This criterion gauges the acceptance of the selected remedial alternative by the community at large. It is not provided in this document. It is evaluated and summarized by NYSDEC as part of the public participation period which precedes approval of this AA/RAWP.

Land Use: Where cleanup to pre-disposal conditions is determined infeasible, NYSDEC may consider the current, intended, and reasonably anticipated future land uses of the Site and its surroundings in the selection of the remedy.

3.3 Remedial Alternatives Analysis Evaluation of Alternatives

3.3.1 Alternative 1: No Further Action

Overall Protection of Public Health and the Environment: The alternative does not eliminate or effectively control the potential exposure to contaminants in surface pathways.

Compliance with SCGs: The remedy does not comply with the site-specific SCGs of the Unrestricted and Restricted-Residential SCOs for the Site.

Impacted soils that exceed the Restricted Use SCOs will remain on the Site within, below, and adjacent to the former tar well foundations.

Short-term Effectiveness: No remedial activities would be performed under the No Further Action Alternative. Therefore, there would be no short-term environmental impacts or risks to on site workers or the community related to this remedy. This would be because there would not be any workers performing any remedial activities at the Site.

Long-term Effectiveness and Performance: Since no MGP-impacted material will be removed from the Site, the remedy will not provide long-term effectiveness at meeting the RAOs and eliminating the risks from the Site. There is a potential for construction worker exposure to MGP-impacted subsurface soil during future intrusive activities (i.e. during excavation to repair or replace existing subsurface utilities/structures or to install new underground facilities).

Reduction of Toxicity, Mobility or Volume with Treatment: The remedy will not reduce the toxicity, mobility, or volume of the source material at the Site.

Implementability: The No Further Action Alternative doesn’t involve any active remedial response and poses no technical or administrative implementability concerns.

Costs: There are no costs associated with this alternative.

Land Use. The current, intended, and reasonably anticipated future land use of the Site is not anticipated to change.

3.3.2 Alternative 2: Excavation of MGP-Source Material and Adjacent MGP-Impacted Materials

Overall Protection of Public Health and the Environment: The alternative eliminates or effectively controls the potential exposure to contaminants by removing MGP-related source material within the former tar wells and adjacent soils to the CP-51 criteria. Institutional controls will be implemented to manage potential future exposures to the MGP-impacted materials, which will remain at depth below approximately 20 feet of clean backfill and new surface pavement.

Alternative 2 achieves each RAO as described below:

- *Prevent, to the extent practicable, ingestion/direct contact with MGP related soil contamination.* MGP-related source material will be removed from the Site, including the former tar wells and adjacent soils that exceed the CP-51 criteria. Impacted materials remaining at the Site will not be readily accessible.
- *Remove/treat, to the extent practicable, MGP related source material and residuals which may impact groundwater.* The removal of MGP-related source material will reduce potential impacts to groundwater.
- *Prevent, to the extent practicable, contact with, or ingestion of groundwater with MGP related contaminant levels exceeding class GA standards.* Removal of MGP-related source material will remove most of the source of the groundwater impacts at the Site. Overtime, site groundwater quality will improve due to natural attenuation. Currently, there is no evidence of MGP-related impacts to off-site groundwater. Despite this, institutional controls of groundwater are required and will be implemented to prevent groundwater use at the Site and control exposure to impacted groundwater.

Compliance with SCGs: By removing the more significantly impacted MGP-related source material from within the former tar well foundations and the adjacent soils that exceed the CP-51 criteria, the remedy complies with the site-specific SCGs and requirements set forth by the NYSDEC. The dewatering under this alternative would also result in the capture, removal, and treatment of impacted groundwater at the site.

Short-term Effectiveness: The short-term adverse impacts related to this remedy include the potential nuisance odors during construction and potential short term exposures to on-site construction workers and local residents during construction. Installation of the excavation support will generate vibrations and noise, which may impact adjacent structures and businesses. In addition, the remedy may adversely affect traffic in the local community due to the transport of materials from the Site.

The remedy implements a CAMP to detect, and if necessary mitigate, vapors, or dust generated during the execution of the remedy.

A vibration monitoring program will be established if necessary to measure potential vibrations at the Site for the gas line in Hill Street and the existing brick wall near the northern tar well.

A traffic plan will be established to address staging of trucks for transportation of impacted soils. The plan will attempt to minimize impacts on the local community through sequencing of the work.

Long-term Effectiveness and Performance: This alternative will provide long term effectiveness at meeting the RAOs and eliminating or mitigating the risks to exposure. MGP-related source material within the former tar wells and adjacent MGP-impacted soils will be removed. Impacted soils will be excavated to the CP-51 criteria.

Reduction of Toxicity, Mobility or Volume with Treatment: The remedy will remove most source material at the Site via direct excavation. The toxicity of the remaining impacts should be reduced over time via natural attenuation.

Implementability: Impacted soil removal is technically feasible. Remedial contractors for removal of the impacted soil are readily available and this remedy has been implemented on similar sites.

The remedy is administratively feasible. Although the Site's small size may present a challenge from an implementability standpoint, the work will be performed in two opposite corners of the Site; at each of the two tar wells. Work can be sequenced and overlapped such that staging, stockpiling, and other construction related activities can be performed in a timely manner.

Costs: The estimated cost is$1.84 million and is summarized in Table B-1, Appendix B.

Land Use: The current, intended, and reasonably anticipated future land use of the Site is commercial and is not anticipated to change. The remedy would meet Commercial land use by using the CP-51 criteria.

3.3.3 Alternative 3: Unrestricted Land Use Excavation

Overall Protection of Public Health and the Environmental: The alternative eliminates or effectively controls the potential exposure to contaminants by removing all MGP-related source material and MGP-impacted materials to meet the Unrestricted Use SCOs.
The alternative achieves each RAO as described below:

- *Prevent, to the extent practicable, ingestion/direct contact with MGP related soil contamination.* All MGP-related source material and soils that exceed the Unrestricted Use SCO will be removed from the Site.
- *Remove, to the extent practicable, MGP related source material and residuals which may impact groundwater*. The removal of all MGP-related source materials and soils

that exceed the Unrestricted Use SCO will prevent potential future impacts to groundwater.

- *Prevent, to the extent practicable, contact with, or ingestion of groundwater with MGP related contaminant levels exceeding class GA standards.* Removal of all MGP-related source materials and soils that exceed the Unrestricted Use SCO will eliminate any potential source of groundwater impacts at the Site.

Compliance with SCGs: By removing all MGP-related source materials soils that exceed the Unrestricted Use SCO, the remedy complies with the site-specific SCGs.

Short-term Effectiveness: The short-term adverse impacts related to this remedy include the potential nuisance odors during construction and potential short-term exposures to on-site construction workers and local residents. Installation of the excavation support will include vibrations and noise, which may impact adjacent structures and businesses. In addition, the remedy may adversely affect traffic in the local community due to the transport of impacted materials from the Site.

The remedy implements a CAMP to detect, and if necessary mitigate, vapors, or dust generated during the execution of the remedy.

A vibration monitoring program will be established if necessary to measure potential vibrations at the Site for the gas line in Hill Street and the existing brick wall near the northern tar well.

A traffic plan will be established to address staging of trucks for transportation of impacted soils. The plan will attempt to minimize impacts on the local community through sequencing of the work.

The length of time required to complete this alternative is over two years. The short-term issues listed above would be affecting those nearby the site for that length of time. This will be a nuisance for those in the vicinity of the Site.

Long-term Effectiveness and Performance: Since all MGP-related source material and soils that exceed the Unrestricted Use SCO will be removed from the Site, the remedy will provide long-term effectiveness at meeting the RAOs and eliminating the potential risks from the Site.

Reduction of Toxicity, Mobility, or Volume with Treatment: The remedy will remove all soils that exceed the Unrestricted Use SCO.

Implementability: Impacted soil removal is technically feasible. Remedial contractors for removal of the impacted soil are readily available and excavation of impacted soil has been implemented on similar sites.

Difficulties associated with this alternative are: (1) due to the limited size of the Site and the locations of the impacted materials, implementation of this remedy would require significant sequencing of work and disruption to the community, (2) the excavation areas are large and additional space would be required for equipment/material staging, (3) managing and treating a substantial amount of water that would accumulate in the excavations possibly requiring an on-site water treatment facility, (4) securing a sufficient number of waste haulers to expeditiously transport the excavated soil for off-site disposal (which would also cause additional traffic concerns), (5) controlling odors that would potentially be generated during excavation in close proximity to the community (6) the need to stabilize soils excavated from below the water table to eliminate free liquids (water) for off-site transport, (7) the potential need to remove subsurface obstructions to drive sheet-pile to required embedment depths, and (8) the likelihood that technical problems could lead to schedule delays resulting in the need for multiple mobilizations to address various areas of the Site within the owner's preferred timeframe for conducting activities at the Site.

Costs: The estimated cost is $14.57million and is summarized in Table B-2, Appendix B.

Land Use. The land use would be unrestricted.

4. Preferred Remedy

Based on comparing the two soil excavation alternatives, Alternative 2 is the preferred remedy. The RAOs are achieved through a combination of excavation and institutional controls. Removal of MGP-related source material and soil that exceeds the CP-51criteria will dramatically reduce the potential future contribution of source materials to groundwater quality.

Alternative 2 is more easily implemented than Alternative 3 and is equally or nearly equally protective of human health and the environment over the long term. The additional excavation under Alternative 3 would result in significantly increased short-term risks related to increased soil volume/handling and construction (i.e. worker exposure, injuries, odors, noise, spills, traffic, etc.) and the “potential” added benefits of those actions do not outweigh those risks.

Alternative 2 meets the property owner’s restrictions on access and schedule duration. The MGP-impacted material below the proposed excavation depth will be addressed through institutional controls to prevent exposure to these materials.

The selected alternative is presented in Figure 3-1 and includes the following:

- Excavating MGP-related source material from, and adjacent to the former tar wells. The excavations will extend to 20 feet below grade. The tar well structures will also be removed.
- Excavation of approximately 1,393 cubic yards of soil and debris that exceed the CP-51 criteria of 500 ppm PAHs and/or exhibit MGP-related visual impacts greater than tar sheen in the top 20 feet.
- Implementing a CAMP during the intrusive portion of remedial activities.
- Development and implementation of a SMP. The SMP will identify the institutional controls and post-remediation monitoring and inspections required for the Site.

The SMP will include:

- As an Appendix to the SMP an Excavation Work Plan is included for any future intrusive work that will penetrate the cover system (asphalt) or encounter or disturb the remaining impacts.. It will provide detailed procedures required to manage remaining MGP-residuals at the site after completion of the remedial action.
- Institutional controls to maintain use restrictions regarding site development or groundwater use identified in the environmental easement.

- Requirements to provide an annual certification to NYSDEC that engineering controls continue to perform as designed remain in place and are effective, as required by regulations.
- A monitoring plan for groundwater with MGP-related contaminants in the areas downgradient of the area remediated.

Excavation of the areas described above removes most of the MGP-related source material from the Site. This MGP-related source material removal reduces the potential for future exposure to site-related contaminants in soil and groundwater. The potential flux of contaminants into groundwater is reduced by removal and off-site destruction of the MGP-related source material.

As indicated above, Alternative 2 requires an SMP which details the institutional and engineering controls to prevent and control potential exposure to remaining contaminants. Groundwater at the Site is not currently used for water supply, and the environmental easement/ deed restriction will prevent groundwater from being used in the future. Future routine excavation activities will be controlled through the prescribed methods and protocols for managing work, groundwater, and soils in the SMP. In addition, a soil vapor intrusion study must be conducted for any buildings built on-site.

Alternative 2 will be effective over the long term. With proper maintenance of remedial controls, the remedy will continue to support the current land use of the property.

5. Scope of Work

This section provides a general overview of the preferred remedy (Alternative 2), which includes the excavation and off-site disposal of MGP-related source materials within and surrounding the former tar wells. The remedial excavations will extend to approximately 20 feet below the ground surface. The tar well structures will be removed.

The excavation limits for each tar well can be found in Figure 3-1 and in the Contract Drawings. Excavated materials from the Site will be disposed of off-site at a properly permitted National Grid-approved disposal facility. Approximately 1,393 cubic yards of soil and debris will be removed from the former tar well foundations and surrounding soils. The excavations will be backfilled to restore the site to its pre-remediation grades. Backfill materials will consist of imported clean material perthe NYSDEC requirements. The Site will be restored including repaving after the excavation has been backfilled.

The preferred remedy will also include the following remedial components as described below.

- **Perimeter Air Monitoring and Odor Suppression.** The remedy activities will be monitored in accordance with the HASP, included as Appendix C, and the CAMP, included as Appendix D. Odor mitigation methods such as covering excavation areas with plastic and/or the use of odor suppressing foam may be required during the site work and are discussed in Section 6.
- **Storm Water Pollution Prevention.** Performance of the remedy will require erosion and sediment controls to prevent run-off from entering the exclusion zone and provide for the collection and treatment of storm water that contacts impacted materials as described in Section 7.
- **Waste Management.** All impacted materials removed from the Site (soil, groundwater) will be disposed of off-site at a properly permitted National Grid approved facility. Dewatering and decontamination fluids will be collected and transported off-site for treatment. All wastes will be handled in accordance with the requirements in Section 10 and the Contract Documents.
- **Construction Dewatering.** Localized dewatering will be performed as needed to facilitate excavation and backfill.
- **Community Impacts.** During working hours, the contractor will make every effort to minimize potential nuisance impacts to the community. These include, but are not limited to, odors, noise, and traffic concerns associated with the execution of the remedy.

5.1 Mobilization and Site Access

Prior to mobilization, the contractor will prepare and submit all required documents identified in the Contract Documents for review and approval by National Grid, the Engineer, and NYSDEC. The Engineer will review contractor submittals to check for conformance with Contract Documents.

The contractor will apply for and obtain all necessary permits associated with the performance of the AA/RAWP. These permits may include, but are not limited to, storm water pollution prevention, road closures, temporary construction entrances, building and/or demolition, air emissions, noise, etc.

The contractor will contact a private utility locator service to identify any utilities on private properties. Any underground utility protection and/or relocation will be the responsibility of the contractor.

The Engineer will conduct a pre-construction site meeting, after the project is awarded, with the contractor, National Grid, owner and NYSDEC prior to the commencement of RA. The meeting will be conducted to review specified construction requirements and schedules, as well as to review the responsibilities of the contractor, the Engineer, and National Grid with respect to the RA implementation.

Prior to the start of work, the contractor will conduct a pre-construction survey and inspection of the property to document existing conditions. The survey will be conducted under the oversight of the Engineer and the findings reviewed and approved by the Engineer and National Grid prior to mobilization.

A New York State licensed surveyor will be contracted to establish a temporary baseline grid and benchmarks for the remedial work. The grid and benchmarks will be established in English Units (feet) in the following datum:

Horizontal: New York State Plane Grid East as represented by NAD 1983;
Vertical: National Geodetic Vertical Datum 1929, (NGVD29).

The surveyors will return as needed to establish other reference points, layout work, and survey record information such as the locations of documentation/confirmation samples and the limits of the excavations. Other site personnel may perform additional intermediate surveys as needed.

The contractor will mobilize all necessary labor, equipment, supplies and materials to complete the RA upon approval by National Grid. The appropriate exclusion zone(s) and contaminant reduction zone(s) will be established to conduct the planned activities safely and effectively consistent with the conceptual approach shown on the Contract Documents.

The contractor will access the Site from Hill Street.

5.2 Site Preparation

The contractor will be responsible for preparing the Site for the RA. Site preparation activities necessary to provide support for the work, include the demolition of the bocce courts, establishment of work zones, support facilities, decontamination facilities, erosion control measures, and installation of temporary security fencing around the work area and frac tank staging area.

The contractor will be responsible for preserving existing trees, fences, and structures/appurtenances as noted in the Contract Documents. The contractor will be instructed to protect the brick wall located near the northern tar well and the mural located near the southern tar well while performing the RA.

The contractor will be required to obtain approval from a properly licensed National Grid-approved disposal facility for all excavated and dewatered material, prior to beginning any excavation work. All excavated soil that exceeds the CP-51 criteria will be disposed of at a properly licensed National Grid-approved Subtitle C (hazardous) or Subtitle D (non-hazardous) landfill facility. All dewatered/decontamination water will be disposed of off-site at a liquid waste disposal facility.

Soil erosion and sediment control measures will be installed prior to excavation and maintained throughout the project in accordance with the Erosion and Sediment Control Plan in Section 7, and the Contract Documents.

An 8-foot high odor control/privacy fence will be erected to enclose and control access to the construction site for the duration of the RA. The contractor shall obtain any variance required with the City for installation of the temporary fencing. The Site Security Plan, Section 8, and the Contract Drawings, indicate the location and installation of the temporary fence.

Following preparation of the Site, a decontamination/anti-traction pad will be constructed just inside of the Site gate. However, the final placement may be altered by the contractor to accommodate their selected means and methods of construction. The Site Decontamination Plan, Section 9, and the Contract Drawings detail the placement and operation of the decontamination/anti-traction pad.

At the completion of remedial activities, the contractor will be responsible for restoring the Site to pre-existing conditions.

5.3 Excavation Limits

The approach to the RA will be excavation and removal of MGP-related source material within and surrounding the former tar wells. The tar well structures themselves will also be removed. Soils that exceed 500 ppm total PAHs (CP-51) in the top 20 feet will also be removed.

Based on the existing site characterization data, the anticipated extent of the excavation is shown on Figure 3-1. Approximately 164 cubic yards of soil and debris will be removed from the northern tar well area and approximately 1,229 cubic yards of soil and debris will be removed from the southern tar well area. Both excavations will extend to 20 feet bgs.

5.4 Utility Preservation/Replacement

The contractor will be responsible for protecting any utility lines that may be encountered during the excavation.

If any of the utility lines are damaged during the RA, the contractor will be responsible for the repair, replacement, and/or restoration of these lines. During excavation, all utilities encountered will be protected and care taken to prevent damaging any lines. Appropriate tools (i.e., hand tools, non-sparking tools, etc.) as required by the utility owner will be used during excavations around existing utilities. Utility features are noted in the Contract Drawings, to the extent known.

5.5 Material Handling

Suitable space is available for stockpiling excavated materials, which will be performed as prescribed in the Contract Documents. Direct loading of excavated materials is also permitted if the *in-situ* samples of the MGP-impacted material have been accepted by the disposal facility. All loading of excavated material will occur within the site. Excavated materials will be amended using cement kiln dust, or other amendments acceptable to the NYSDEC and the disposal facility, as needed to reduce the water content to acceptable levels. All trucks will be lined with plastic liners before loading occurs. Once a truck is filled with excavated material, spray-on odor suppressing materials such as Rusmar Foam or Biosolve® may be used to reduce potential odor emissions during transit, if necessary. A plastic tarp will then be used to cover the excavated materials. All trucks must be equipped with solid sealable covers and the use of mesh roll top covers will not be allowed. The truck will then exit the excavation area and proceed immediately to a decontamination pad. Following decontamination, the truck will proceed directly to the designated treatment, storage and disposal facility. All trucks accessing the Site will follow the Traffic and Parking Management Plan, and the Truck Route Plan shown on the Contract Drawings.

Based on the investigation data, it is anticipated that excavated material will be transported as non-hazardous material, with the exception of some soils in the northern tar well, which may need to be transported as hazardous material.

Excavated materials, from either the northern or southern tar well excavation, exhibiting visual impacts (blebs, globs, coatings, lenses, saturation, and/or viscous or solid tar) will be segregated and sampled to confirm the hazardous material threshold for TCLP benzene limit is not exceeded. The stockpiled materials will be transported to the appropriate type of off-site disposal facility based on the results of the TCLP analysis.

5.6 Odor and Fugitive Dust Control

The contractor will provide odor suppressant system consisting of chemical foam (e.g., Rusmar foam, Biosolve®) or other approved method. The contractor will keep sufficient odor suppressant on-site to manage the odors generated from the excavated materials, including, but not limited to open excavations, limited stockpiles, or materials loaded into trucks for transportation and disposal. The odor suppressant system will be stored near the excavation and will be easily mobile. Further details about the management of the odor suppressant system are presented in Section 6 and the Contract Documents. Open excavations containing MGP-related source material will be backfilled or covered at the end of each working day to suppress odors.

Conditions within the excavation area will be monitored in accordance with the contractor HASP, Section 6, and the Contract Documents. Conditions on the perimeter will be monitored in accordance with the HASP, CAMP, Section 6, and the Contract Documents.

5.7 Site Restoration

Upon completion of the RA, the Site will be restored to original conditions as indicated in the Contract Documents. The Restoration Plan is shown in the Contract Drawings. Restoration actions will include, but may not be limited to the following:

- Backfill and compaction of the excavated areas to return the site to its pre-RA grades.
- Demobilization of the dewatering system.
- Removal of the temporary earth support structure.
- Demobilization of the CAMP equipment.
- Removal of the decontamination pads.
- Restoring any relocated utilities to their original condition, as needed.

- Grading and paving of the parking lot area.
- Removal of all erosion control measures after permanent stabilization.
- Replacing any removed or damaged structures or appurtenances, if damaged during RA.
- Replacing the bocce courts.
- Restoration of the brick wall and mural, if necessary.
- Post restoration survey of the property to document conditions following restoration.

6. Vapor/Odor Management

Excavation activities at remediation sites typically generate airborne dust and odors that have the potential to migrate off-site. In recognition of this potential hazard, the NYSDOH has promulgated a CAMP that establishes action levels of respirable dust and VOCs that are protective of the surrounding community. The requirements of the CAMP are contained in Appendix 1A of the 2002 Draft DER-10 Technical Guidance for the Site Investigations and Remediation and the Contract Documents. The CAMP is intended to supplement, but be discrete from the air-monitoring program implemented by the contractor for purposes of evaluating site worker health and safety.

6.1 CAMP Summary

A site-specific CAMP has been prepared for the Site and is included in Appendix D. The CAMP is designed to provide monitoring procedures, Alert Limits, Action Limits, and contingency measures if Action Limits are approached.

Alert Limit: An Alert Limit is a contaminant concentration or odor intensity that triggers contingent measures. An Alert Limit does not suggest the existence of a health hazard, but serves instead as a screening tool to trigger contingent measures if necessary, to assist in minimizing off-site transport of contaminants and odors during remedial activities.

Action Limit: An Action Limit is a contaminant concentration or odor intensity that triggers work stoppage.

During times of ground intrusive activities, fence line perimeter air monitoring will be conducted using a combination of real-time (continuous and almost instantaneous) air monitoring at fixed locations and walk-around supplemental monitoring using hand-held instruments on an as-needed basis. Contaminants commonly found at former MGP sites will be monitored, including VOCs, odors, and dust.

The CAMP includes a Contingency Plan that defines Alert Levels, Action Levels, and specific response activities to be implemented during working hours if an exceedance of an Alert Limit or Action Limit for a measured compound occurs. The response actions, potentially including work stoppage, are intended to prevent or significantly reduce the migration of airborne contaminants from the Site.

If the real-time perimeter Action Limits are exceeded or significant nuisance odors are noted, National Grid, the Engineer, and the contractor will consult to determine what type of emission control action is appropriate. Actions that may be taken to reduce emissions include the following:

- Spraying water on exposed soil surfaces and/or roadways to suppress windblown dust.
- Covering working areas of exposed impacted soils, trucks loaded with impacts soils, or stockpiles of impacted soils with tarpaulins with vapor suppressing foam or other vapor control agent.
- Temporarily relocating work to an area with potentially lower emission levels.
- Reduce the production rate or change the sequence of work activities.
- Change the work methods or equipment to alternatives that minimize air emissions.

In practice, these actions will typically be employed proactively to prevent action levels from being reached at the exclusion zone perimeter in the first instance. These above-mentioned Alert and Action Level Concentrations along with additional guidelines are summarized in the Contract Documents. The anticipated locations of the air monitoring stations are also noted, subject to change according to the contractor’s means and methods.

7. Erosion and Sediment Control Plan

The erosion and sediment controls are intended to mitigate erosion and sedimentation from the Site as indicated on the Contract Drawings.

7.1 Description of Construction Activities

This project involves the excavation of approximately 1,393 cubic yards of source material from two former tar wells. Excavation depths will be 20 feet bgs at both tar well locations. Dewatering of the excavation will be required during this project because excavations will extend into the water table. Groundwater was observed at approximately 15 feet bgs.

All storm water runoff from the exterior of the excavation area will be handled in accordance with Section 12 and the Contract Documents. In generally, storm water runoff will be collected, routed, and discharged into the local drainage structures prior to contact with any impacted materials. Access areas between the excavation area and the adjacent public streets will contain decontamination stations for all trucks and equipment. The decontamination waters will be collected and stored in an on-site frac tank.

7.2 Potential Areas for Erosion and Sedimentation

The Site slopes from the southeast to the northwest and is primarily paved. Trucks/ equipment exiting the excavation area could track soils onto the traveled areas. Wet excavated soils could seep out of the trucks and onto public roads.

7.3 Implementation of Erosion Control Measures

Sediment fence/hay bales will be installed around all areas to be excavated. Decontamination stations will act as anti-tracking pads, thereby, removing all soil and sediment from all trucks/equipment wheels and bodies that are exiting the Site onto public streets. All trucks shall have watertight compartments to prevent seepage from wet soil from leaking onto public streets.

The contractor shall install and maintain the erosion control measures indicated in the Contract Documents for the duration of the excavation work. Additional erosion control measures may be needed due to unforeseen conditions. The contractor shall install additional measures as necessary and as directed by National Grid or National Grid’s representative.

7.4 Restoration

Upon completion of the remedy, the contractor will remove all sediment fencing and restore the surface to pre-RA conditions in accordance with Section 14 and the Contract Documents. All sediment accumulated in the fencing will be removed and transported to a properly licensed National Grid-approved disposal facility.

8. Site Security Plan

The objectives of the site security plan are to prevent the vandalism/destruction of construction equipment and to prevent access and minimize health and safety concerns for the surrounding residential neighborhood, as shown on the Contract Documents.

8.1 Perimeter Security

A temporary fence will be erected around the perimeter of the RA work area. At a minimum, the fence will be 8-foot high, equipped with a privacy screen. A variance will be established with the City, if necessary, for installation of the temporary fencing to this height. The fence will extend around all work areas to include the excavation area, waste handling equipment, and storage areas if any. The fence will have two gates that will have the ability to be locked at the end of each working day. If necessary, (considering the site may be otherwise lighted by building floodlights, municipal streetlights, etc.), the contractor will provide temporary lighting at the gate.

8.2 Equipment Security

All vehicles and/or equipment left in the work area must be secured at the end of each working day. In addition, vehicles and equipment must remain inside the perimeter fence, or at a remote secured area if left on site overnight or during non-work days. No vehicles or equipment may be left overnight in an unsecured location. It is the responsibility of the contractor to ensure that all non-essential equipment is de-energized when left on-site and not in use to prevent electrical/fire/explosive hazards.

9. Decontamination Plan

The objectives of the decontamination plan at the Site are to provide the procedures and equipment necessary to decontaminate personnel and equipment to prevent cross-contamination from the excavation area to public areas (i.e., highways, roads, support trailer, vehicles, etc.). This plan does not replace the decontamination procedures outlined in the HASP, Appendix C, or in the Contract Documents. This plan provides additional guidelines on decontamination locations, necessary equipment, and procedures.

9.1 Decontamination Procedures

The contractor will establish decontamination areas for the following activities.

- Personnel decontamination
- Equipment decontamination

9.1.1 Personnel Decontamination Station

A personnel decontamination station where workers can drop equipment and remove personal protective equipment (PPE) will be set up within the work zone. It will be equipped with basins for water and detergent, and trash bags or cans for containing disposable PPE and discarded materials. Once personnel have decontaminated at this station and taken off their PPE, they will proceed to a sink where they will wash themselves as a secondary means of personal hygiene (e.g., hands, face, etc.).

The specific decontamination procedures and requirements for the disposal of decontamination wastewater are outlined in the HASP, Appendix C, and the Contract Documents.

9.1.2 Equipment Decontamination Station

Heavy equipment decontamination will be performed within the limits of the on-site decontamination pads. Heavy contamination will be brushed off equipment using a broom and/or brushes within the excavation area prior to movement to the decontamination pads to decrease the amount of respirable particulates leaving the remediation area. If necessary, at the decontamination/anti-tracking pad, all heavy equipment will be pressure washed before leaving the site.

All equipment leaving the Site will be decontaminated per these guidelines, the guidelines indicated in the HASP, Appendix C, and the Contract Documents. In addition, any equipment previously utilized to excavate impacted material will be decontaminated prior to use in backfilling (e.g. excavator bucket).

Decontamination/anti-tracking pads will be located and operated at any point that equipment leaves the Site, and are shown in the Contract Documents. The decontamination pad(s) will be sufficiently sized to ensure that the largest piece of contractor equipment can be adequately decontaminated. Provisions will be made to control overspray at the decontamination pad(s).

Wastewater from equipment decontamination will be collected and pumped into the frac tanks. Disposal of the wastewater will be handled in accordance with the Waste Management Plan (Section 10 and the Contract Documents). Soils collected from the decontamination pads will be bulked with the excavated material and sent to the properly licensed National Grid-approved disposal facility as necessary in accordance with the Contract Documents.

9.1.3 Material Transport Vehicle Decontamination

Trucks transporting soil off-site will enter the excavation area as described in the Traffic Control Plan (Section 13 and the Contract Documents). Care will be exercised when loading trucks so as not to spill material on the outside of the trucks. Upon exiting the excavation area, the contractor will stage the trucks on the equipment decontamination/anti-traction pad. Trucks will then be visually inspected (i.e., box sidewalls, box tailgate, and tires, etc.), cleaned with brushes/brooms and will be decontaminated with pressure sprayers, if necessary, prior to being allowed to leave the Site. In addition, trucks will be required to be covered with solid plastic tarp prior to departing the Site. All trucks must be equipped with solid sealable covers and the use of mesh roll top covers will not be allowed. All collected soil and decontamination fluids will be collected and managed in accordance with the Waste Management Plan (Section 10 and the Contract Documents).

9.2 Decontamination Equipment

The contractor will be responsible for maintaining a sufficient supply of materials/equipment required to implement decontamination procedures. These materials are indicated in the HASP, Appendix C, and the Contract Documents.

10. Waste Management Plan

The waste management plan provides the contractor with guidelines for managing each waste stream.

The contractor will dispose of all waste materials generated during the RA in accordance with all applicable laws and regulations at a National Grid-approved disposal facility and in accordance with the Contract Documents. National Grid and/or the contractor will prepare and submit a generator profile of soils and wastes generated at the Site to the treatment/disposal facility.

10.1 Disposal Record Keeping

All manifests and/or bills of lading for all shipments will be submitted to the Engineer prior to any vehicle departing the Site. All manifests and/or bills of lading will be reviewed by the Engineer and signed by a designated agent for National Grid.

A log of all shipments and copies of all manifests and/or bills of lading will be maintained by the Engineer on-site for reference in the contractor’s trailer. Upon completion of the RA, the Engineer will provide National Grid with all logs and manifests and/or bills of lading. Copies of the logs, manifests, and bills of lading will be included in the RA Report following completion of the RA to create a permanent record of disposal.

10.2 Material Shipping Procedures

All material transportation vehicles leaving the Site must be watertight and will be decontaminated in accordance with the decontamination plan prior to departing the Site. The watertight beds will be lined with plastic truck liners prior to material being placed in the bed. If significant odors are noted, the material in the bed may be covered with Rusmar foam or similar odor suppressant prior to being covered in plastic. Finally, a solid tarp will be affixed to the truck bed to prevent volatilization or fugitive dust emissions during transit to the disposal facility. If a truck arrives at the Site without a solid tarp, plastic sheeting will be used to cover the material in the bed. All trucks must be equipped with solid sealable covers and the use of mesh roll top covers will not be allowed.

Individual waste streams will be handled in accordance with the Contract Documents.

10.3 Soil Disposal Characterization Analyses

During the PDI, waste characterization samples were taken of the soil, and the data is summarized in Appendix A. Two samples (composites from each tar well) were analyzed as outlined in the EPA Title 40, Code of Federal Regulations (CFR) Part 261, Subpart C - TCLP, to determine if hazardous characteristics were present, as follows:

- TCLP Volatile Organic Compounds (VOCs) (EPA Methods 1311 TCLP and 8260B)
- TCLP Semivolatile Organic Compounds (SVOCs) (EPA Methods 1311 TCLP and 8270D)
- TCLP Metals (EPA Methods 1311 TCLP and 6010B)
- TCLP Mercury (EPA Methods 1311 TCLP and 7470A)
- TCLP chlorinated pesticides/herbicides (EPA SW-846 Methods 1311/8081A)

Four samples (two composites at each tar well) were also analyzed for the following additional parameters:

- VOC (GC-MS) (EPA SW-846 Method 8260B)
- SVOC (GC-MS) (EPA SW-846 Method 8270C)
- Total Cyanide (EPA Method 9012A)
- Total Mercury (EPA Method 7471A)
- Reactive Cyanide (EPA SW-846 Method 7.3.3/9014)
- Reactive Sulfide (EPA SW-846 Method 7.3.4/9034)
- Ignitability (EPA Method 1030)
- Extractable Organic Halogens (EPA SW-846 Method 9023)
- pH (EPA Method 9045C)
- Percent Solids/Percent Moisture (EPA Method CLPISM01.2)
- Total British Thermal Units (American Society for Testing and Materials(ASTM)-D240-87)
- Total Metals (EPA Method 6010B)
- Hexavalent chromium (EPA SW-846 Method 3060A/7196A)
- Diesel range organics (EPA SW-846 Method 8015B – DRO)
- Gasoline range organics (EPA SW-846 Method 8015B –GRO)
- PCBs (EPA SW-846 Method 8082)

The TCLP benzene concentration detected in the NAPL sample collected at the northern tar exceeded the benzene hazardous characteristic criteria (D018-leachability for benzene) of 0.5 mg/L listed in Title 40 CFR Chapter 1 Part 261. The concentration was 8.5 mg/L.

In accordance with NYSDEC DER-4, soils that have been contaminated with coal tar waste from former MGPs, which only exhibit the toxicity characteristic for benzene may be conditionally excluded from the requirements of 6 NYCRR Parts 370 -374 and 376 and can be transported as non-hazardous material when destined for permanent thermal treatment. However, the sample collected inside the northern tar well consisted primarily of viscous

NAPL (a liquid). Liquid waste that fails the TCLP benzene limit is not exempt. As such, for risk management purposes, the waste generated during excavation of the tarry portion of the northern tar well may be segregated and managed as a hazardous waste.

The waste sample collected at the southern tar well did not exceed any of the TCLP limits. However, the physical impacts in the sample were not as heavy as those seen in samples collected during the RI. Therefore, some additional sampling of waste soil at the southern tar well may be required. Excavated materials, from either the northern or southern tar well excavation, exhibiting visual impacts greater than staining (sheen, blebs, globs, coatings, lenses, saturation, and/or viscous or solid tar) shall be segregated and sampled to confirm the TCLP benzene limit is not exceeded.

The contractor will be responsible for any additional collection and analyses of soil disposal samples as required for acceptance by the receiving facility. The contractor will use the results to select acceptable primary and backup licensed National Grid-approved disposal facilities. If the selected facility or facilities require additional disposal characterization data, it is the responsibility of the contractor to coordinate with National Grid and obtain the appropriate samples prior to the start of excavation activities. The contractor shall provide the Engineer the results of all analyses immediately upon receipt.

10.4 Dewatering/Wastewater Characterization Analyses

No real-time sampling of wastewater is anticipated due to off-site disposal. However, if the need arises, the discharge and/or influent to the frac tank(s) will be sampled by the contractor in accordance with the Contract Documents and the conditions of the receiving facility for off-site disposal and the results provided to National Grid and the Engineer.

Pre-characterization for disposal of the dewatered and decontamination wastewater will need to be performed.

The contractor will be responsible for the collection and analyses of dewatering/wastewater disposal samples as required for acceptance by the receiving facility. The contractor will use the results to select acceptable primary and backup licensed National Grid-approved disposal facilities. If the selected facility or facilities require additional disposal characterization data, it is the responsibility of the contractor to coordinate with National Grid and obtain the appropriate samples prior to the start of excavation activities. The contractor shall provide the Engineer the results of all analyses immediately upon receipt.

11. Sample Collection and Analysis Plan

The documentation sample collection and analysis plan has been designed to support the requirements of the RA. The RA includes the removal of MGP-related source material.

Material within the former tar wells will be removed to the limits indicated on the Contract Drawings. In general, the excavations will extend to 20 feet bgs. The area will be backfilled with clean fill.

The contractor will develop a Quality Assurance Project Plan (QAPP) that is consistent with the generic QAPP and the requirements indicated in the Contract Documents.

All analytical testing will be performed by a laboratory that holds a current NYSDOH Environmental Laboratory Approval Program certification. A copy of the documentation sampling data will be maintained at the Engineer’s trailer during the RA.

11.1 Representative Sampling of Backfill

The excavations will be backfilled with imported materials. The contractor will provide backfill material and conduct backfilling in accordance with the Contract Documents. At a minimum, a sample of the backfill will be collected at the beginning of backfill operations. If the backfill source changes, it will also be sampled.

11.2 Confirmation Sampling

Due to the density of existing analytical data, confirmation sampling of the bottom and sidewalls of the excavations is not required.

12. Groundwater Management Plan

The groundwater management plan establishes requirements for collection of decontamination and dewatering wastewater, off-site disposal, and collection and discharge of storm water. It is anticipated that flow rates to the excavations will range from approximately 5 gallons per minute at the northern tar well excavation to approximately 25 gallons per minute at the southern tar well excavation. The dewatering equipment must be adequately sized to handle the volumes associated with these flow rates.

12.1 Decontamination and Dewatering Wastewater

Wastewater associated with decontamination activities on the Site will be pumped into a covered frac tank(s) located outside of the excavation area. The frac tank(s) will be sufficiently sized to contain the wastewater and provide some measure of primary treatment (settling) with weirs, baffles or other appropriate technology, and flow equalization, if needed. Effluent will then be disposed of off-site as described in subsection 10.2 and the Contract Documents.

Due to the location of the excavations and the depth to groundwater at the Site, it is anticipated that groundwater will be encountered during excavation to meet target depths during the RA. Groundwater measurements from the recent RI and previous investigations indicate that the approximate depth to water in the excavation area is approximately 15 feet bgs. Dewatering will be required for the water contained within the excavations. The contractor will pump dewatering liquids to a frac tank(s) and dispose of off-site as described in subsection 10.2 and the Contract Documents.

12.2 Off-Site Disposal of Wastewater

The contractor will arrange for the off-site disposal of all generated wastewater. All generated wastewater requiring off-site disposal will be handled in accordance with Section 10 and the Contract Documents.

12.3 Storm Water Runoff Control

The excavation area is under a paved parking lot and storm water drainage is handled primarily through surface runoff to local storm water drainage features and infiltration to the subsurface. In preparation for and throughout the duration of the RA, the control and diversion of storm water runoff is essential to reduce the potential for flooding of adjacent properties and impacted material discharges off site.

Storm water contact with the impacted soils will be limited due to the erosion and sediment control barriers around the area of excavation. Therefore, it is not anticipated that runoff from the exterior will come in contact with the excavation area. The contractor will be required to utilize appropriate control measures to route the runoff from the collection system to the municipal storm sewer. The contractor will do so in accordance with the Contract Documents. Storm water runoff control measures may include the installation of haybaleberms, barriers, and a sump for the collection and discharge of the water.

13. Traffic Control Plan

The Traffic Control Plan indicates the traffic routes to and from the Site for:

- Trucking soil and bulky waste off site.
- Importing clean fill to the Site.
- Liquid waste hauler off-loading dewatered liquids if necessary.
- Contractor access and parking.
- Equipment access and storage.

These routes and other traffic control specific guidelines can be found in the Contract Documents.

14. Schedule of Remedial Activities

Upon completion of the remedial activities, the Site will be restored to accommodate continued use of the Site for the same purposes as those prior to remediation.

Excavations will be backfilled to existing grades with imported clean fill. Restoration actions shall include, but may not be limited to:

- Backfill and compaction of the excavated areas.
- Demobilization of the dewatering storage frac tank(s).
- Removal of the temporary earth support structure.
- Demobilization of the CAMP equipment.
- Removal of the decontamination pads.
- Removal of all erosion control measures after permanent stabilization.
- Replacing any removed or damaged structures or appurtenances, if damaged during RA.
- Restoring any relocated utilities to their original condition as necessary.
- Grading and paving of the parking lot area.
- Grading the Site to prevent ponding or runoff of storm water that could adversely affect the Site or adjacent properties.
- Restore/replace landscaping and retaining walls damaged during the RA.
- Paving of the entire site.
- Restoration of the parking lot, bocce courts, driveways, curb, and sidewalk on the property wherever they were removed or damaged.
- Post restoration survey of the property to document conditions following restoration.

15. Final RA Engineering Report (FRAER)

Following completion of the remedial activities a Final Remedial Action Engineering Report (FRAER) will be prepared in accordance with the VCO and stamped by an engineer licensed to practice in the State of New York. The FRAER will include:

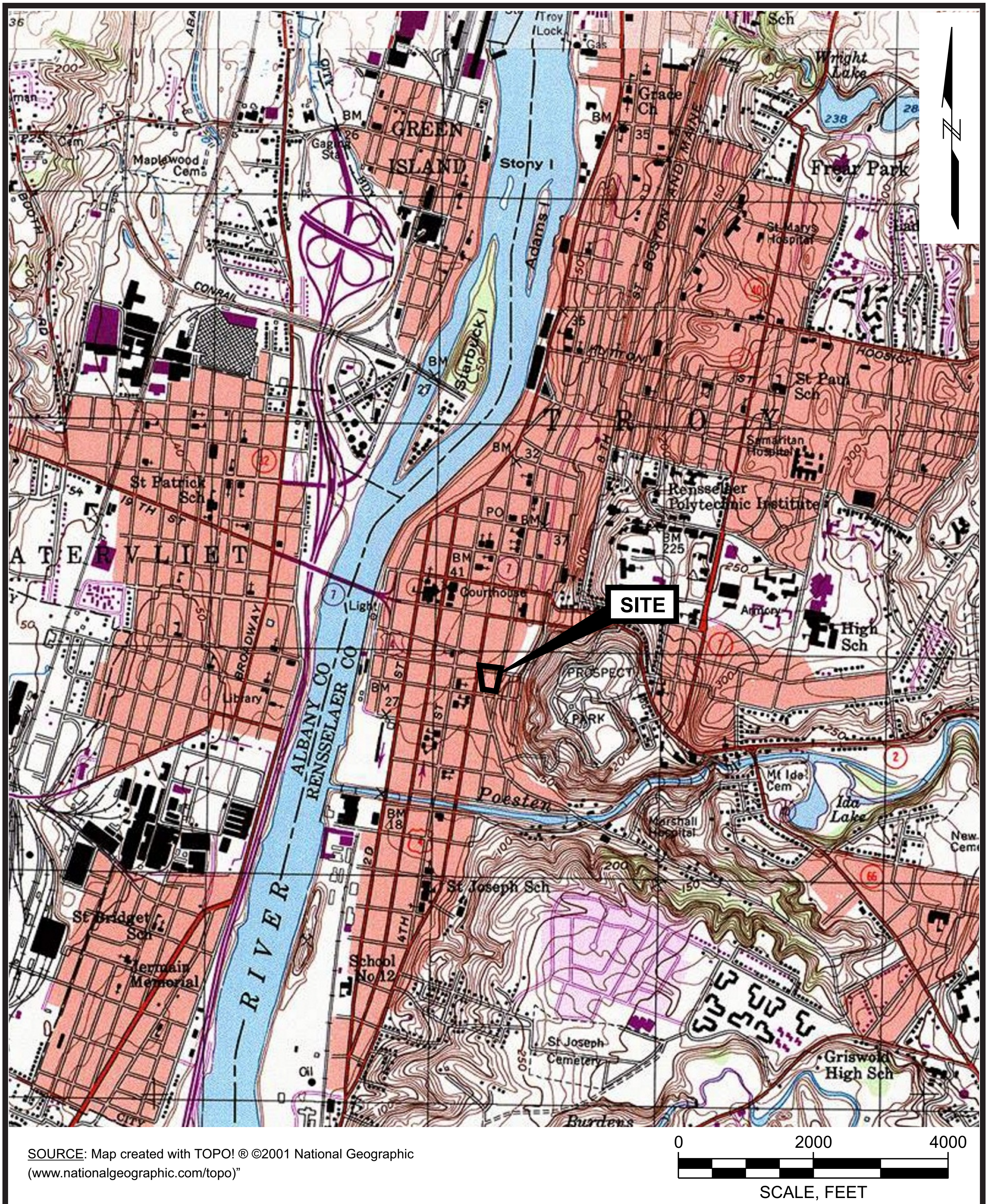
- Background and Site Description
- Remedial Action Objectives
- Description of Remedial Actions performed, with accompanying documentation
    - Governing Documents
    - Remedial Program Elements
    - Contaminated Materials Removal
    - Remedial Performance/Documentation Sampling
    - Imported Backfill
    - Contamination remaining at the Site
    - Soil Cover System
    - Engineering Controls
    - Institutional Controls
    - Deviations from the RAWP
    - Tables
    - Figures
- Record drawings, specifications, addenda, actual volumes of excavated material and treated/discharged wastewater
- Approval and Closure documents from NYSDEC
- Approved permits
- Shipping manifests and bills of lading (contaminated soil, clean fill, and construction dewatering liquids).
- Summary of Air Monitoring Data collected during the remedial activities
- Certification that material transported off-site was disposed of at a properly licensed National Grid-approved disposal facility or Treatment Storage and/or Disposal Facility

16. References

GEI Consultants, Inc. Remedial Investigation Report, Troy (Liberty Street) Non-Owned Former MGP Site, July 2012

GEI Consultants, Inc. Pre-Design Investigation Data Report, Troy (Liberty Street) Non-Owned Former MGP Site, May 2013

Figures



SOURCE: Map created with TOPO! ® ©2001 National Geographic (www.nationalgeographic.com/topo)"

REMEDIAL ACTION WORK PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
TROY, NEW YORK

nationalgrid

GEI Consultants

SITE LOCATION MAP

Project 093300-2-1203

August 2013

Figure 1

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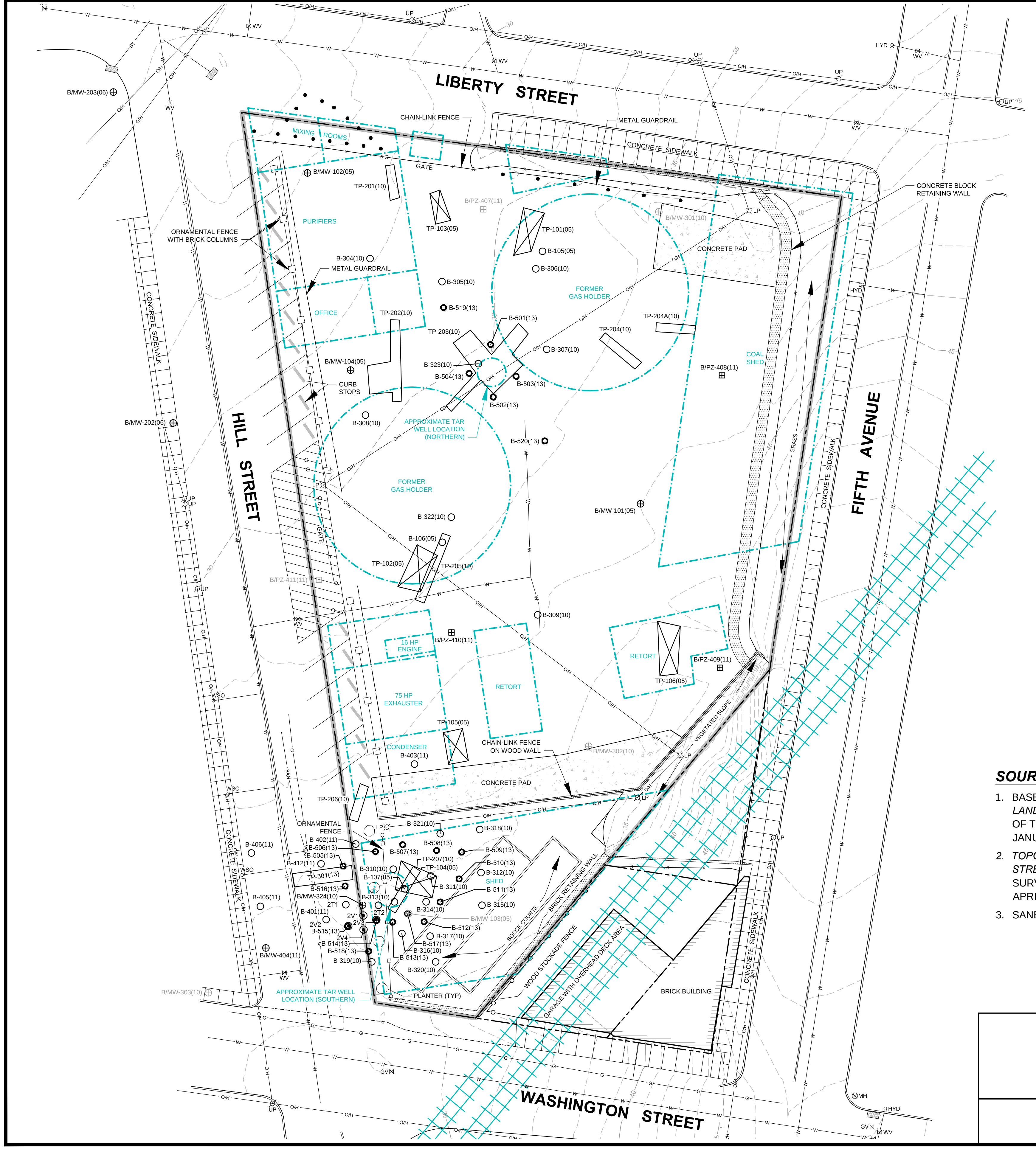

LEGEND:

	PROPERTY LINE
	SITE BOUNDARY
45	GROUND SURFACE CONTOURS
	CONCRETE BLOCK RETAINING WALL
	CHAIN-LINK FENCE
	METAL FENCE WITH BRICK PILLARS
	GUIDE RAIL
	EDGE OF PAVEMENT
	HISTORICAL RAILROAD TRACKS (APPROXIMATE)
	HISTORICAL STRUCTURE BASED ON 1885 SANBORN FIRE INSURANCE MAP
	HISTORICAL GAS HOLDER/TAR WELL (SURVEYED UNLESS NOTED)
	CONCRETE PAD
●	BOLLARD
HYD	HYDRANT
UP	WOOD UTILITY POLE
LP	STEEL LIGHT POLE
CB	CATCH BASIN
⊗MH	MANHOLE
GV	GAS VALVE
○WSO	WATER SHUT OFF
WV	WATER VALVE
O/H	OVERHEAD UTILITY LINES
W	CITY OF TROY WATER MAIN
G	GAS LINE
SAN	SANITARY SEWER LINE
ST	STORM SEWER LINE
TP-101(05)	TEST PIT (EA ENGINEERING PC, 2005)
○ B-105(05)	SOIL BORING (EA ENGINEERING PC, 2005)
⊕B/MW-101(05)	SOIL BORING/MONITORING WELL (EA ENGINEERING PC, 2005)
⊕B/MW-201(06)	SOIL BORING/MONITORING WELL (EA ENGINEERING PC, 2006)
TP-201(10)	TEST PIT (GEI, 2010)
○B-304(10)	SOIL BORING (GEI, 2010)
⊕B/MW-301(10)	SOIL BORING/MONITORING WELL (GEI, 2010)
○2T1	NYSEARCH COAL TAR VAPORIZATION STUDY BORING (GEI, 2010)
⊙2V1	NYSEARCH COAL TAR VAPORIZATION STUDY SOIL VAPOR SAMPLE (GEI, 2010)
○B-401(11)	SOIL BORING (GEI, 2011)
⊞B/PZ-407(11)	SOIL BORING/PIEZOMETER (GEI, 2011)
⊕B/MW-404(11)	SOIL BORING/MONITORING WELL (GEI, 2011)
TP-301(13)	TEST PIT (GEI, 2013)
B-501(13)	SOIL BORING (GEI, 2013)
⊞B/PZ-407(11)	PIEZOMETER DECOMMISSIONED MARCH 2013
⊕B/MW-302(10)	MONITORING WELL DECOMMISSIONED MARCH 2013

NOTES:

1. ELEVATIONS REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29). HORIZONTAL LOCATIONS REFERENCED TO NORTH AMERICAN DATUM OF 1983 (NAD 83).
2. BOUNDARIES BASED ON SURVEY BY DELTA ENGINEERS, DATED JANUARY 2013.

SOURCES:

1. BASE MAP TAKEN FROM *TOPOGRAPHIC AND BOUNDARY SURVEY, PORTION OF THE LANDS OF THE CITY OF TROY, NEW YORK (FORMER MGP SITE), 34 HILL STREET,* CITY OF TROY, RENSSELAER COUNTY, STATE OF NEW YORK, SCALE: 1" = 20', DATE: JANUARY 22, 2013 AND APRIL 19, 2013 BY DELTA ENGINEERS, VERNON, NY.
2. *TOPOGRAPHIC SURVEY AND MAP OF NIAGARA MOHAWK MGP SITE SITUATED AT HILL STREET,* CITY OF TROY, COUNTY OF RENSSELAER, N.Y., SCALE: 1" = 50', SITE SURVEYED IN DECEMBER 2005, DECEMBER 2006, OCTOBER 2010, DECEMBER 2010 AND APRIL 2011 BY M.J. ENGINEERING AND LAND SURVEYING, P.C., CLIFTON PARK, NY.
3. SANBORN FIRE INSURANCE MAP, 1885.

0 40 80

SCALE, FEET

REMEDIAL ACTION WORK PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
TROY, NEW YORK

nationalgrid

GEI Consultants

SAMPLE LOCATION MAP

Project 093300-2-1203
August 2013
Figure 2

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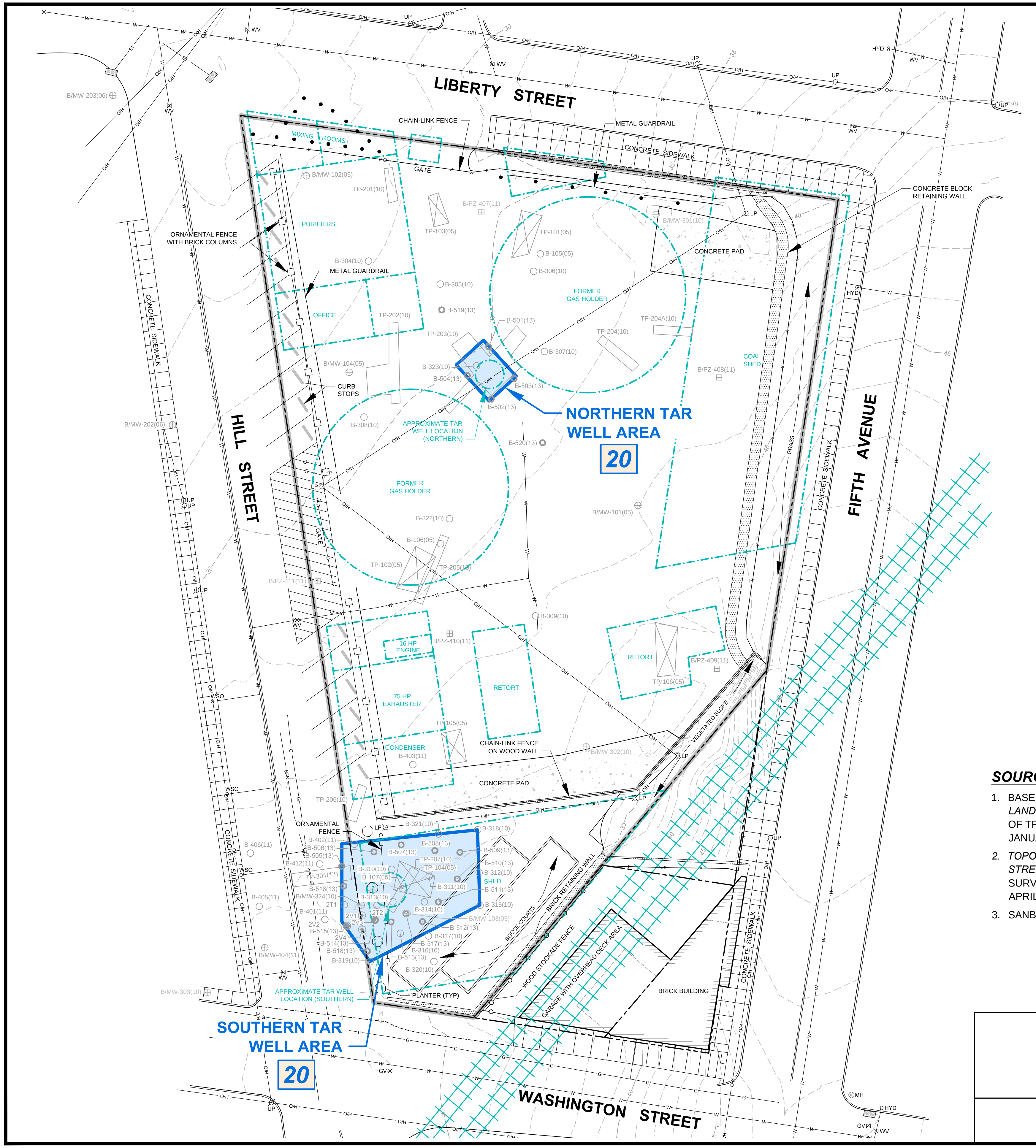

LEGEND:

20	PROPOSED EXCAVATION
20	PROPOSED EXCAVATION DEPTH
	PROPERTY LINE
	SITE BOUNDARY
45	GROUND SURFACE CONTOURS
	CONCRETE BLOCK RETAINING WALL
	CHAIN-LINK FENCE
	METAL FENCE WITH BRICK PILLARS
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TP-301(13)	TEST PIT (GEI, 2013)
B-501(13)	SOIL BORING (GEI, 2013)
⊞ B/PZ-407(11)	PIEZOMETER DECOMMISSIONED MARCH 2013
B/MW-302(10)	MONITORING WELL DECOMMISSIONED MARCH 2013

NOTES:

1. ELEVATIONS REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29). HORIZONTAL LOCATIONS REFERENCED TO NORTH AMERICAN DATUM OF 1983 (NAD 83).
2. BOUNDARIES BASED ON SURVEY BY DELTA ENGINEERS, DATED JANUARY 2013.
3. EXCAVATION EXTENTS ARE BASED ON SOILS THAT CONTAIN GREATER THAN 500 ppm TOTAL PAHs AND/OR VISIBLE TAR CONTAMINATION TO 20 FEET BGS.

SOURCES:

1. BASE MAP TAKEN FROM *TOPOGRAPHIC AND BOUNDARY SURVEY, PORTION OF THE LANDS OF THE CITY OF TROY, NEW YORK (FORMER MGP SITE), 34 HILL STREET,* CITY OF TROY, RENSSELAER COUNTY, STATE OF NEW YORK, SCALE: 1" = 20', DATE: JANUARY 22, 2013 AND APRIL 19, 2013 BY DELTA ENGINEERS, VERNON, NY.
2. *TOPOGRAPHIC SURVEY AND MAP OF NIAGARA MOHAWK MGP SITE SITUATED AT HILL STREET,* CITY OF TROY, COUNTY OF RENSSELAER, N.Y., SCALE: 1" = 50', SITE SURVEYED IN DECEMBER 2005, DECEMBER 2006, OCTOBER 2010, DECEMBER 2010 AND APRIL 2011 BY M.J. ENGINEERING AND LAND SURVEYING, P.C., CLIFTON PARK, NY.
3. SANBORN FIRE INSURANCE MAP, 1885.

0 40 80

SCALE, FEET

REMEDIAL ACTION WORK PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
TROY, NEW YORK

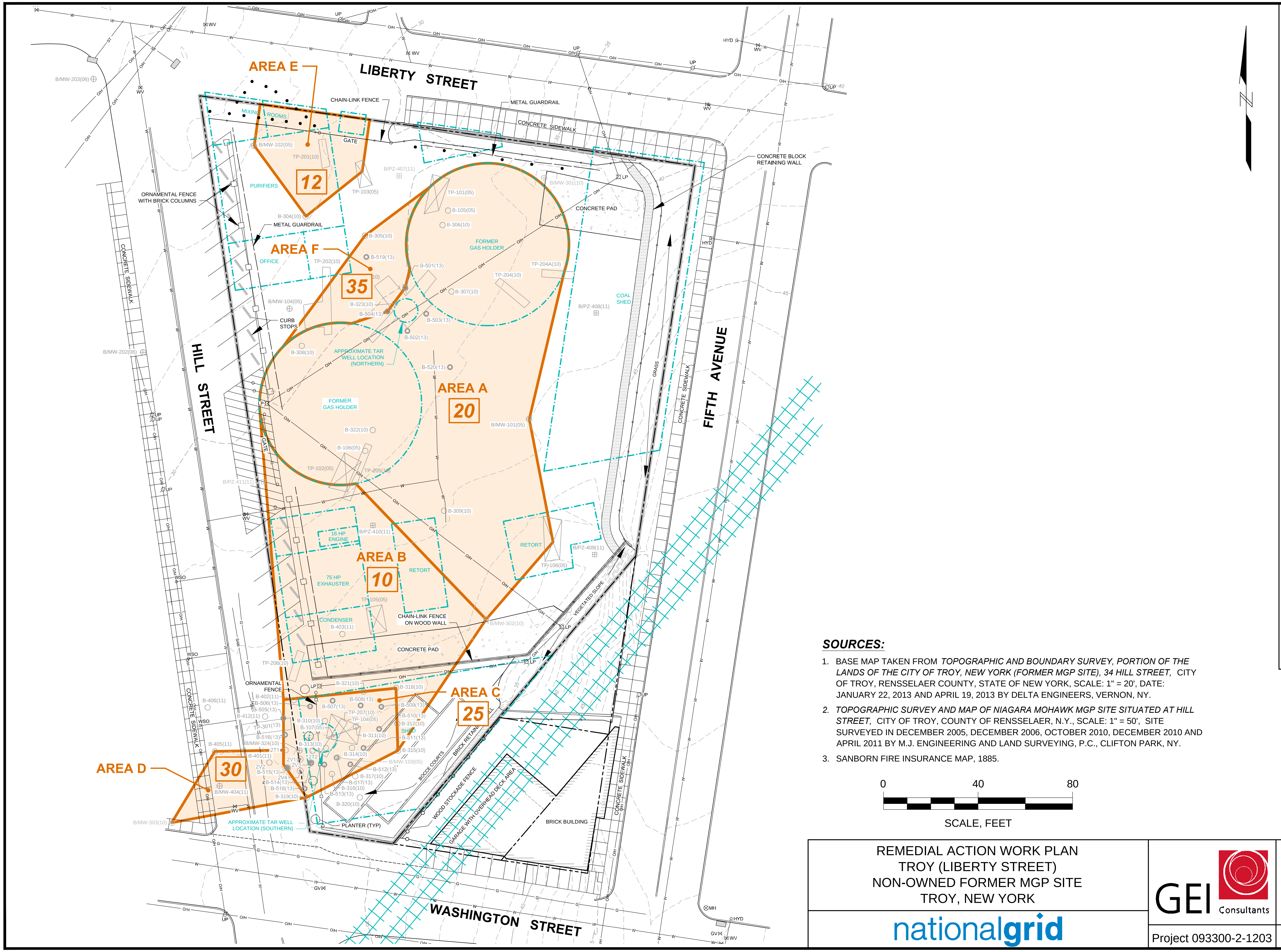
nationalgrid

GEI Consultants

ALTERNATIVE 2

Project 093300-2-1203 | August 2013 | Figure 3-1

I:\Project\National Grid\TROY\LIBERTY_ST\Remedial Action Work Plan\Drawings\Troy-RAWP Figures.dwg



LEGEND:

▭	PROPOSED EXCAVATION
20	PROPOSED EXCAVATION DEPTH
— - - — - - —	PROPERTY LINE
▬	SITE BOUNDARY
— — 45 — —	GROUND SURFACE CONTOURS
▨	CONCRETE BLOCK RETAINING WALL
—x—x—	CHAIN-LINK FENCE
☐—☐	METAL FENCE WITH BRICK PILLARS
—— —— —— -	GUIDE RAIL
═	EDGE OF PAVEMENT
╪╪╪	HISTORICAL RAILROAD TRACKS (APPROXIMATE)
▭	HISTORICAL STRUCTURE BASED ON 1885 SANBORN FIRE INSURANCE MAP
○	HISTORICAL GAS HOLDER/TAR WELL (SURVEYED UNLESS NOTED)
▭	CONCRETE PAD
●	BOLLARD
HYD	HYDRANT
UP	WOOD UTILITY POLE
LP	STEEL LIGHT POLE
CB	CATCH BASIN
⊗MH	MANHOLE
⋈ GV	GAS VALVE
○WSO	WATER SHUT OFF
⋈ WV	WATER VALVE
—— O/H ——	OVERHEAD UTILITY LINES
—— W ——	CITY OF TROY WATER MAIN
—— G ——	GAS LINE
—— SAN ——	SANITARY SEWER LINE
—— ST ——	STORM SEWER LINE
TP-101(05)	TEST PIT (EA ENGINEERING PC, 2005)
○ B-105(05)	SOIL BORING (EA ENGINEERING PC, 2005)
⊕B/MW-101(05)	SOIL BORING/MONITORING WELL (EA ENGINEERING PC, 2005)
⊕B/MW-201(06)	SOIL BORING/MONITORING WELL (EA ENGINEERING PC, 2006)
TP-201(10)	TEST PIT (GEI, 2010)
○B-304(10)	SOIL BORING (GEI, 2010)
⊕B/MW-301(10)	SOIL BORING/MONITORING WELL (GEI, 2010)
○2T1	NYSEARCH COAL TAR VAPORIZATION STUDY BORING (GEI, 2010)
⊙2V1	NYSEARCH COAL TAR VAPORIZATION STUDY SOIL VAPOR SAMPLE (GEI, 2010)
○B-401(11)	SOIL BORING (GEI, 2011)
⊞B/PZ-407(11)	SOIL BORING/PIEZOMETER (GEI, 2011)
⊕B/MW-404(11)	SOIL BORING/MONITORING WELL (GEI, 2011)
TP-301(13)	TEST PIT (GEI, 2013)
○B-501(13)	SOIL BORING (GEI, 2013)
⊞ B/PZ-407(11)	PIEZOMETER DECOMMISSIONED MARCH 2013
⊕ B/MW-302(10)	MONITORING WELL DECOMMISSIONED MARCH 2013

NOTES:

1. ELEVATIONS REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29). HORIZONTAL LOCATIONS REFERENCED TO NORTH AMERICAN DATUM OF 1983 (NAD 83).
2. BOUNDARIES BASED ON SURVEY BY DELTA ENGINEERS, DATED JANUARY 2013.
3. EXCAVATION EXTENTS ARE BASED ON SOILS THAT EXCEED UNRESTRICTED USE SOIL CLEANUP OBJECTIVES.

SOURCES:

1. BASE MAP TAKEN FROM *TOPOGRAPHIC AND BOUNDARY SURVEY, PORTION OF THE LANDS OF THE CITY OF TROY, NEW YORK (FORMER MGP SITE), 34 HILL STREET,* CITY OF TROY, RENSSELAER COUNTY, STATE OF NEW YORK, SCALE: 1" = 20', DATE: JANUARY 22, 2013 AND APRIL 19, 2013 BY DELTA ENGINEERS, VERNON, NY.
2. *TOPOGRAPHIC SURVEY AND MAP OF NIAGARA MOHAWK MGP SITUATED AT HILL STREET,* CITY OF TROY, COUNTY OF RENSSELAER, N.Y., SCALE: 1" = 50', SITE SURVEYED IN DECEMBER 2005, DECEMBER 2006, OCTOBER 2010, DECEMBER 2010 AND APRIL 2011 BY M.J. ENGINEERING AND LAND SURVEYING, P.C., CLIFTON PARK, NY.
3. SANBORN FIRE INSURANCE MAP, 1885.

REMEDIAL ACTION WORK PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
TROY, NEW YORK

nationalgrid

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ALTERNATIVE 3

Project 093300-2-1203 | August 2013 | Figure 3-2

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ALTERNATIVES ANALYSIS/REMEDIAL ACTION WORK PLAN
TROY (LIBERTY STREET) NON-OWNED
FORMER MGP SITE
TROY, NEW YORK
AUGUST 2013

Appendix A

Previous Subsurface Investigations Boring/Well Logs and Laboratory Analytical Data (electronic only)

GEI Consultants
GEI Consultants, Inc.
455 Winding Brook Road
Glastonbury, CT 06033
(860) 368-5300

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

PAGE 1 of 2

B-501(13)

GROUND SURFACE ELEVATION (FT): 30.0076
LOCATION: Adjacent to Northern Tar Well
NORTHING: 1418766.433 **EASTING:** 709852.6453
TOTAL DEPTH (FT): 30.00
DRILLED BY: ADT / Ritchie Comfort
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/11/2013 - 3/11/2013
DRILLING DETAILS: Hollow Stem Auger/2 inch ID Split Spoon
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFORMATION					STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID
	TYPE and NO.	PEN FT.	REC FT.	Blows (/6 in.)	PID (ppm)				
0		4.0				▨	🟩		
5	S-1	2.0	0.6	1-2-3-4	0.1	▨	🟩		
	S-2	2.0	1.2	2-2-2-3	0.2, 2.5	▨	🟩		
	S-3	2.0	1.2	24-18-4-4	26.6, 30.4	▨	🟩 🟨	NLO NLO	B-501(13) 9-10
10	S-4	2.0	0.5	2-2-2-3	38.0	▨	🟨	NLO	
	S-5	2.0	0.4	3-3-3-4	17.7	▨	🟨	NLO	B-501(13) 12-14
15	S-6	2.0	0.0	5-6-8-13		▨	🟨	NLO	B-501(13) 15-17
	S-7	2.0	0.2	16-13-13-17	26.8	▨	🟨	NLO	
	S-8	2.0	1.0	5-10-8-8	14.5, 12.9, 25.2, 23.9	▨	🟨	NLO	B-501(13) 18-20
20	S-9	2.0	0.1	15-15-11-11		●	🟨	NLO	
	S-10	2.0	0.5	25-25-37-37	0.0	⁘	🟨	NLO	

SOIL / BEDROCK DESCRIPTION

Hand and vacuum cleared to 4' bgs, FILL.

LEAN CLAY (CL); ~90% fines, ~10% sand, fine to coarse; moist to wet, brown, concrete and brick fragments, FILL.

NARROWLY GRADED SILTY SAND (SM); ~85% sand, fine to medium, ~15% fines; wet, brown, trace brick fragments, FILL.

NARROWLY GRADED SILTY SAND (SM); ~85% sand, fine to medium, ~15% fines; wet, brown, trace brick fragments, FILL.

LEAN CLAY (CL); ~95% fines, ~5% sand, fine; wet, brown, FILL.

WIDELY GRADED GRAVEL (GW); ~100% gravel, angular; moderate naphthalene-like odor, saturated, gray, FILL.

SILT (ML); ~95% fines, ~5% sand, fine; moderate naphthalene-like odor, wet, light brown, trace fine gravel, FILL.

LEAN CLAY (CL); fine to medium, ~100% fines; strong naphthalene-like odor, moist, gray, trace brown fine to medium sand, trace fines, trace coal fragments at ~10.5' bgs, FILL.

SILT (ML); ~100% fines; strong naphthalene-like odor, wet, gray brown, trace fine sand, slight staining, FILL.

WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; moderate naphthalene-like odor, moist to wet, gray, FILL.

NARROWLY GRADED SAND WITH GRAVEL (SP); ~70% sand, fine to medium, ~25% gravel, fine to coarse, angular, ~5% fines; slight naphthalene-like odor, light brown, FILL.

NARROWLY GRADED SAND WITH GRAVEL (SP); ~70% sand, fine to medium, ~25% gravel, fine to coarse, angular, ~5% fines; slight naphthalene-like odor, saturated, light brown, FILL.

WIDELY GRADED GRAVEL WITH SAND (GW); ~90% gravel, fine to coarse, ~10% sand, fine to coarse; slight naphthalene-like odor, brown.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET
NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR
CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

GEI Consultants, Inc.
455 Winding Brook Road
Glastonbury, CT 06033
(860) 368-5300

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-501(13)

DEPTH FT.	SAMPLE INFORMATION					STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	Blows (/6 in.)	PID (ppm)					
25	S-11	2.0	1.7	8-15-33-38	0.0, 0.0, 0.0	░ ░	🟨 🟩	NLO		NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; slight naphthalene-like odor, wet, dark brown, shoe contained fine to coarse sand (no odor). WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; slight naphthalene-like odor, saturated, dark brown, trace fines. WIDELY GRADED SAND (SW); ~100% sand, fine to medium; wet, dark brown, trace fines. WIDELY GRADED GRAVEL (GW); ~95% gravel, fine to coarse, subrounded & subangular, ~5% sand, fine; brown brown to light, trace reddish-brown fines and fine sand. NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; saturated, gray, trace fines. WIDELY GRADED GRAVEL (GW); fine to medium, ~100% gravel, fine to coarse, angular to subangular; saturated, gray brown to, trace fine to medium sand.
	S-12	2.0	1.2	11-9-6-7	0.0, 0.0, 0.0	●	🟩			
30	S-13	2.0	0.9	21-9-7-8	0.0, 0.0	░ ●	🟩 🟩			

End of Boring at 30 feet.
Poor recoveries 12 to 18' bgs with a 2-inch spoon. A 3-inch spoon was pushed 14-18' bgs for better recovery.
Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
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IN. = INCHES
FT. = FEET

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TLO = TAR LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
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BORING LOG

PAGE 1 of 2

B-502(13)

GROUND SURFACE ELEVATION (FT): 30.1978
LOCATION: Adjacent to Northern Tar Well
NORTHING: 1418748.095 **EASTING:** 709853.5453
TOTAL DEPTH (FT): 30.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/14/2013 - 3/14/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	2.0	0.1, 0.1, 0.1, 0.1	▨	🟩			NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; dry, gray to dark brown, trace fines, trace fine to coarse gravel, angular coal fragments at ~7.5', FILL.
					▨	🟨	NLO	B-502(13) 9.5-10	Bricks, FILL. NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; slight naphthalene-like odor, dry, gray, coal ash, shoe is moist, FILL.
10	S-2	5.0	2.9	0.0, 0.0, 0.0, 0.0, 0.0	▨	🟨	NLO	B-502(13) 11-12	SILT (ML); ~90% fines, ~10% sand, fine to medium; slight naphthalene-like odor, moist to wet, brown gray, trace fine gravel, trace brick fragments, FILL.
					▨	🟨	NLO		SILT (ML); ~100% fines; slight naphthalene-like odor, moist to wet, brown gray, trace fine to medium sand, trace fine gravel, trace brick fragments, FILL.
					▨	🟩			LEAN CLAY (CL); ~100% fines; moist, gray, trace fine sand, trace fine gravel, FILL.
					▨	🟩			SILT (ML); ~100% fines; moist, light brown, trace fine sand, trace brick fragments, FILL.
15	S-3	5.0	3.2	0.0, 0.0, 0.0, 0.0, 0.0	▨	🟩			
					⁘	🟩		B-502(13) 19-20	WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine, ~5% fines; moist to wet, brown, trace coarse gravel, trace reddish brown fine sand.
20	S-4	5.0	2.0	0.0, 0.0, 0.0	⁘	🟩			NARROWLY GRADED SAND WITH GRAVEL (SP); ~60% sand, medium to coarse, ~40% gravel, fine to coarse; wet, brown, trace fines, gravel is all shapes.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
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MLO = MUSTY LIKE ODOR

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BORING LOG

PAGE 2 of 2

B-502(13)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25	S-5	5.0	0.4	0.0	▨	🟩			NARROWLY GRADED SAND (SP); poor recovery, same as above.
30									End of Boring at 30 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B-503(13)

GROUND SURFACE ELEVATION (FT): 30.3179
LOCATION: Adjacent to Northern Tar Well
NORTHING: 1418755.367 **EASTING:** 709861.5192
TOTAL DEPTH (FT): 30.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/14/2013 - 3/14/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	2.3	0.3, 0.4, 0.4, 2.4, 0.3	▨	🟩		B-503(13) 8-9	SILT (ML); fine, ~90% fines, ~10% sand, fine to medium; moist, brown to gray, angular and subrounded, trace tiny wood and brick fragments, FILL.
10	S-2	5.0	1.7	0.2, 0.2, 0.2, 0.0	▨	🟩 🟨	NLO		WIDELY GRADED SAND WITH SILT (SW); ~90% sand, ~10% fines; moist, brown, trace fine gravel, FILL. Slight naphthalene-like odor.
					▨	🟨	NLO		Slight naphthalene-like odor, 2" cobble, FILL.
					▨	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, gray, trace black coal fragments, FILL.
					▨	🟨	NLO		SILT (ML); ~100% fines; slight naphthalene-like odor, dry to moist, gray, trace fine sand, brittle, firm, trace coal fragments, FILL.
					▨	🟩			SILT (ML); ~100% fines; moist, brown, trace fine to medium sand, soft, pliable, FILL.
					▨	🟩		B-503(13) 14.5-15	SILT (ML); fine to medium, ~100% fines; moist, brown, FILL.
15	S-3	5.0	3.0	0.0, 0.0, 0.0, 0.0	▨	🟨	NLO		SILT (ML); ~95% fines, ~5% sand, fine; slight naphthalene-like odor, moist, gray to light brown, FILL.
					▨	🟩			SILT (ML); ~90% fines, ~10% sand, fine; wet, brown, trace fine gravel, trace brick fragments, FILL.
					⁘	🟩		B-503(13) 18-19	WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse; wet, brown, angular and subrounded, trace fines, trace brick fragments, FILL.
20	S-4	5.0	3.2	0.0, 0.0, 0.0	⁘	🟩			NARROWLY GRADED SAND WITH GRAVEL (SP); ~85% sand, fine to coarse, ~15% gravel, fine to coarse; wet, brown, angular and subrounded, trace fines.
					⁘	🟩			NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; wet, brown to gray, trace coarse sand, trace fines.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

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OLO = ORGANIC LIKE ODOR
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MLO = MUSTY LIKE ODOR

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-503(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	SAMPLE INFO PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟩			NARROWLY GRADED SAND (SP); ~100% sand, fine; wet, brown, trace coarse subrounded gravel.
25	S-5	5.0	2.7	0.0, 0.2, 0.0		🟩			NARROWLY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~40% gravel, fine to coarse; saturated, brown, subrounded and angular.
30									End of Boring at 30 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
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NLO = NAPHTHALENE LIKE ODOR
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CLO = CHEMICAL LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B-504(13)

GROUND SURFACE ELEVATION (FT): 30.0787
LOCATION: Adjacent to Northern Tar Well
NORTHING: 1418756.355 **EASTING:** 709845.1089
TOTAL DEPTH (FT): 30.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/14/2013 - 3/14/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	1.8	0.2, 0.2, 0.2, 0.0	▨	🟨	NLO	B-504(13) 6-8	SILT (ML); ~95% fines, ~5% sand, fine to medium; slight naphthalene-like odor, dry, brown gray, trace brick and coal fragments, FILL.
					▨	🟩			SILT (ML); ~100% fines; dry to moist, brown gray, firm, trace subrounded gravel, lean clay at the bottom, FILL.
10	S-2	5.0	4.8	0.2, 0.2, 0.2, 0.2, 0.2, 0.2, 0.3	▨	🟩			SILT (ML); ~100% fines; moist, gray, trace fine sand, trace fine to coarse gravel, soft, FILL.
					▨	🟨	SLO		ELASTIC SILT (MH); ~100% fines; slight sulfur-like odor, wet, brown gray.
					▨	🟩		B-504(13) 11.5-12	LEAN CLAY (CL); ~100% fines; wet, brown gray, trace fine sand, tiny coal fragments.
					▨	🟨	NLO		SILT (ML); fine to coarse, fine to coarse, ~100% fines; slight naphthalene-like odor, wet to moist, brown to light brown, trace fine sand, brick fragments at ~14' bgs.
15	S-3	5.0	2.9	0.2, 0.2, 0.2, 0.2, 0.2	▨	🟨			
					▨	🟩		B-504(13) 18.5-19.5	WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse; wet, brown to dark gray, subangular and subrounded, trace fines, traces of tiny brick fragments and coal ash.
					░	🟩			WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, ~5% fines; wet, light brown to gray.
20	S-4	5.0	3.6	0.2, 0.2, 0.2, 0.2, 0.2, 0.1	░	🟩			
					░	🟩			WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse; saturated, brown and gray, trace fines, % gravel decreases with depth.

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NLO = NAPHTHALENE LIKE ODOR
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MLO = MUSTY LIKE ODOR

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BORING LOG
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B-504(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25	S-5	5.0	3.9	0.3, 0.3, 0.2, 0.2, 0.0	⁘	🟩			WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine; saturated to wet, brown, firm fine sand at the bottom.
30									End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG

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B-505(13)

GROUND SURFACE ELEVATION (FT): 32.3578
LOCATION: Near the Southern Tar Well
NORTHING: 1418584.134 **EASTING:** 709801.0513
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Ritchie Comfort
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/12/2013 - 3/12/2013
DRILLING DETAILS: Hollow Stem Auger/2 inch ID Split Spoon
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFORMATION					STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID
	TYPE and NO.	PEN FT.	REC FT.	Blows (/6 in.)	PID (ppm)				
0		5.0				▨	🟩		
5	S-1	2.0	1.3	2-3-5-5	0.0, 0.0, 0.0	▨	🟩		
	S-2	2.0	1.7	4-3-4-5	0.0, 0.0, 0.0, 0.0	▨	🟩		B-505(13) 8-9
10	S-3	2.0	1.6	2-4-3-3	0.0, 0.0, 0.0, 0.0	▨	🟩		
	S-4	2.0	1.9	3-8-8-6	0.1, 0.1. 0.1, 0.0	▨	🟩		
	S-5	2.0	0.7	6-3-3-4	0.0, 0.0	▨	🟨	NLO	B-505(13) 13-15
15	S-6	2.0	1.1	3-4-3-4		▨	🟨	NLO NLO	
	S-7	2.0	1.0	10-13-13-15	0.1, 0.7	▨	🟨	NLO NLO	B-505(13) 18-19
20	S-8	2.0	1.6	9-6-13-14	0.4, 0.3, 0.1, 0.0	▨ ░	🟨	NLO NLO	
	S-9	2.0	1.0	11-12-15-15	0.2, 0.0	░	🟨	NLO	
	S-10	2.0	2.0	13-7-9-10	0.2, 0.2, 0.2, 0.2	░	🟨	NLO	

SOIL / BEDROCK DESCRIPTION

Hand and vacuum cleared to 5' bgs, FILL.

LEAN CLAY (CL); ~95% fines, ~5% sand, fine to coarse; moist, brown, trace fine gravel, FILL.
LEAN CLAY (CL); ~95% fines, ~5% sand, fine to coarse; moist, gray, trace fine gravel, FILL.
WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; moist, brown gray, trace fines, trace fine gravel, FILL.
LEAN CLAY (CL); ~95% fines, ~5% sand, fine to coarse; moist, gray, trace fine gravel, FILL.
WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; moist, brown gray, trace fines, trace fine gravel, FILL.
LEAN CLAY (CL); ~95% fines, ~5% sand, fine to coarse; moist, brown, FILL.
LEAN CLAY (CL); ~95% fines, ~5% sand, fine to coarse; moist, gray, FILL.
SILT WITH SAND (ML); ~85% fines, ~15% sand, fine; moist, brown, FILL.
SILT WITH SAND (ML); ~85% fines, ~15% sand, fine; wet, brown gray, FILL.
ELASTIC SILT (MH); ~100% fines, low plasticity; wet, brown gray, trace fine sand, firm, FILL.
NARROWLY GRADED GRAVEL (GP); ~100% gravel, angular; moist, black, FILL.
WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, subrounded; moist, gray, trace fines, FILL.
SILTY SAND (SM); ~60% sand, fine to coarse, ~40% fines; slight naphthalene-like odor, wet, gray, FILL.
SILTY SAND (SM); ~80% sand, fine to medium, ~15% fines, ~5% gravel, fine to coarse, subangular; moderate naphthalene-like odor, wet, brown gray, FILL.
SILT (ML); ~90% fines, ~10% sand, fine; moderate naphthalene-like odor, wet, brown, FILL.
SILT (ML); ~95% fines, ~5% sand, fine; slight naphthalene-like odor, wet, light brown, FILL.
NARROWLY GRADED SAND (SP); ~100% sand,

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BORING LOG
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B-505(13)

DEPTH FT.	SAMPLE INFORMATION					STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	Blows (/6 in.)	PID (ppm)					
25						⁘	🟨			fine to medium; moderate naphthalene-like odor, wet, gray, trace fines, FILL. NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% gravel, fine, subrounded; moderate naphthalene-like odor, wet, gray, trace fines, fine to coarse sand 19.5-20.25' bgs, FILL. NARROWLY GRADED SAND WITH GRAVEL (SP); ~80% sand, fine to medium, ~20% gravel, fine to coarse, subrounded; moderate naphthalene-like odor, saturated, gray, bottom 0.2' traces of reddish brown sand. WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~40% gravel, fine to coarse, subrounded; slight naphthalene-like odor, saturated, gray, trace cobbles. WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~25% gravel, fine to coarse, subrounded; slight naphthalene-like odor, saturated, gray, trace cobbles, yellow fine to medium sand at bottom.

End of Boring at 25 feet.
A 2-inch spoon was used 5-17' bgs. A 3-inch spoon was used 17-25' bgs for better recovery.
Fill with bentonite chips.

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BORING LOG

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B-506(13)

GROUND SURFACE ELEVATION (FT): 32.5479
LOCATION: Near the Southern Tar Well
NORTHING: 1418589.169 **EASTING:** 709812.3815
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/14/2013 - 3/14/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▩	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	2.0	0.2, 0.2, 0.2, 0.2, 0.2	▩	🟩			LEAN CLAY (CL); ~100% fines; moist to wet, brown gray, silt and clay, non-plastic and plastic soil, FILL.
					▩	🟨	NLO	B-506(13) 9.5-10	CLAYEY SAND (SC); ~50% sand, fine to medium, ~45% fines, ~5% gravel, fine; moderate naphthalene-like odor, moist, dark gray, same as above, coal ash, FILL.
10	S-2	5.0	3.5	0.3, 0.3, 0.3, 0.5, 0.3	▩	🟩			
					▩	🟨	NLO	B-506(13) 12-13	NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% gravel, fine; moist, brown, trace fines, brick fragments, FILL. LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, gray, trace fine sand, trace fine gravel, lense of fine to medium sand with silt at ~12.5, FILL.
					▩	🟩			
15	S-3	5.0	4.0	0.2, 0.2, 0.2, 0.2, 0.2	▩	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, SAA, petroleum odor mix, FILL.
					▩	🟨	NLO NLO		SILT (ML); fine, ~95% fines, ~5% sand; slight naphthalene-like odor, wet, brown gray, trace tiny brick fragments, petroleum odor mix, FILL.
					▩	🟩			
					░	🟨	NLO	B-506(13) 19.5-20	SILTY SAND WITH GRAVEL (SM); ~50% sand, fine to medium, ~30% gravel, fine to coarse, ~20% fines; slight naphthalene-like odor, wet, brown gray, tiny wood fragments or decomposed organics, petroleum odor mix, FILL.
20	S-4	5.0	4.4	0.2, 0.2, 0.2, 0.2, 0.2	▥	🟩			
					▨	🟩			SILT (ML); ~100% fines; wet, olive green.
					░	🟨	NLO		WIDELY GRADED SAND (SW); fine to coarse, ~100% fines; slight naphthalene-like odor, wet, brown gray, trace fines, trace fine gravel, petroleum odor mix. SILT (ML); ~95% fines, ~5% sand, fine to medium; wet, brown, trace coal fragments.

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BORING LOG

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B-506(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	 PEN FT.	 REC FT.	 PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25					░	🟨 🟩			LEAN CLAY (CL); ~95% fines, ~5% sand, fine to coarse; wet, gray. WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine; slight naphthalene-like odor, wet, dark gray, trace fines, gravel is various shapes and size, petroleum odor mix. WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to coarse, ~30% gravel, fine to coarse; wet, brown, trace fines, gravel is various shapes and size. End of Boring at 25 feet. Fill with bentonite chips.

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BORING LOG

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B-507(13)

GROUND SURFACE ELEVATION (FT): 32.5946
LOCATION: Near the Southern Tar Well
NORTHING: 1418591.597 **EASTING:** 709821.9199
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/14/2013 - 3/14/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO: TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▩	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	1.7	0.2, 0.2, 0.2	▩	🟩			NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; dry, brown, coal fragments at ~5.5' bgs, FILL.
					▩	🟩			LEAN CLAY (CL); ~100% fines; moist, gray, some wood fragments, some staining, FILL.
10	S-2	5.0	1.8	0.3, 0.4, 1.5, 0.0	▤	🟨	NLO	B-507(13) 9.5-10	LEAN CLAY (CL); ~95% fines, ~5% sand, fine; slight naphthalene-like odor, moist, gray, brick fragments, firm, FILL.
					▩	🟨	NLO		SILTY SAND (SM); ~75% sand, fine to coarse, ~20% fines, ~5% gravel, fine to coarse; strong naphthalene-like odor, saturated, brown and gray, brick and coal fragments, black staining, FILL.
					▩	🟨		B-507(13) 14-15	
15	S-3	5.0	3.1	2.4, 1.4, 0.3, 0.3, 0.3	▩	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, gray, firm, FILL.
					▩	🟨	NLO		SILT (ML); fine, ~100% fines; slight naphthalene-like odor, moist, gray, trace angular gravel, brick fragments, FILL.
					▩	🟩			Moist, yellow, mortar or ash, FILL.
					▩	🟩			LEAN CLAY (CL); ~100% fines; moist, gray, trace fine sand, FILL.
					▩	🟩		B-507(13) 18.5-19	SILT (ML); ~100% fines; moist, olive green, trace fine to medium sand, FILL.
					▩	🟨	NLO		NARROWLY GRADED SAND (SP); ~100% sand; slight naphthalene-like odor, wet, brown gray, trace fine to medium sand, trace rounded gravel, FILL.
20	S-4	5.0	3.1	1.7, 0.6, 2.5, 0.8, 0.5	▨	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, wet, gray, trace angular gravel, trace brick fragments.

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B-507(13)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25					⠿	🟨	NLO		WIDELY GRADED SAND (SW); ~100% sand; slight naphthalene-like odor, wet, gray, trace fines, trace gravel.

End of Boring at 25 feet.
Fill with bentonite chips.

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BORING LOG

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B-508(13)

GROUND SURFACE ELEVATION (FT): 32.7776
LOCATION: Near the Southern Tar Well
NORTHING: 1418589.581 **EASTING:** 709833.7609
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/15/2013 - 3/15/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		2.0			▨	🟩			Hand and vacuum cleared to 2' bgs, FILL.
	S-1	3.0	1.3	0.0	▨	🟩			NARROWLY GRADED SAND WITH SILT AND GRAVEL (SP-SM); ~60% sand, fine to medium, ~30% gravel, coarse, ~10% fines; dry, brown and gray, hard drilling, FILL.
5	S-2	5.0	2.7	0.0, 0.0, 0.0, 0.0, 0.0	▨	🟩			NARROWLY GRADED SAND WITH GRAVEL (SP); ~85% sand, fine to medium, ~15% gravel, coarse, angular, ~5% fines; dry, gray, coal ash, FILL.
					▨	🟩			LEAN CLAY (CL); ~100% fines; dry, gray, trace fine sand, firm, FILL.
					▨	🟩		B-508(13) 9.5-10	NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; dry, brown, trace fine angular gravel, trace fines, FILL.
10	S-3	5.0	1.2	5.5	▨	🟨	NLO	B-508(13) 12.5-15	SILTY SAND (SM); ~75% sand, fine to coarse, ~20% fines, ~5% gravel, fine; strong naphthalene-like odor, wet, dark gray, FILL.
15	S-4	5.0	3.2	0.5, 2.6, 1.0, 1.0, 1.9	▨	🟧	NLO		Moderate naphthalene-like odor, faint sheen in slough.
					░	🟨	NLO		SILTY SAND (SM); ~80% sand, fine to medium, ~15% fines, ~5% gravel, fine to coarse; moderate naphthalene-like odor, moist to wet, brown gray, trace coarse sand, gravel all shapes, brick fragments at ~17' and 20' bgs, FILL.
20	S-5	5.0	2.2	1.3, 1.3, 2.8, 1.3	▥	🟨	NLO	B-508(13) 19.5-20	SILT WITH SAND (ML); ~85% fines, ~15% sand, medium coarse; strong naphthalene-like odor, wet, brown gray, trace fine to coarse gravel, all shapes.
					▥	🟨	NLO		SILT (ML); ~95% fines, ~5% sand; strong naphthalene-like odor, wet, brown gray.

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DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
					▥	🟨			
25									End of Boring at 25 feet. Fill with bentonite chips.

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PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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PROJECT:	Troy Liberty Street
CITY/STATE:	Troy, New York
GEI PROJECT NUMBER:	093300-1-1113

BORING LOG

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B-509(13)

GROUND SURFACE ELEVATION (FT): 32.9488
LOCATION: Near the Southern Tar Well
NORTHING: 1418589.023 **EASTING:** 709842.5253
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/15/2013 - 3/15/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	1.5	0.0, 0.0, 0.0	▨	🟩			WIDELY GRADED SAND (SW); ~95% sand, ~5% fines; dry, brown, brick fragments, ash, FILL.
					▨	🟩			WIDELY GRADED GRAVEL (GW); ~100% gravel, fine to coarse, angular; dry, gray, FILL.
					▨	🟩		B-509(13) 9-10	LEAN CLAY (CL); ~100% fines; moist, brown, trace fine sand, trace gravel, FILL.
10	S-2	5.0	1.7	0.2, 23.4, 2.7, 0.4	▨	🟩			LEAN CLAY (CL); ~100% fines; wet, brown, trace fine sand, trace gravel, FILL.
					▨	🟨	NLO	B-509(13) 11-14	WIDELY GRADED SAND WITH SILT (SW); ~85% sand, fine to coarse, ~10% fines, ~5% gravel, fine; moderate naphthalene-like odor, moist, black and brown, coal fragments and ash, black stained portions, FILL.
					▨	🟨	NLO		WIDELY GRADED SAND WITH SILT (SW); ~85% sand, fine to coarse, ~10% fines, ~5% gravel, fine to coarse; moderate naphthalene-like odor, wet, brown, black stained portions, FILL.
15	S-3	5.0	3.1	0.1, 0.0, 0.0, 0.0, 0.0	▨	🟨	NLO		WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~80% sand, ~10% gravel, ~10% fines; slight naphthalene-like odor, wet, coal fragments, gravel all shapes, FILL.
					▥	🟩		B-509(13) 16.5-17.5	SILT (ML); ~95% fines, ~5% sand, fine to medium; saturated, loose.
					▥	🟩			SILT (ML); ~95% fines, ~5% sand; moist to wet, brittle, layer of fine gravel at ~18' bgs, 5% fine to coarse red brown gravel bottom 0.5'.
20	S-4	5.0	2.1	0.2, 0.5, 0.3, 0.2, 0.1	●	🟩			WIDELY GRADED GRAVEL WITH SAND (GW); ~70% gravel, fine to coarse, ~25% sand, medium to coarse, ~5% fines; saturated to wet.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL	ppm = PARTS PER MILLION	NLO = NAPHTHALENE LIKE ODOR	CrLO= CREOSOTE LIKE ODOR
REC = RECOVERY LENGTH OF SAMPLE	IN. = INCHES	PLO = PETROLEUM LIKE ODOR	OLO = ORGANIC LIKE ODOR
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)	FT. = FEET	TLO = TAR LIKE ODOR	SLO = SULFUR LIKE ODOR
		CLO = CHEMICAL LIKE ODOR	MLO = MUSTY LIKE ODOR
		ALO = ASPHALT LIKE ODOR	

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BORING LOG
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B-509(13)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25					▨	🟩			

End of Boring at 25 feet.
Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
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TLO = TAR LIKE ODOR
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BORING LOG

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B-510(13)

GROUND SURFACE ELEVATION (FT): 33.2662
LOCATION: Near the Southern Tar Well
NORTHING: 1418579.635 **EASTING:** 709841.5964
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/15/2013 - 3/15/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	0.9	0.1, 0.1	▨	🟩		B-510(13) 5-10	NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; wet to saturated, brown, trace gravel, mortar, brick, concrete, coal, FILL.
10	S-2	5.0	2.2	0.3, 2.3, 0.2, 0.1	▨	🟩			
					▨	🟨	NLO	B-510(13) 11-12	NARROWLY GRADED SAND WITH SILT (SP-SM); ~85% sand, fine to medium, ~10% fines, ~5% gravel; moderate naphthalene-like odor, moist, brown and black, brick and coal fragments, mortar, stained portions, FILL.
					▨	🟨	NLO		NARROWLY GRADED SAND WITH SILT (SP-SM); ~85% sand, fine to medium, ~10% fines, ~5% gravel; slight naphthalene-like odor, moist, brown, FILL.
					▨	🟩			Brown, FILL.
15	S-3	5.0	2.5	0.0, 0.0, 0.0, 0.0	‖	🟩		B-510(13) 15-20	SILT (ML); ~95% fines, ~5% sand, fine; wet, brown.
					‖	🟩			SILT (ML); ~100% fines; moist, brown, firm, brittle.
					‖	🟩			SILT (ML); ~90% fines, ~10% gravel, fine to coarse; dry to moist, brown.
20	S-4	5.0	2.8	0.0, 0.0, 0.0	‖	🟩			SILT (ML); ~95% fines, ~5% sand, fine; wet, brown.
					∴	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~35% gravel, fine to coarse, ~5% fines; wet, gray to brown, gravel all shapes.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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BORING LOG

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B-510(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25					⁘	🟩			

End of Boring at 25 feet.
Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
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SLO = SULFUR LIKE ODOR
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BORING LOG

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B-511(13)

GROUND SURFACE ELEVATION (FT): 33.3621
LOCATION: Near the Southern Tar Well
NORTHING: 1418571.567 **EASTING:** 709834.9669
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/15/2013 - 3/15/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	1.5	0.1, 0.1, 0.1	▨	🟩		B-511(13) 5-7.5	WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, fine to coarse, ~10% fines; dry, brown, trace gravel, bricks, coal ash at 8' bgs, FILL.
					▨	🟩			LEAN CLAY (CL); ~100% fines; moist, gray, FILL.
10	S-2	5.0	1.6	0.1, 0.7, 0.2, 0.2	▨	🟩			SILTY SAND (SM); ~80% sand, fine to medium, ~20% fines; dry, gray, FILL.
					▨	🟨	NLO	B-511(13) 11-13	Moderate naphthalene-like odor, dry, black coal fragments, tiny wood chips, FILL.
					▨	🟩			SILT (ML); ~80% fines, ~10% gravel, ~10% sand; moist, brown, trace fine reddish brown sand, coarse gravel at 15' bgs, FILL.
15	S-3	5.0	2.9	0.2, 0.2, 0.1, 0.0, 0.0	⁘	🟩			NARROWLY GRADED SAND (SP); ~95% sand, ~5% fines; dry, brown orange, firm.
					⁘	🟩			NARROWLY GRADED SAND (SP); ~95% sand, ~5% fines; wet, gray.
					⁘‖	🟩			NARROWLY GRADED SAND WITH SILT (SP-SM); ~90% sand, ~10% fines; saturated, gray brown.
					‖	🟩			SILT (ML); ~100% fines; moist, brown.
					⁘‖	🟩		B-511(13) 19-20	SILTY SAND (SM); ~80% sand, fine to medium, ~15% fines, ~5% gravel, fine; wet, brown gray, trace fine reddish brown sand, firm, hard drilling.
20	S-4	5.0	2.0	0.1, 0.1, 0.1, 0.1	‖	🟩			SILT (ML); ~80% fines, ~10% gravel, ~10% sand, fine to medium; wet to moist, brown.
					⁘	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~60%

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL	ppm = PARTS PER MILLION	NLO = NAPHTHALENE LIKE ODOR	CrLO= CREOSOTE LIKE ODOR
REC = RECOVERY LENGTH OF SAMPLE	IN. = INCHES	PLO = PETROLEUM LIKE ODOR	OLO = ORGANIC LIKE ODOR
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)	FT. = FEET	TLO = TAR LIKE ODOR	SLO = SULFUR LIKE ODOR
		CLO = CHEMICAL LIKE ODOR	MLO = MUSTY LIKE ODOR
		ALO = ASPHALT LIKE ODOR	

CLIENT:	**National Grid**	**BORING LOG**	
PROJECT:	**Troy Liberty Street**	**PAGE 2 of 2**	**B-511(13)**
CITY/STATE:	**Troy, New York**		
GEI PROJECT NUMBER:	**093300-1-1113**		

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25					▨	🟩			sand, fine to coarse, ~35% gravel, fine to coarse, ~5% fines; wet, gray to brown, gravel all shapes. End of Boring at 25 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

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IN. = INCHES
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BORING LOG

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B-512(13)

GROUND SURFACE ELEVATION (FT): 33.4133
LOCATION: Near the Southern Tar Well
NORTHING: 1418564.657 **EASTING:** 709829.3927
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/15/2013 - 3/15/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		5.0			▩	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	2.1	0.0, 0.0, 0.0, 0.0	▩	🟩			NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; dry, brown and red, bricks, coarse stone, FILL.
					▩	🟩		B-512(13) 9-10	SILTY SAND (SM); ~80% sand, fine to coarse, ~20% fines; wet, brown gray, trace gravel, FILL.
10	S-2	5.0	2.3	0.0, 0.0, 0.0, 0.0	▩	🟨	NLO		SILTY SAND (SM); slight naphthalene-like odor, same as above, 0.2' coarse stone at 12.1' bgs, FILL.
					▩	🟨	NLO	B-512(13) 12.5-13.5	NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; moderate naphthalene-like odor, moist, dark gray and black, trace fine gravel, FILL.
					▩	🟨	NLO		SILT (ML); ~90% fines, ~5% gravel, fine, ~5% sand, fine; slight naphthalene-like odor, moist, gray, FILL.
					▩	🟩			SILTY SAND (SM); ~75% sand, fine to coarse, ~15% fines, ~10% gravel, fine; dry, brown to red brown, FILL.
15	S-3	5.0	2.6	0.0, 0.0, 0.0, 0.0, 0.0	░	🟩		B-512(13) 15-16	SILTY SAND (SM); ~85% sand, ~15% fines; wet, brown, trace fine gravel.
					▥	🟩			SILT (ML); ~90% fines, ~10% sand, fine; wet, brown, firm, trace fine reddish brown sand.
					▥	🟩			SILT WITH SAND (ML); ~80% fines, ~20% sand, fine; wet, brown, firm, trace fine gravel.
20	S-4	5.0	2.3	0.2, 0.2, 0.1, 0.1, 0.1	⁙	🟩			WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to coarse, ~20% gravel, fine, ~10% fines; saturated, brown gray.

NOTES:

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IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
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TLO = TAR LIKE ODOR
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B-512(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25					░	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~35% gravel, fine to coarse, ~5% fines; wet, brown, gravel all shapes.
									End of Boring at 25 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

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BORING LOG

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B-513(13)

GROUND SURFACE ELEVATION (FT): 33.216
LOCATION: Near the Southern Tar Well
NORTHING: 1418564.561 **EASTING:** 709818.3941
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO: TYPE and NO.	SAMPLE INFO: PEN FT.	SAMPLE INFO: REC FT.	SAMPLE INFO: PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0				🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	1.9	0.0, 0.1, 0.2		🟩		B-513(13) 9-10	Brown, red, dark gray, mix of sand, bricks, trace ash, trace gravel, clay in shoe, moist, FILL.
10	S-2	5.0	2.3	0.1, 0.1, 9.3, 15.1		🟩 🟨 🟨 🟧 🟨	NLO NLO NLO NLO NLO	B-513(13) 13-14	LEAN CLAY (CL); ~100% fines; moist, trace fine sand, FILL. NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; slight naphthalene-like odor, moist, gray brown, trace fine gravel, firm, FILL. LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, trace fine sand, FILL.
15	S-3	5.0	2.5	0.6, 1.6, 1.3, 3.1, 1.9		🟧 🟨 🟨 🟨 🟨 🟨	NLO NLO NLO NLO NLO NLO	B-513(13) 15.5-16.5	Strong naphthalene-like odor, wood, black stained, trace sheen, FILL. SILT (ML); ~90% fines, ~10% sand, fine; strong naphthalene-like odor, moist, brown to dark brown, trace subrounded gravel, trace black stains, FILL. Strong naphthalene-like odor, trace tiny lenses (1 mm) of black NAPL in pores, sheen, FILL. SILT (ML); ~80% fines, ~10% gravel, fine to coarse, ~10% sand, fine; strong naphthalene-like odor, moist, brown, sheen in water poured from the core, sheen in soil, FILL.
20	S-4	5.0	3.0	0.6, 1.6, 1.3, 3.1, 1.9		🟨 🟨 🟨	NLO NLO NLO		Strong naphthalene-like odor, thin lense (1 mm) of brown NAPL, FILL. SILT (ML); ~80% fines, ~10% gravel, fine to coarse, ~10% sand, fine; strong naphthalene-like odor, moist, brown gray. NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; strong naphthalene-like odor, moist to wet, gray, trace subrounded gravel. SILT (ML); ~100% fines; strong naphthalene-like odor,

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IN. = INCHES
FT. = FEET

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B-513(13)

DEPTH FT.	SAMPLE INFO: TYPE and NO.	SAMPLE INFO: PEN FT.	SAMPLE INFO: REC FT.	SAMPLE INFO: PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25					▨	🟩		B-513(13) 24.5-25	moist, light brown, trace fine sand, trace staining. WIDELY GRADED SAND (SW); ~100% sand; strong naphthalene-like odor, wet, black gray, trace fines, trace fine gravel. SILT (ML); ~80% fines, ~10% sand, fine; slight naphthalene-like odor, saturated, brown, trace gravel, trace brick. SILT (ML); ~80% fines, ~10% sand; slight naphthalene-like odor, saturated, gray brown, trace organics. WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~40% gravel, fine to coarse; slight naphthalene-like odor, saturated, dark gray, black staining. WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~40% gravel, fine to coarse; saturated, brown gray. End of Boring at 25 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
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MLO = MUSTY LIKE ODOR

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455 Winding Brook Road
Glastonbury, CT 06033
(860) 368-5300

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B-514(13)

GROUND SURFACE ELEVATION (FT): 33.153
LOCATION: Near the Southern Tar Well
NORTHING: 1418565.168 **EASTING:** 709812.7402
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0			▨	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-1	5.0	1.6	0.5, 0.4, 0.3	▨	🟩			(SP-SM); poor recovery, brown, red, dark gray, mix of sand, bricks, ash, gravel, clay in shoe, moist, FILL.
10	S-2	5.0	1.7	0.4, 4.8, 15.8	▨	🟩			SILT (ML); ~85% fines, ~10% sand, fine to coarse, ~5% gravel; dry, brown, trace brick fragments, FILL.
					▨	🟨	NLO	B-514(13) 12-13	LEAN CLAY (CL); ~100% fines; moist, brown gray, FILL. Moderate naphthalene-like odor, moist, gray, black stained, FILL.
					▨	🟧			Slight sheen on angular gravel/coarse stone at ~15' bgs.
15	S-3	5.0	4.0	2.2, 10.6, 38.6, 14.2, 12.4	▨	🟧	NLO	B-514(13) 15.5-16	SILT (ML); ~95% fines, ~5% sand, fine to coarse; strong naphthalene-like odor, moist to wet, brown, traces of staining and sheen, FILL.
					░	🟨	NLO		NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% fines; strong naphthalene-like odor, wet, brown and gray, coarse gravel at 21.6' bgs. Black stained, slight sheen.
20	S-4	5.0	1.8	8.8, 2.8, 2.3	░	🟧		B-514(13) 20-21.5	
					░	🟨	NLO NLO		NARROWLY GRADED SAND (SP); ~100% sand, fine; strong naphthalene-like odor, moist, orange brown. WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~15% gravel, fine; moderate naphthalene-like odor, moist, brown gray.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

GEI Consultants GEI Consultants, Inc. 455 Winding Brook Road Glastonbury, CT 06033 (860) 368-5300	**CLIENT:** **National Grid** **PROJECT:** **Troy Liberty Street** **CITY/STATE:** **Troy, New York** **GEI PROJECT NUMBER:** **093300-1-1113**	**PAGE** **2 of 2**	**BORING LOG** **B-514(13)**

DEPTH FT.	**SAMPLE INFO**				**STRATA**	**VISUAL IMPACTS**	**ODOR**	**ANALYZED SAMPLE ID**	**SOIL / BEDROCK DESCRIPTION**
	TYPE and NO.	**PEN FT.**	**REC FT.**	**PID (ppm)**					
25					⁘	🟨			
									End of Boring at 25 feet. Fill with bentonite chips.

NOTES:

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CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

PAGE 1 of 2

B-515(13)

GROUND SURFACE ELEVATION (FT): 32.9441
LOCATION: Near the Southern Tar Well
NORTHING: 1418563.079 **EASTING:** 709802.681
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Ritchie Comfort
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/12/2013 - 3/12/2013
DRILLING DETAILS: Hollow Stem Auger/3 inch ID Split Spoon
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFORMATION: TYPE and NO.	PEN FT.	REC FT.	Blows (/6 in.)	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID
0		5.0				▩	🟩		
5	S-1	2.0	2.0	9-8-5-6	0.0, 0.4, 0.0, 0.6	▩	🟩		
	S-2	2.0	1.8	5-6-5-6	0.0, 0.0, 0.0, 0.0	▩	🟩		
	S-3	2.0	2.0	4-3-3-4	0.0, 0.0, 0.0, 0.0	▩	🟩		B-515(13) 9-10
10	S-4	2.0	2.0	8-11-12-10	0.0, 0.0, 0.0, 0.0	▩	🟩 🟨	NLO	B-515(13) 12.6-12.8
	S-5	2.0	1.4	6-10-7-7	0.0, 0.0, 0.0	▩	🟨	NLO NLO NLO NLO	
15	S-6	2.0	1.2		0.0, 0.0, 0.0	▩ ⁘	🟨	NLO NLO	
	S-7	2.0	2.0	4-6-6-6	0.0, 0.0, 0.0, 0.0	⁘ ▥	🟨	NLO NLO	B-515(13) 18.5-19
	S-8	2.0	1.6	4-11-20-15	0.0, 0.0, 0.0, 0.0	▥ ◇	🟨	NLO NLO	
20	S-9	2.0	0.6	10-18-17-16	0.0, 0.0	◇	🟨	NLO	
	S-10	2.0	2.0	9-13-10-13	0.0, 0.0, 0.0, 0.0	◇	🟨	NLO	B-515(13) 23-23.5

SOIL / BEDROCK DESCRIPTION

Hand and vacuum cleared to 5' bgs, FILL.

SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine to coarse; moist, brown, bricks at 2.3' bgs, FILL.

WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; moist, brown, trace cobble, FILL.

LEAN CLAY (CL); ~100% fines; moist, gray, firm, FILL.

LEAN CLAY (CL); ~100% fines; moist, gray brown, layers of fine to medium sand, FILL.

NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; moist to wet, dark gray, trace fines, 50% clay mixed in 10-10.6' bgs, FILL.

LEAN CLAY (CL); ~100% fines; wet, gray, layers of fine to medium sand, FILL.

LEAN CLAY (CL); ~100% fines; moist, brown and gray, FILL.

CLAYEY SAND (SC); ~80% sand, fine to medium, ~20% fines; moist, brown, trace fine subrounded gravel, FILL.

CLAYEY SAND (SC); ~80% sand, fine to coarse, ~20% fines; moist, dark gray, FILL.

Slight naphthalene-like odor.

CLAYEY SAND (SC); ~80% sand, ~20% fines; slight naphthalene-like odor, moist, dark gray to brown, FILL.

Slight naphthalene-like odor, wet, SAA, wet, FILL.

NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; slight naphthalene-like odor, wet, brown to reddish brown, trace fine subangular gravel, FILL.

SILT (ML); ~85% fines, ~10% sand, fine, ~5% gravel, fine; slight naphthalene-like odor, moist, dark gray, FILL.

Slight naphthalene-like odor, moist, FILL.

NARROWLY GRADED SAND (SP); ~95% sand, fine, ~5% fines; slight naphthalene-like odor, moist, brown.

NARROWLY GRADED SAND (SP); ~95% sand, fine, ~5% fines; slight naphthalene-like odor, wet,

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DEPTH FT.	**SAMPLE INFORMATION**					**STRATA**	**VISUAL IMPACTS**	**ODOR**	**ANALYZED SAMPLE ID**	**SOIL / BEDROCK DESCRIPTION**
	TYPE and NO.	**PEN FT.**	**REC FT.**	**Blows (/6 in.)**	**PID (ppm)**					
							🟨			brown, loose. SILT (ML); ~95% fines, ~5% sand, fine; slight naphthalene-like odor, moist, brown, brittle, firm. SILT (ML); ~90% fines, ~10% sand, fine to medium; slight naphthalene-like odor, saturated, brown. WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; slight naphthalene-like odor, wet, dark gray, bottom 0.3' - coarse gravel and trace fine reddish brown sand. WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine; moderate naphthalene-like odor, saturated to wet, dark gray. WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel; moderate naphthalene-like odor, saturated to wet, brown gray, trace fines. NARROWLY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~85% sand, fine to coarse, ~10% fines, ~5% gravel, fine to coarse; moderate naphthalene-like odor, saturated to wet, brown gray.
25							🟨	NLO		

End of Boring at 25 feet.
A 3-inch spoon was used for the entire boring for better recoveries.
Fill with bentonite chips.

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GEI Consultants, Inc.
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CLIENT: National Grid	**BORING LOG**	
PROJECT: Troy Liberty Street	**PAGE** 1 of 2	**B-516(13)**
CITY/STATE: Troy, New York		
GEI PROJECT NUMBER: 093300-1-1113		

GROUND SURFACE ELEVATION (FT): 32.528
LOCATION: Near the Southern Tar Well
NORTHING: 1418577.155 **EASTING:** 709801.7991
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Ritchie Comfort
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	1.9	0.8, 0.7, 0.8	▩	🟩			Hand and vacuum cleared to 5' bgs, FILL.
5	S-2	5.0	3.6	0.6, 0.5, 0.5, 0.5, 0.4	▩	🟩			SILT (ML); ~90% fines, ~10% sand, fine to medium; dry, brown, trace brick fragments, FILL.
					▩	🟩			LEAN CLAY (CL); ~100% fines; moist, gray, trace fine sand, FILL.
					▩	🟩		B-516(13) 7.5-8	LEAN CLAY (CL); ~100% fines; wet, brown, layers of fine sand, FILL.
					▩	🟩			NARROWLY GRADED SAND WITH SILT (SP); ~90% sand, fine, ~10% fines; moist, gray, FILL.
10	S-3	5.0	2.1	0.4, 1.2, 0.7	▩	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, brown gray, trace fine sand, trace fine gravel, all shapes, FILL.
					▩	🟨	NLO		LEAN CLAY (CL); ~100% fines; moderate naphthalene-like odor, moist, brown gray, trace fine sand, trace fine gravel, all shapes, FILL.
					▩	🟨	NLO	B-516(13) 14-15	CLAYEY SAND WITH GRAVEL (SC); ~60% sand, ~20% gravel, ~20% fines; moderate naphthalene-like odor, moist, brown, FILL.
15	S-4	5.0	3.9	0.6, 0.7, 0.7, 0.6, 0.8	▩	🟨	NLO		WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, fine to coarse, ~10% fines; moderate naphthalene-like odor, saturated, gray, trace gravel, slight black staining, FILL.
					▥	🟨	NLO	B-516(13) 18.25-18.75	SILT (ML); ~90% fines, ~10% sand; moderate naphthalene-like odor, wet, brown, thin black stained portions, vertical stains (1-2mm) 16.0-16.3' bgs.
					░	🟨	NLO		NARROWLY GRADED SAND (SP); ~100% sand; moderate naphthalene-like odor, wet, brown gray, trace fines, trace fine gravel.
20	S-5	5.0	3.6		░	🟨			
					●	🟨	NLO	B-516(13) 22.5-23	WIDELY GRADED GRAVEL WITH SAND (GW); ~60% gravel, fine to coarse, ~40% sand, fine to coarse; slight naphthalene-like odor, wet, brown gray.
					░	🟨	NLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~80%

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CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

PAGE 2 of 2

B-516(13)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25					░	🟨			sand, fine to coarse, ~20% gravel, fine to coarse; slight naphthalene-like odor, wet, brown gray, trace fines. End of Boring at 25 feet. Fill with bentonite chips.

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GEI Consultants, Inc. 455 Winding Brook Road Glastonbury, CT 06033 (860) 368-5300	**CLIENT:** National Grid **PROJECT:** Troy Liberty Street **CITY/STATE:** Troy, New York **GEI PROJECT NUMBER:** 093300-1-1113	**BORING LOG** **PAGE 1 of 2** **B-517(13)**

GROUND SURFACE ELEVATION (FT): 33.1925
LOCATION: Near the Southern Tar Well
NORTHING: 1418567.47 **EASTING:** 709823.5884
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0	S-1	5.0	2.4	0.2, 0.2, 0.2, 0.1		🟩			Asphalt, brown sand and silt, brick fragments, coal fragments, dry, no odor, FILL.
5	S-2	5.0		0.1, 0.1		🟩			Same as above, dry to moist, black stained soil in shoe, FILL.
10	S-3	5.0	2.6	0.4, 2.8, 0.4, 10.4, 2.0		🟩 🟨 🟪 🟨	NLO NLO	B-517(13) 11-12	LEAN CLAY (CL); ~100% fines; moist, brown gray, trace fine sand, trace gravel, FILL. SILT (ML); ~100% fines; strong naphthalene-like odor, wet, gray brown, 2 mm thin vertical lense of black NAPL, FILL. WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, fine to coarse, ~5% fines; strong naphthalene-like odor, wet, gray black, brick fragments, faint sheen ~13.8' bgs, FILL.
15	S-4	5.0	4.7	0.6, 0.6, 0.9, 2.3, 3.3		🟨	NLO NLO NLO NLO NLO		SILT (ML); ~100% fines; slight naphthalene-like odor, dry, light brown, trace fine to medium sand. SILT (ML); ~100% fines; moderate naphthalene-like odor, moist, gray, black stained 16.4 to 16.7' bgs - strong odor. SILT (ML); ~100% fines; moderate naphthalene-like odor, moist, trace fine to medium sand, trace gravel. NARROWLY GRADED SAND WITH GRAVEL (SP-SM); ~85% sand, fine to medium, ~10% gravel, ~5% fines; moderate naphthalene-like odor, wet, brown gray, black stained 17.5 to 17.7' bgs - strong odor.
20	S-5	5.0	3.0	1.2, 1.0, 0.8, 0.7, 0.6		🟨	NLO NLO		LEAN CLAY (CL); ~95% fines, ~5% sand, fine to medium; moderate naphthalene-like odor, wet, gray, black stained 18.6 to 19.0' bgs - strong odor. SILT (ML); ~95% fines, ~5% sand; moderate naphthalene-like odor, wet to saturated, trace fine sand, portions of black stained soil. WIDELY GRADED SAND WITH GRAVEL (SW); ~80%

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GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-517(13)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25					░	🟨		B-517(13) 24.5-25	sand, fine to coarse, ~20% gravel, fine to coarse; moderate naphthalene-like odor, wet, dark gray, trace fines, rounded and subrounded gravel.

End of Boring at 25 feet.
Fill with bentonite chips.

NOTES:

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GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B-518(13)

GROUND SURFACE ELEVATION (FT): 33.0204
LOCATION: Near the Southern Tar Well
NORTHING: 1418554.339 **EASTING:** 709810.0309
TOTAL DEPTH (FT): 25.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	2.3		▨	🟩			Brown fine to medium sand, trace coarse stone, some silt, trace gravel, dry, FILL.
					▨	🟨			Black stained.
					▨	🟩			
5	S-2	5.0	2.6	0.2, 0.2, 0.2, 0.2	▨	🟩		B-518(13) 5-7.5	WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; moist to wet, brown gray, trace fine to coarse gravel, black coal fragments, FILL.
					▨	🟩			LEAN CLAY (CL); ~100% sand; wet, gray, firm,FILL.
10	S-3	5.0	2.1	0.2, 0.2, 0.2, 0.2	▨	🟩			LEAN CLAY (CL); ~100% sand; moist, gray, trace fine sand, soft, FILL.
					▨	🟩			NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~10% fines; moist, gray, trace gravel, various shapes, FILL.
					▨	🟩			NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% gravel, fine; moist, brown, trace coal fragments,FILL.
					▨	🟨	NLO	B-518(13) 14.5-16	NARROWLY GRADED SAND (SP); ~90% sand, ~10% gravel, fine to coarse; moderate naphthalene-like odor, moist, black stained, FILL.
15	S-4	5.0	2.3	1.8, 1.1, 0.8, 2.2, 1.2	▥	🟨	NLO		SILT (ML); ~95% fines, ~5% sand; moderate naphthalene-like odor, moist, gray, black stained to 16' bgs.
					▥	🟨	NLO		SILT (ML); ~95% fines, ~5% sand; slight naphthalene-like odor, wet to moist, gray to light brown.
					░	🟨	NLO		NARROWLY GRADED SAND (SP); ~95% sand, ~5% fines; slight naphthalene-like odor, moist, gray.
20	S-5	5.0	2.2	0.5, 0.4, 0.5, 0.8	▥	🟨	NLO		SILT (ML); ~100% fines; slight naphthalene-like odor, wet, brown gray brown gray, trace fine sand.
					░	🟨	NLO	B-518(13) 21-22	NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~5% gravel, fine to coarse, ~5% fines; moderate naphthalene-like odor, wet, gray and brown.

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PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

CLIENT: National Grid **PROJECT:** Troy Liberty Street **CITY/STATE:** Troy, New York **GEI PROJECT NUMBER:** 093300-1-1113	**PAGE** **2 of 2**	**BORING LOG** **B-518(13)**

DEPTH FT.	**SAMPLE INFO** **TYPE and NO.**	**PEN FT.**	**REC FT.**	**PID (ppm)**	**STRATA**	**VISUAL IMPACTS**	**ODOR**	**ANALYZED SAMPLE ID**	**SOIL / BEDROCK DESCRIPTION**
					▒	🟨			
25									End of Boring at 25 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
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ppm = PARTS PER MILLION
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CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B-519(13)

GROUND SURFACE ELEVATION (FT): 29.5413
LOCATION: Angled Near Northern Tar Well
NORTHING: 1418779.382 **EASTING:** 709836.1634
TOTAL DEPTH (FT): 40.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/19/2013 - 3/19/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	 PEN FT.	 REC FT.	 PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	2.8	0.4, 0.1, 0.1, 1.1	■	🟩			FILL.
					▨	🟨	NLO		SILTY SAND (SM); ~85% sand, fine to medium, ~15% fines; slight naphthalene-like odor, dry, brown, trace gravel, coal and brick fragments, FILL.
5	S-2	5.0	2.4	0.4, 0.2, 0.1, 0.3, 0.4	▨	🟩			NARROWLY GRADED SAND WITH SILT (SP-SM); ~90% sand, fine to medium, ~10% fines; dry, light brown to brown, silt layer between 7 and 8', trace gravel and brick fragments at 8', FILL.
10	S-3	5.0	1.5	0.0, 0.0, 0.0, 0.0, 0.0	▨	🟩			SILTY SAND (SM); ~75% sand, fine to medium, ~20% fines, ~5% gravel; dry, brown, trace brick fragments, FILL.
15	S-4	5.0	4.5	0.0, 0.0, 0.1, 0.1, 0.2	▨	🟩			SILT WITH SAND (ML); ~90% fines, ~10% sand, fine to medium; saturated, gray brown, trace gravel, FILL.
					▨	🟩			SILT (ML); ~100% fines; saturated, gray, layers of fine sand, trace gravel, FILL.
					▨	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, gray, thin black stained streaks, FILL.
					▨	🟨	NLO		SILT (ML); ~100% fines; slight naphthalene-like odor, moist, gray brown olive, trace fine sand, FILL.
20	S-5	5.0	3.3	0.1, 0.1, 0.1, 0.1, 0.1	▨	🟨	NLO		LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, gray, trace fine sand, slight staining, FILL.
					▨	🟩			SILT (ML); ~100% fines; wet, olive, trace fine sand, trace fine gravel, FILL.
					▨	🟩			SILT (ML); ~95% fines, ~5% sand, fine; wet, brown red, trace fine gravel, FILL.
					▨	🟩			NARROWLY GRADED SAND (SP); ~95% sand, fine to

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BORING LOG
PAGE 2 of 2
B-519(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟨	NLO		medium, ~5% fines; wet, gray, FILL.
25	S-6	5.0	3.5	0.2, 0.1, 0.1, 0.2, 17.2		🟨 🟩 🟩 🟪	NLO NLO	B-519(13) 29-30	NARROWLY GRADED SAND (SP); ~90% sand, fine to medium, ~5% gravel, ~5% fines; wet, olive, FILL. WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, ~5% fines; slight naphthalene-like odor, moist, gray to light brown, FILL. SILT (ML); ~95% fines, ~5% sand; slight naphthalene-like odor, wet, gray to olive, slight thin staining, FILL. WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; wet, gray, FILL. WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to coarse, ~15% gravel, fine to coarse, ~5% fines; wet, gray to brown, FILL.
30	S-7	5.0	4.0	0.2, 1.7, 0.4, 0.2, 0.2		🟨 🟨 🟨 🟩	NLO NLO NLO	B-519(13) 34-35	SILT WITH GRAVEL (ML); ~70% fines, ~30% gravel, fine to coarse; strong naphthalene-like odor, moist, dark gray, 1 mm thin sticky tar stringers, FILL. SILT WITH SAND (ML); ~90% fines, ~10% sand; strong naphthalene-like odor, wet, gray, FILL. WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse; moderate naphthalene-like odor, wet, brown, trace fines. WIDELY GRADED GRAVEL WITH SAND (GW); ~70% gravel, fine to coarse, ~30% sand, fine to coarse; moderate naphthalene-like odor, wet, brown, trace fines.
35	S-8	5.0	3.9	0.3, 1.2, 0.4, 0.2, 0.2		🟩	NLO NLO	B-519(13) 39-40	WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine to coarse; trace fines. WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine to coarse; slight naphthalene-like odor, wet, brown. WIDELY GRADED GRAVEL WITH SAND (GW); ~70% gravel, fine to coarse, ~30% sand, fine to coarse; moderate naphthalene-like odor, wet, brown.
40									End of Boring at 40 feet. Fill with bentonite chips.

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CLIENT:	National Grid
PROJECT:	Troy Liberty Street
CITY/STATE:	Troy, New York
GEI PROJECT NUMBER:	093300-1-1113

BORING LOG

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B-520(13)

GROUND SURFACE ELEVATION (FT):	30.802	**LOCATION:**	Angled Near Northern Tar Well
NORTHING: 1418732.764	**EASTING:** 709871.5646	**TOTAL DEPTH (FT):**	40.00
DRILLED BY:	ADT / Marty Bachner	**DATUM VERT. / HORZ.:**	MSL / NAD83
LOGGED BY:	Drew Blicharz	**DATE START / END:**	3/20/2013 - 3/20/2013
DRILLING DETAILS:	Geoprobe / 6610DT		
WATER LEVEL DEPTHS (FT):			

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	2.2	0.1, 0.1	■ ▨	🟩			Asphalt, FILL. NARROWLY GRADED SAND (SP); ~95% sand, fine to medium, ~5% gravel; dry, brown, coal fragments, brick at ~4', gravel is rounded and subangular, FILL.
5	S-2	5.0	2.8	0.1, 0.1, 0.1, 0.1	▨	🟩 🟨 🟩	 NLO 		WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~90% sand, fine to coarse, ~15% gravel, fine to coarse, subrounded, ~10% fines; wet, brown, FILL. Slight naphthalene-like odor, moist, wood chunk. WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~10% gravel, fine to coarse; moist, brown, trace fines, coal fragments, bricks, FILL.
10	S-3	5.0	3.1	0.7, 4.3, 6.1, 2.9, 1.4	▨	🟨	NLO NLO NLO NLO NLO NLO	B-520(13) 11-12	Fine, subrounded; moderate naphthalene-like odor, moist, brick, trace fine to medium sand, FILL. WIDELY GRADED SAND (SW); ~90% sand, ~5% gravel, ~5% fines; slight naphthalene-like odor, wet, brown, black stained, coal fragments, wood fragments, FILL. SILT (ML); ~100% fines; strong naphthalene-like odor, moist, FILL. LEAN CLAY (CL); ~100% fines; moderate naphthalene-like odor, moist, gray, firm, FILL. LEAN CLAY (CL); ~95% fines, ~5% sand, fine to medium; moderate naphthalene-like odor, moist, brown and gray, trace fine to coarse subangular gravel, FILL. LEAN CLAY (CL); ~100% fines; slight naphthalene-like odor, moist, gray, firm, brick fragments at ~13.5', FILL.
15	S-4	5.0	4.2	0.6, 2.7, 5.6, 2.7, 0.7	▨	🟨	NLO NLO NLO NLO NLO NLO NLO		WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; moderate naphthalene-like odor, wet, brown, trace fine gravel, trace brick fragments, FILL. SILT (ML); ~95% fines, ~5% sand, fine to medium; moderate naphthalene-like odor, wet, brown, FILL. Strong naphthalene-like odor, wet, SAA, black stained, FILL. WIDELY GRADED SAND WITH SILT (SW); ~90% sand, fine to coarse, ~10% gravel, fine, ~10% fines; moderate naphthalene-like odor, wet, brown, FILL. LEAN CLAY (CL); ~100% fines; moderate naphthalene-like odor, wet, gray, trace fine sand, firm, FILL.
20	S-5	5.0	4.0	0.3, 0.4, 0.3, 0.3, 0.2	▨	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel, fine to coarse, subrounded; moderate

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BORING LOG
PAGE 2 of 2
B-520(13)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID
					▨	🟩		
25	S-6	5.0	2.2	0.2, 0.2, 0.2, 0.2	▨	🟨	NLO NLO	
					▨	🟨	NLO	B-520(13) 27.5-30
30	S-7	5.0	1.7	0.2, 0.2, 0.2	∴	🟨	NLO	
					∘	🟨		B-520(13) 34-35
35	S-8	5.0	3.0	0.2, 0.2, 0.2, 0.2, 0.2	∘	🟩		
					∘	🟨	NLO	
					∘	🟩		B-520(13) 38-40
40								

SOIL / BEDROCK DESCRIPTION

naphthalene-like odor, moist, gray, FILL.
LEAN CLAY (CL); ~100% fines; moderate naphthalene-like odor, moist, gray to brown, layer of fine to medium sand, slight staining at bottom, FILL.
LEAN CLAY (CL); ~100% fines; moist, gray, firm, FILL.
SILT (ML); ~100% fines; moist, gray to olive brown, trace fine sand and subrounded gravel, wood fragments and slight staining at ~22', FILL.
SILT WITH SAND (ML); ~90% fines, ~10% sand, fine to medium; slight naphthalene-like odor, wet, brown, FILL.
NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; slight naphthalene-like odor, wet, light brown, trace fine subrounded and subangular gravel, FILL.
WIDELY GRADED SAND WITH GRAVEL (SW); ~85% sand, fine to coarse, ~15% gravel, fine to coarse; slight naphthalene-like odor, wet, brown, trace fines, gravel subrounded and subangular, FILL.
NARROWLY GRADED SAND (SP); ~95% sand, fine to coarse, ~5% gravel, fine to coarse, subangular; slight naphthalene-like odor, wet, brown.
WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~40% gravel, fine to coarse; wet, brown, gravel is all shapes.
NARROWLY GRADED SAND (SP); ~90% sand, fine to coarse, ~10% gravel, fine to coarse; saturated, brown, predominantly coarse sand, layer of coarse subangular gravel at 32.5'.

Slight naphthalene-like odor.

End of Boring at 40 feet.
Fill with bentonite chips.

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GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

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NTW1

GROUND SURFACE ELEVATION (FT): 30.1309
LOCATION: Inside the Northern Tar Well
NORTHING: 1418757.551 **EASTING:** 709853.4592
TOTAL DEPTH (FT): 20.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/20/2013 - 3/20/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)		
0	S-1	5.0		NA	▨	Asphalt, mixture of sand and gravel, FILL.
					▨	Roof of tar well ~2.4' bgs.
						Some void space below roof.
5	S-2	5.0		NA		Mixture of sand, silt, clay, gravel, bricks, FILL.
						Various degrees of tar impacts between ~8-15' bgs, odors below.
10	S-3	5.0		NA		
15	S-4	5.0		NA		
						~0.2' wood chunk at 16.9' bgs.
20						End of Boring at 20 feet. Boring was drilled to acquire impacted soil for waste characterization. Fill with soil cuttings.

NOTES:

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BORING LOG

PAGE 1 of 1

NTW2

GROUND SURFACE ELEVATION (FT): 30.0192
LOCATION: Inside the Northern Tar Well
NORTHING: 1418758.857 **EASTING:** 709853.8661
TOTAL DEPTH (FT): 20.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/20/2013 - 3/20/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	STRATA	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0		▨	Asphalt, mixture of sand and gravel, FILL.
				▨	Roof of tar well ~2.4' bgs.
				▨	Some void space below roof.
5	S-2	5.0		▨	Mixture of sand, silt, clay, gravel, bricks, FILL.
				▨	Various degrees of tar impacts between ~8-15' bgs, odors below.
10	S-3	5.0		▨	
15	S-4	5.0		▨	
20					End of Boring at 20 feet. Boring was drilled to acquire impacted soil for waste characterization. Fill with soil cuttings.

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PROJECT: Troy Liberty Street
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GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

PAGE 1 of 1

NTW3

GROUND SURFACE ELEVATION (FT): 30.0422
LOCATION: Inside the Northern Tar Well
NORTHING: 1418758.866 **EASTING:** 709852.5704
TOTAL DEPTH (FT): 20.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/20/2013 - 3/20/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)		
0	S-1	5.0		NA	▨	Asphalt, mixture of sand and gravel, FILL.
					▨	Roof of tar well ~2.4' bgs.
						Some void space below roof.
5	S-2	5.0		NA	▨	Mixture of sand, silt, clay, gravel, bricks, FILL.
						Various degrees of tar impacts between ~8-15' bgs, odors below.
10	S-3	5.0		NA	▨	
15	S-4	5.0		NA	▨	
						~1.5' of bricks, water saturated sand and gravel above.
20						End of Boring at 20 feet. Boring was drilled to acquire impacted soil for waste characterization. Fill with soil cuttings.

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BORING LOG

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NTW4

GROUND SURFACE ELEVATION (FT): 30.1001
LOCATION: Inside the Northern Tar Well
NORTHING: 1418757.228 **EASTING:** 709852.0818
TOTAL DEPTH (FT): 15.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/20/2013 - 3/20/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)		
0	S-1	5.0		NA	▨	Asphalt, mixture of sand and gravel, FILL.
					▨	Roof of tar well ~2.4' bgs.
					▨	Some void space below roof.
5	S-2	5.0		NA	▨	Mixture of sand, silt, clay, gravel, bricks, FILL.
					▨	Various degrees of tar impacts between ~8-15' bgs.
10	S-3	5.0		NA	▨	
15						End of Boring at 15 feet. Boring was drilled to acquire impacted soil for waste characterization. Fill with soil cuttings.

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PROJECT: Troy Liberty Street
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GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

PAGE 1 of 1

STW1

GROUND SURFACE ELEVATION (FT): 32.8951
LOCATION: Inside the Southern Tar Well Footprint
NORTHING: 1418573.596 **EASTING:** 709813.1145
TOTAL DEPTH (FT): 15.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)		
0	S-1	5.0		NA		Asphalt, mixture of brown sand, silt, gravel, FILL.
5	S-2	5.0		NA		Brown gray to black lean clay, brick fragments, FILL.
						MGP impacts ~7.5-13'.
10	S-3	5.0		NA		
						6-inch layer of concrete, FILL.
						Mixture of brown sand, silt, gravel, FILL.
15						End of Boring at 15 feet. Boring was drilled to acquire impacted soil for waste characterization. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 1
STW2

GROUND SURFACE ELEVATION (FT): 32.8476
LOCATION: Inside the Southern Tar Well Footprint
NORTHING: 1418573.378 **EASTING:** 709812.2897
TOTAL DEPTH (FT): 15.00
DRILLED BY: ADT / Marty Bachner
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 3/18/2013 - 3/18/2013
DRILLING DETAILS: Geoprobe / 6610DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)		
0	S-1	5.0		NA	▨	Asphalt, mixture of brown sand, silt, gravel, FILL.
5	S-2	5.0		NA	▨	Brown gray to black lean clay, brick fragments, FILL.
					▨	MGP impacts ~7.5-13'.
10	S-3	5.0		NA	▨	
					▨	6-inch layer of concrete, FILL.
					▨	Mixture of brown sand, silt, gravel, FILL.
15						End of Boring at 15 feet. Boring was drilled to acquire impacted soil for waste characterization. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
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TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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CLIENT:	National Grid
PROJECT:	Troy (Liberty St) Non-Owned Former MGP
CITY/STATE:	Troy, New York
GEI PROJECT NUMBER:	093300-1-1113

TEST PIT LOG

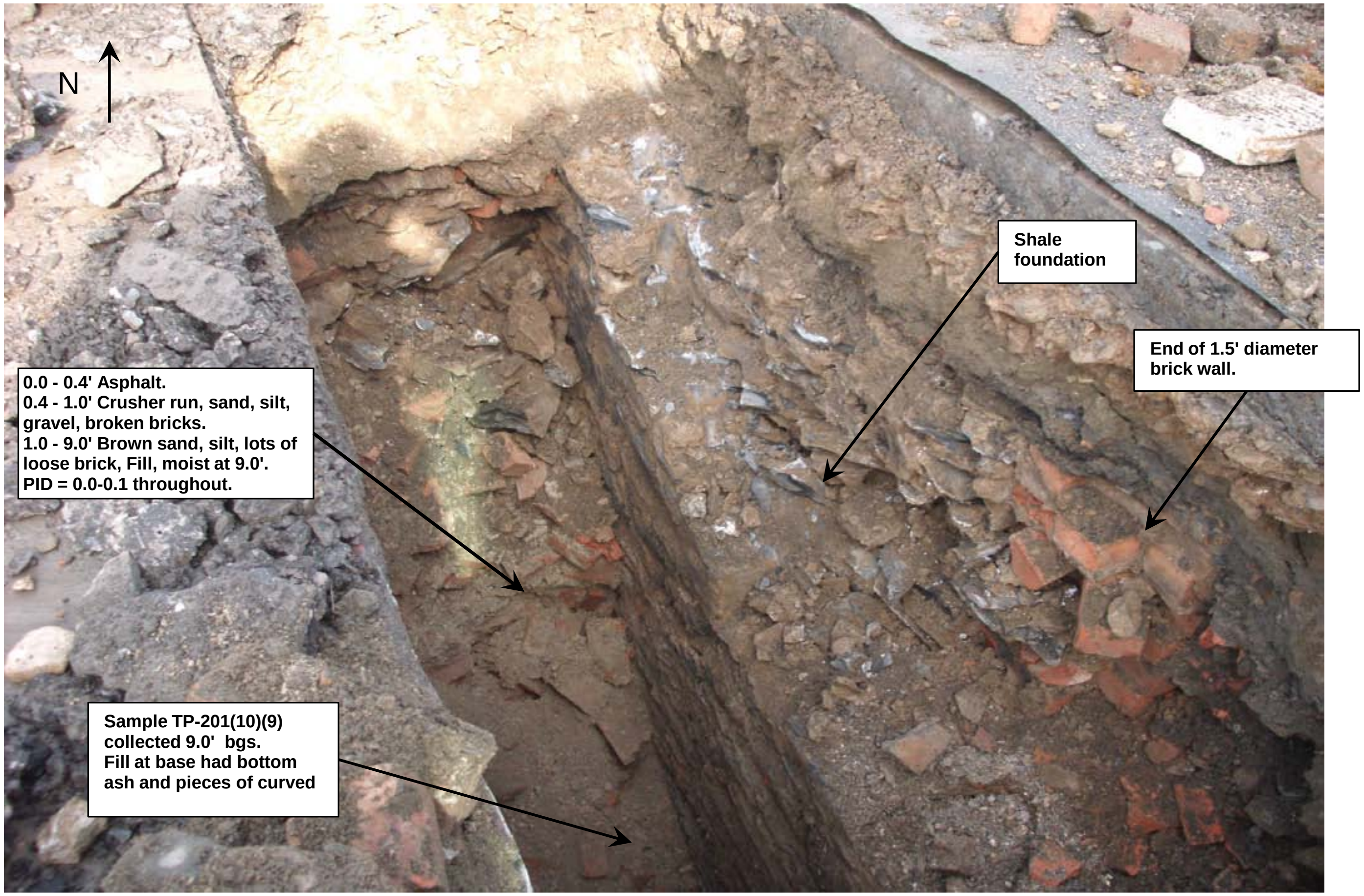
PAGE 1 of 1

TP-201(10)

GROUND SURFACE ELEVATION (FT):	27.97	LOCATION:	Northwest corner of Site
NORTHING:	1418817.5600 EASTING: 709820.9630	TOTAL DEPTH:	~ 9 ft
OBSERVED BY:	John Ripp and Jerry Zak	TOTAL LENGTH:	~ 11.5 ft
OPERATOR:	Mark Maille (Land Remediation)	TOTAL WIDTH:	~ 3 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	DATUM VERT. / HORZ.:	NAVD 88 / NAD83 NY East Zone
WEATHER:	Mid 60s, hazy, dry	DATE START / END	10/25/2010 - 10/25/2010

PHOTOGRAPH

Photograph 1: Facing North



0.0 - 0.4' Asphalt.
0.4 - 1.0' Crusher run, sand, silt, gravel, broken bricks.
1.0 - 9.0' Brown sand, silt, lots of loose brick, Fill, moist at 9.0'.
PID = 0.0-0.1 throughout.

Shale foundation

End of 1.5' diameter brick wall.

Sample TP-201(10)(9) collected 9.0' bgs.
Fill at base had bottom ash and pieces of curved

NOTES:

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IN. = INCHES
FT. = FEET

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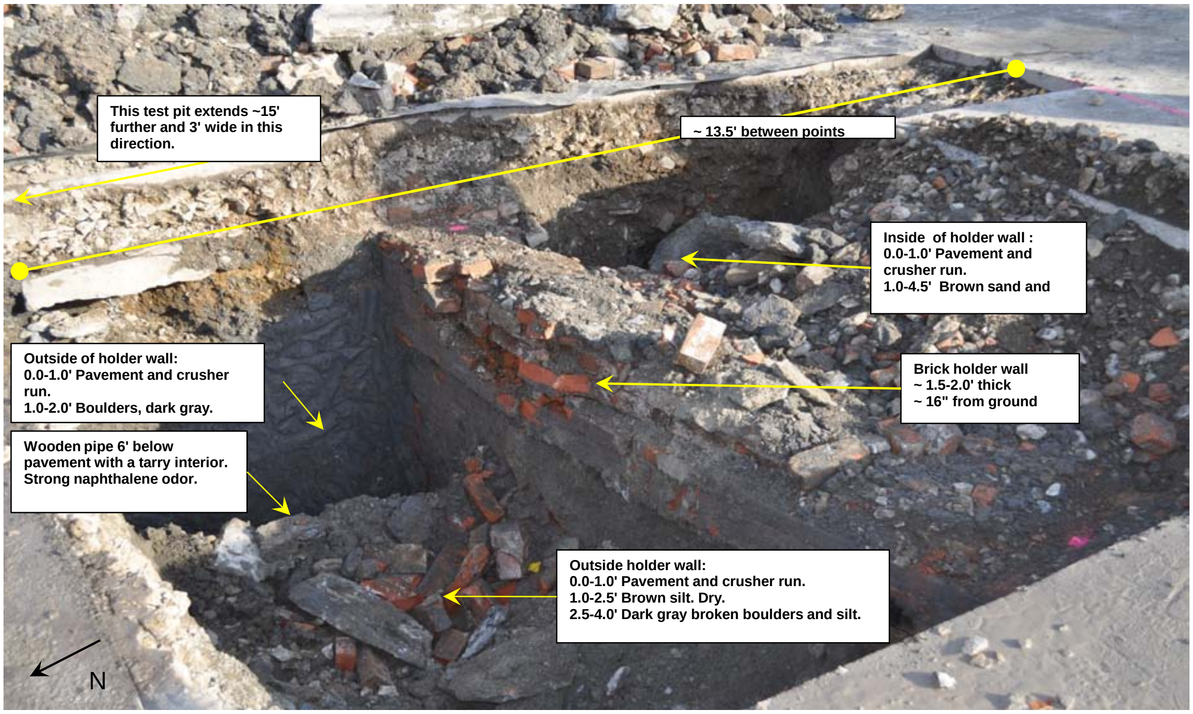
CLIENT:	National Grid	TEST PIT LOG	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	PAGE 1 of 1	TP-202(10)
CITY/STATE:	Troy, New York		
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):			29.39	LOCATION:	North wall of southwestern holder
NORTHING:	1418746.4480	EASTING:	709821.6460	TOTAL DEPTH:	~ 7 ft outside holder / ~ 4.5 ft inside holder
OBSERVED BY:	John Ripp and Jerry Zak			TOTAL LENGTH:	~ 28.5 ft / 11 ft
OPERATOR:	Mark Maille (Land Remediation)			TOTAL WIDTH:	~ 3 ft / 11 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe			DATUM VERT. / HORZ.:	NAVD 88 / NAD83 NY East Zone
WEATHER:	70s, warm, sunny			DATE START / END	10/26/2010 - 10/26/2010

PHOTOGRAPH

Photograph 1: Facing Southeast



This test pit extends ~15' further and 3' wide in this direction.

~ 13.5' between points

Inside of holder wall :
0.0-1.0' Pavement and crusher run.
1.0-4.5' Brown sand and

Outside of holder wall:
0.0-1.0' Pavement and crusher run.
1.0-2.0' Boulders, dark gray.

Brick holder wall
~ 1.5-2.0' thick
~ 16" from ground

Wooden pipe 6' below pavement with a tarry interior. Strong naphthalene odor.

Outside holder wall:
0.0-1.0' Pavement and crusher run.
1.0-2.5' Brown silt. Dry.
2.5-4.0' Dark gray broken boulders and silt.

NOTES:

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IN. = INCHES
FT. = FEET

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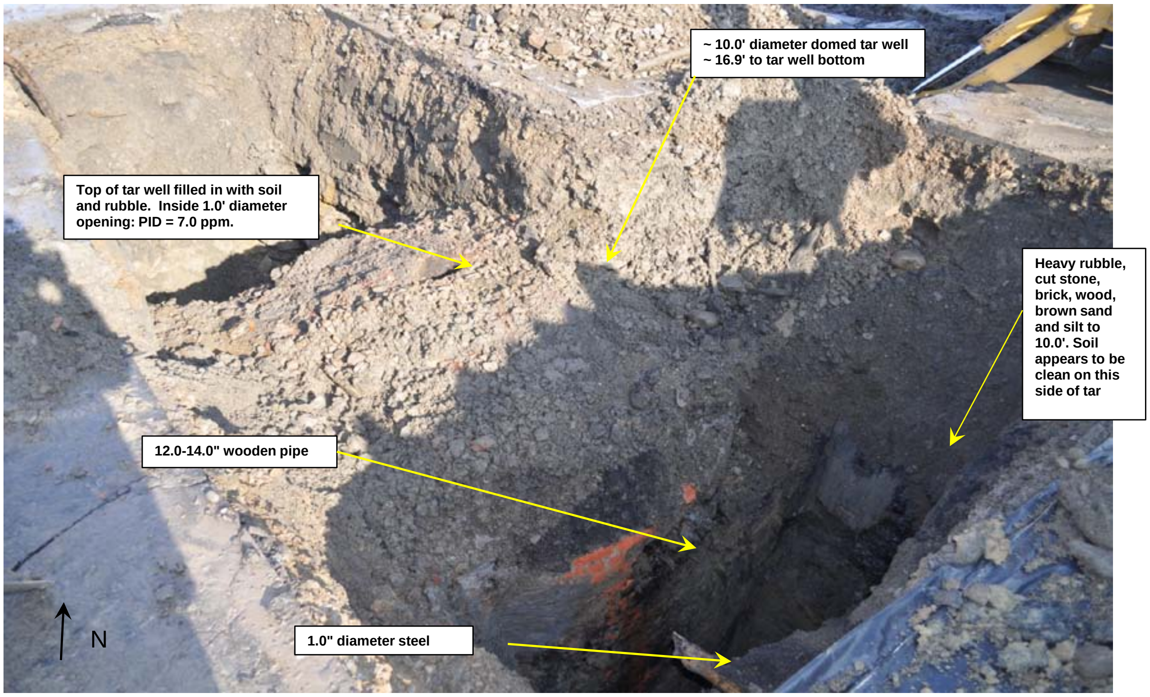
CLIENT:	National Grid	TEST PIT LOG	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	PAGE	TP-203(10)
CITY/STATE:	Troy, New York	1 of 3	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):			29.78	LOCATION:	Tar well No. 1
NORTHING:	1418769.9300	EASTING:	709865.8560	TOTAL DEPTH:	~ 10 ft
OBSERVED BY:	John Ripp and Jerry Zak			TOTAL LENGTH:	~ 12 ft
OPERATOR:	Mark Maille (Land Remediation)			TOTAL WIDTH:	~ 8 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe			DATUM VERT. / HORZ.:	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, cool, fog burning off			DATE START / END	10/26/2010 - 10/26/2010

PHOTOGRAPH

Photograph 1: Facing Northeast



NOTES:

PID = PHOTOIONIZATION DETECTOR READING
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

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CLIENT:	National Grid
PROJECT:	Troy (Liberty St) Non-Owned Former MGP
CITY/STATE:	Troy, New York
GEI PROJECT NUMBER:	093300-1-1113

TEST PIT LOG

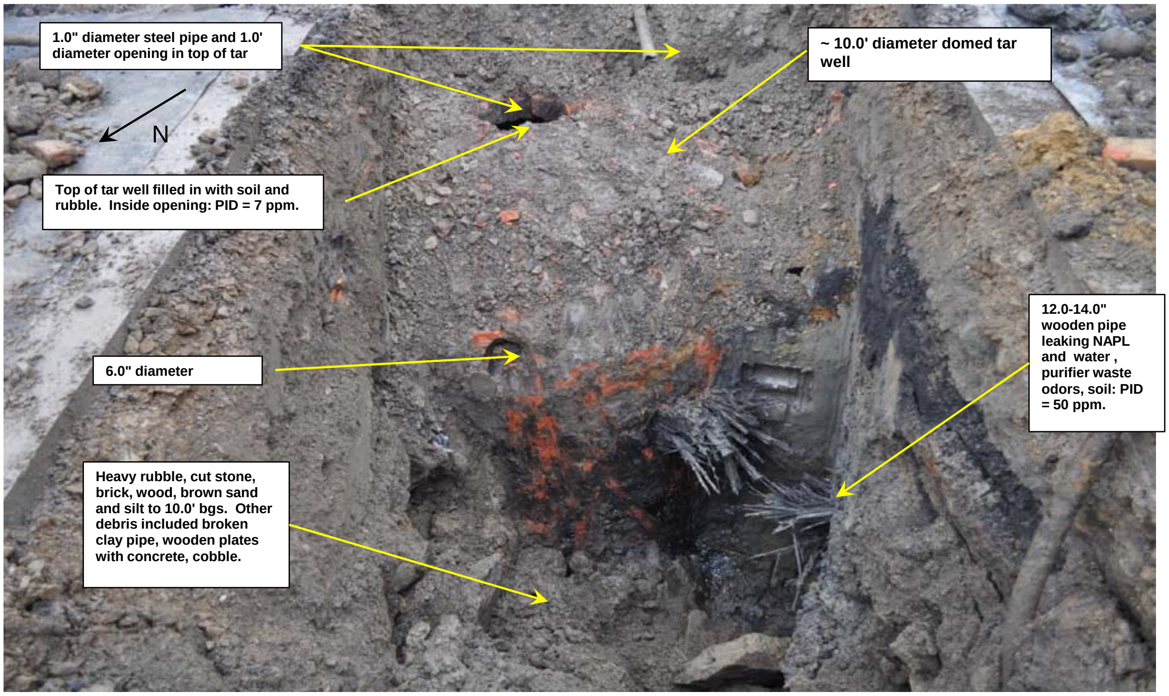
PAGE 2 of 3

TP-203(10)

GROUND SURFACE ELEVATION (FT):	29.78	**LOCATION:**	Tar well No. 1
NORTHING:	1418769.9300 **EASTING:** 709865.8560	**TOTAL DEPTH:**	~ 10 ft
OBSERVED BY:	John Ripp and Jerry Zak	**TOTAL LENGTH:**	~ 12 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 8 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, cool, fog burning off	**DATE START / END**	10/26/2010 - 10/26/2010

PHOTOGRAPH

Photograph 2: Facing Southeast



1.0" diameter steel pipe and 1.0' diameter opening in top of tar

~ 10.0' diameter domed tar well

Top of tar well filled in with soil and rubble. Inside opening: PID = 7 ppm.

12.0-14.0" wooden pipe leaking NAPL and water , purifier waste odors, soil: PID = 50 ppm.

6.0" diameter

Heavy rubble, cut stone, brick, wood, brown sand and silt to 10.0' bgs. Other debris included broken clay pipe, wooden plates with concrete, cobble.

NOTES:

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IN. = INCHES
FT. = FEET

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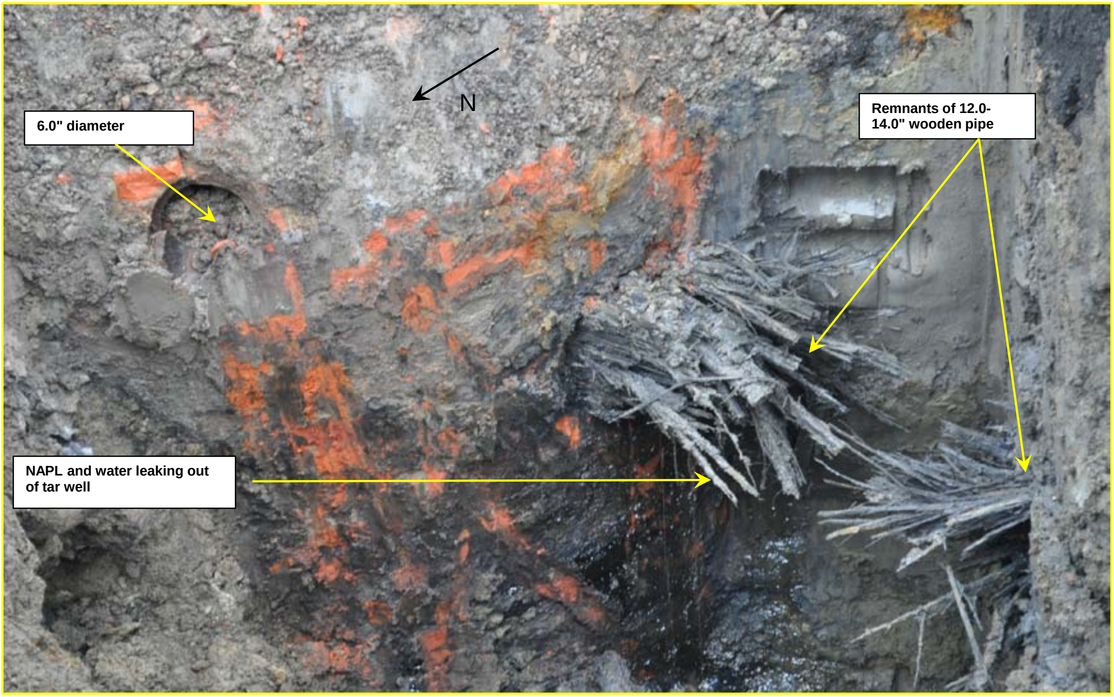
CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	**PAGE** 3 of 3	**TP-203(10)**
CITY/STATE:	Troy, New York		
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	29.78	**LOCATION:**	Northwest side of tar well No.1
NORTHING:	1418769.9300 **EASTING:** 709865.8560	**TOTAL DEPTH:**	~ 10 ft
OBSERVED BY:	John Ripp and Jerry Zak	**TOTAL LENGTH:**	~ 12 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 8 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, cool, fog burning off	**DATE START / END**	10/26/2010 - 10/26/2010

PHOTOGRAPH

Photograph 3: Close-up of northwest side of tar well



NOTES:

PID = PHOTOIONIZATION DETECTOR READING

ppm = PARTS PER MILLION

IN. = INCHES

FT. = FEET

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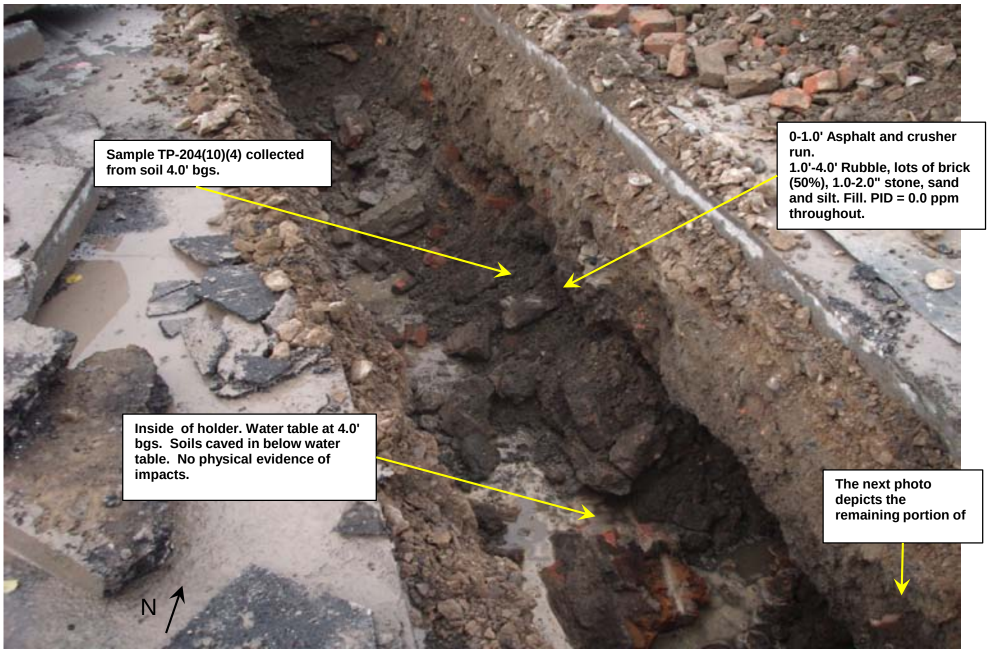
CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	**PAGE**	**TP-204(10)**
CITY/STATE:	Troy, New York	1 of 2	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	30.62		**LOCATION:**	Southeast side of northeastern holder
NORTHING:	1418759.8440	**EASTING:** 709905.5090	**TOTAL DEPTH:**	~ 4 ft to water table
OBSERVED BY:	John Ripp and Jerry Zak		**TOTAL LENGTH:**	~ 14 ft
OPERATOR:	Mark Maille (Land Remediation)		**TOTAL WIDTH:**	~ 3.5 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe		**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, overcast, humid		**DATE START / END**	10/25/2010 - 10/25/2010

PHOTOGRAPH

Photograph 1: Facing Northwest



Sample TP-204(10)(4) collected from soil 4.0' bgs.

0-1.0' Asphalt and crusher run.
1.0'-4.0' Rubble, lots of brick (50%), 1.0-2.0" stone, sand and silt. Fill. PID = 0.0 ppm throughout.

Inside of holder. Water table at 4.0' bgs. Soils caved in below water table. No physical evidence of impacts.

The next photo depicts the remaining portion of

NOTES:
PID = PHOTOIONIZATION DETECTOR READING
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

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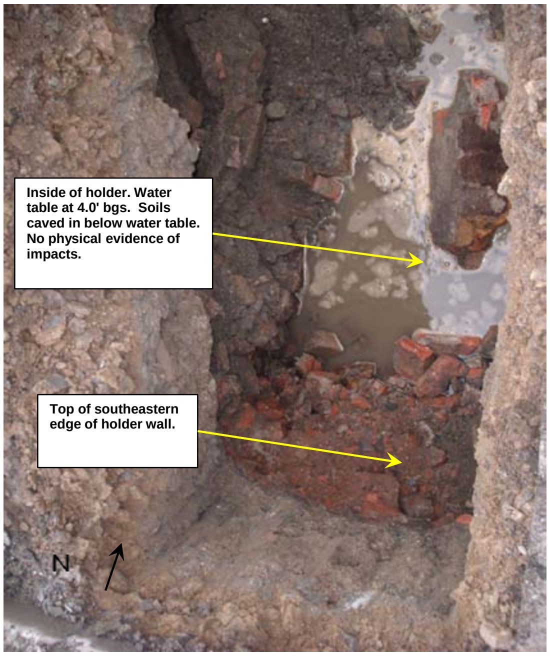
CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	**PAGE**	**TP-204(10)**
CITY/STATE:	Troy, New York	2 of 2	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	30.62	**LOCATION:**	Southeast side of northeastern holder
NORTHING:	1418759.8440 **EASTING:** 709905.5090	**TOTAL DEPTH:**	~ 4 ft to water table
OBSERVED BY:	John Ripp and Jerry Zak	**TOTAL LENGTH:**	~ 14 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 3.5 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, overcast, humid	**DATE START / END**	10/25/2010 - 10/25/2010

PHOTOGRAPH

Photograph 2: Overhead shot


Inside of holder. Water table at 4.0' bgs. Soils caved in below water table. No physical evidence of impacts.

Top of southeastern edge of holder wall.

NOTES:

PID = PHOTOIONIZATION DETECTOR READING
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

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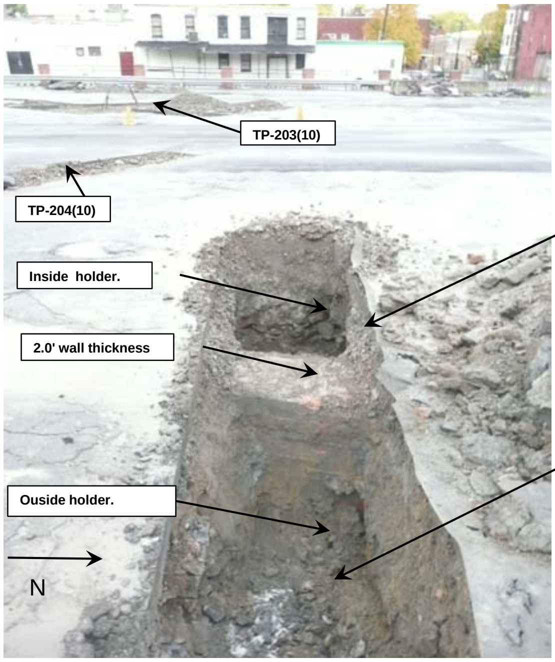
CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	PAGE	TP-204A(10)
CITY/STATE:	Troy, New York	1 of 2	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	30.91	**LOCATION:**	East side of northeastern holder
NORTHING:	1418769.7170 **EASTING:** 709924.0580	**TOTAL DEPTH:**	~ 4 ft to water table
OBSERVED BY:	John Ripp and Jerry Zak	**TOTAL LENGTH:**	~ 13.7 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 3.5 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, overcast, humid	**DATE START / END**	10/25/2010 - 10/25/2010

PHOTOGRAPH

Photograph 1: Facing West



0.0-1.0' Asphalt and crusher run.
1.0-3.0' Layers of brown sand and ash.
3.0-4.0' Broken brick. Hole filled with water and caves in

0.0-1.0' Asphalt and crusher run.
1.0-2.5' Brown sand, dark gray boulders, some gray clay. Refusal on stone, no room to curl bucket near wall.

NOTES:
PID = PHOTOIONIZATION DETECTOR READING
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

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CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	**PAGE**	**TP-204A(10)**
CITY/STATE:	Troy, New York	2 of 2	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	30.91	**LOCATION:**	East side of northeastern holder
NORTHING:	1418769.7170 **EASTING:** 709924.0580	**TOTAL DEPTH:**	~ 4 ft to water table
OBSERVED BY:	John Ripp and Jerry Zak	**TOTAL LENGTH:**	~ 13.7 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 3.5 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, cool, fog burning off	**DATE START / END**	10/25/2010 - 10/25/2010

PHOTOGRAPH

Photograph 2: Facing East

NOTES:

PID = PHOTOIONIZATION DETECTOR READING

ppm = PARTS PER MILLION

IN. = INCHES

FT. = FEET

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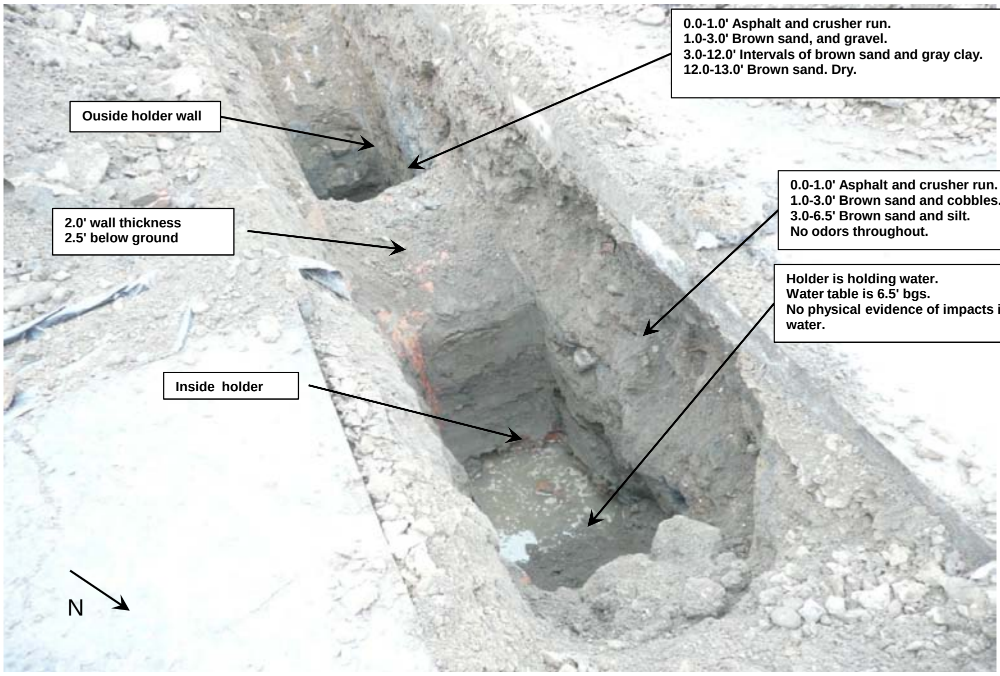
CLIENT:	National Grid	TEST PIT LOG	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	PAGE 1 of 1	TP-205(10)
CITY/STATE:	Troy, New York		
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):			30.44	LOCATION:	South side of southwestern holder
NORTHING:	1418675.8410	EASTING:	709829.4060	TOTAL DEPTH:	~ 13 ft outside wall, ~ 6.5 inside wall
OBSERVED BY:	Jerry Zak			TOTAL LENGTH:	~ 26 ft
OPERATOR:	Mark Maille (Land Remediation)			TOTAL WIDTH:	~ 2 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe			DATUM VERT. / HORZ.:	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, overcast			DATE START / END	10/27/2010 - 10/27/2010

PHOTOGRAPH

Photograph 1: Facing Southwest



0.0-1.0' Asphalt and crusher run.
1.0-3.0' Brown sand, and gravel.
3.0-12.0' Intervals of brown sand and gray clay.
12.0-13.0' Brown sand. Dry.

Ouside holder wall

0.0-1.0' Asphalt and crusher run.
1.0-3.0' Brown sand and cobbles.
3.0-6.5' Brown sand and silt.
No odors throughout.

2.0' wall thickness
2.5' below ground

Holder is holding water.
Water table is 6.5' bgs.
No physical evidence of impacts in water.

Inside holder

NOTES:

PID = PHOTOIONIZATION DETECTOR READING
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IN. = INCHES
FT. = FEET

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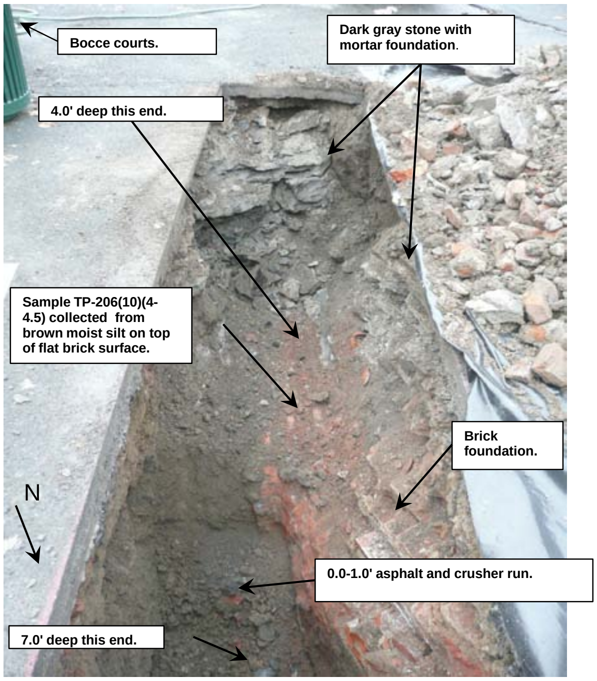
CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	**PAGE**	**TP-206(10)**
CITY/STATE:	Troy, New York	1 of 1	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	31.84	**LOCATION:**	Southern most parking spot off of Hill Street
NORTHING:	1418599.3640 **EASTING:** 709806.1010	**TOTAL DEPTH:**	~ 4 ft southern end, ~ 7.0 ft deep northern end
OBSERVED BY:	Jerry Zak	**TOTAL LENGTH:**	~ 12.5 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 2 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, overcast, humid, sprinkles	**DATE START / END**	10/27/2010 - 10/27/2010

PHOTOGRAPH

Photograph 1: Facing South



NOTES:

PID = PHOTOIONIZATION DETECTOR READING
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

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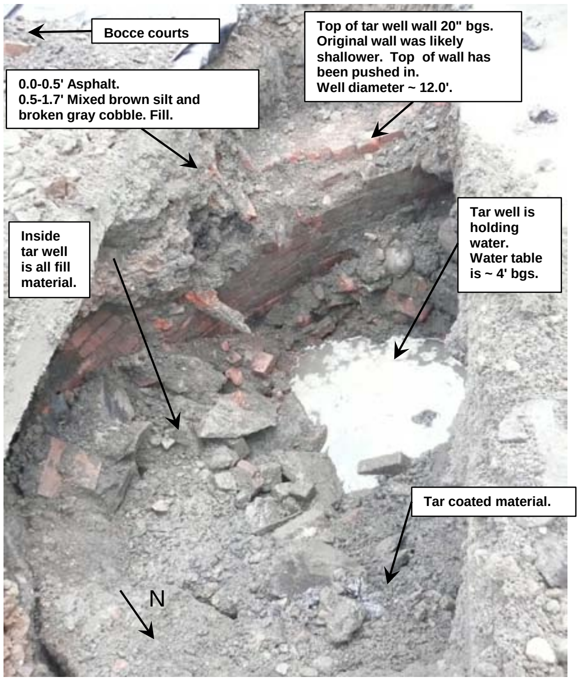
CLIENT:	National Grid	**TEST PIT LOG**	
PROJECT:	Troy (Liberty St) Non-Owned Former MGP	**PAGE**	**TP-207(10)**
CITY/STATE:	Troy, New York	1 of 1	
GEI PROJECT NUMBER:	093300-1-1113		

GROUND SURFACE ELEVATION (FT):	32.58	**LOCATION:**	Within metal fence adjacent to bocce courts
NORTHING:	1418567.4520 **EASTING:** 709819.2220	**TOTAL DEPTH:**	~ 4 ft
OBSERVED BY:	Jerry Zak	**TOTAL LENGTH:**	~ 17 ft
OPERATOR:	Mark Maille (Land Remediation)	**TOTAL WIDTH:**	~ 3 ft
EQUIPMENT:	CAT 420 rubber-tired backhoe	**DATUM VERT. / HORZ.:**	NAVD 88 / NAD83 NY East Zone
WEATHER:	60s, overcast	**DATE START / END**	10/27/2010 - 10/27/2010

PHOTOGRAPH

Photograph 1: Facing South inside tar well No. 2



NOTES:
PID = PHOTOIONIZATION DETECTOR READING
ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

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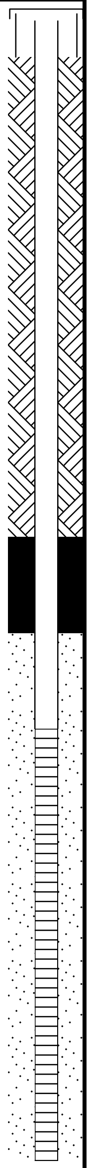
CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B/MW-301(10)

GROUND SURFACE ELEVATION (FT): 31.15
LOCATION: Northeast parking lot adjacent concrete pad
NORTHING: 1418815.8544 **EASTING:** 709910.486
TOTAL DEPTH (FT): 35.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/25/2010 - 11/1/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0		0.0	🟩			FILL, concrete and crusher run, hand and vacuum cleared.
					🟩			WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded and subangular, ~10% fines; dry, brown to dark brown, FILL, brick fragments scattered throughout, trace crushed mortar, vacuum cleared to 5'.
5	S-1	5.0	2.87	1.6, 0.0	🟩			
					🟩			WIDELY GRADED SAND (SW); ~85% sand, fine to medium, ~10% gravel, fine to medium, subrounded, ~5% fines; dry, brown, FILL, trace reddish orange fine sand, crushed cobble at 9'.
10	S-2	5.0	3	0.0	🟩			
					🟩			SILTY SAND (SM); ~60% sand, fine to medium, ~35% fines, ~5% gravel, fine to medium, subangular; dry, brown, FILL, trace reddish orange fine sand.
					🟩			VARVED DEPOSITS: LEAN CLAY AND SILT (CL-ML); ~75% fines, low plasticity, ~25% sand; moist, reddish brown, FILL.
15	S-3	5.0	2.35	0.0, 10.0, 0.0	🟩			
					🟦	PLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, ~15% gravel, ~5% fines; strong petroleum-like odor, moist, dark gray.
					🟦		B/MW-301(10) (18-19.25)	
					🟦	PLO		WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~75% sand, fine to coarse, ~15% gravel, fine, ~10% fines; slight petroleum-like odor, wet, light brown, trace reddish orange fine sand.
20	S-4	5.0	2.75	0.0	🟦		B/MW-301(10) (20.5-22)	
					🟦	PLO		WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; slight

WELL DETAILS



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IN. = INCHES
FT. = FEET

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CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
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B/MW-301(10)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)						
						🟦			petroleum-like odor, wet, light brown to reddish brown.	
25	S-5	5.0	1.7	0.0						
						🟦	PLO		WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, fine to coarse, ~10% fines; slight petroleum-like odor, wet, light brown to reddish brown.	
						🟩			WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~50% sand, ~40% gravel, coarse, subangular, ~10% fines; wet, dark brown.	
30	S-6	5.0	1.7	0.0						
								B/MW-301(10) (33.8-35)		
35									End of Boring at 35 feet. Monitoring well installed.	

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BORING LOG

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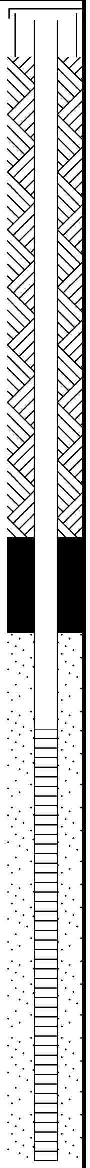
B/MW-302(10)

GROUND SURFACE ELEVATION (FT):	33.03	**LOCATION:**	South parking lot adjacent concrete pad
NORTHING: 1418629.0611	**EASTING:** 709885.7376	**TOTAL DEPTH (FT):**	35.00
DRILLED BY:	Zebra Environmental / Ethan Plank	**DATUM VERT. / HORZ.:**	MSL / NAD83
LOGGED BY:	Drew Blicharz	**DATE START / END:**	10/25/2010 - 11/1/2010
DRILLING DETAILS:	Geoprobe / 7720DT		
WATER LEVEL DEPTHS (FT):			

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		2.8		0.0			SILTY SAND (SM); ~75% sand, ~15% fines, ~10% gravel; dry, dark brown, FILL, clay pipe with slight MGP-like odor, hand and vacuum cleared to 2.8'.
	S-1	2.2	2.25	0.6, 0.0	NLO		Slight naphthalene-like odor. SILTY SAND (SM); ~75% sand, ~20% fines, ~5% gravel; dry, brown to dark brown, FILL, crushed angular stone and gravel 3.5-4', mortar and tiny brick fragments.
5	S-2	5.0	3.9	0.0			VARVED DEPOSITS: LEAN CLAY AND SILT (CL-ML); ~85% fines, ~15% sand; dry, brown with light reddish brown, FILL, trace reddish orange fine sand.
10	S-3	5.0	2.15	0.2, 0.0			SILTY SAND (SM); ~70% sand, fine to medium, ~15% fines, ~5% gravel; dry, brown, FILL, crushed stone 12.25-12.75'. WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to medium, ~10% fines, ~5% gravel; dry, brown, FILL, crushed brick at 13.75'.
15	S-4	5.0	2.78	0.0			WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~65% sand, fine to medium, ~25% gravel, fine, subangular, ~10% fines; dry, brown, FILL. WIDELY GRADED GRAVEL WITH SAND (GW); ~85% gravel, ~15% sand; dry, white light brown, FILL, coarse crushed stone and gravel. WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to medium, ~20% gravel, fine to coarse, subangular, ~10% fines; dry, brown, trace reddish orange fine sand.
20	S-5	5.0	3.3	0.0, 0.8, 1.5		B/MW-302(10) (21-22) B/MW-302(10) (22-24)	WIDELY GRADED GRAVEL WITH SAND (GW); ~50% gravel, fine to coarse, subrounded, ~45% sand, fine to medium, ~5% fines; wet, brown. WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, ~35% gravel, fine to coarse, ~5% fines; wet, brown.

WELL DETAILS



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BORING LOG
PAGE 2 of 2
B/MW-302(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
25	S-6	5.0	3.25	0.0		🟩				
30	S-7	5.0	3.43	0.0		🟩		B/MW-302(10) (34-34.5)	WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, ~5% fines; wet, brown, trace reddish orange fine sand at 34.25', moderately dense.	
35									End of Boring at 35 feet. Monitoring well installed.	

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BORING LOG

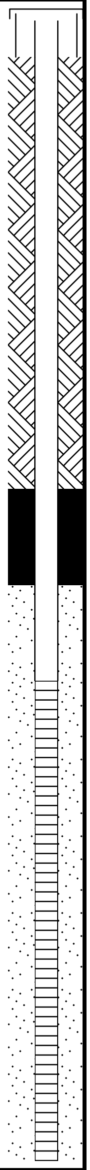
PAGE 1 of 2

B/MW-303(10)

GROUND SURFACE ELEVATION (FT): 33.29
LOCATION: Northeast corner Washington St and Hill St
NORTHING: 1418542.9962 **EASTING:** 709752.7507
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/29/2010 - 10/29/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
0		5.0		0.0	▨	🟩		FILL, concrete, silty sand with gravel, hand and vacuum cleared to 5'.
5	S-1	5.0	3.51	0.0	▨	🟩		SILTY SAND (SM); ~70% sand, ~25% fines, ~5% gravel; wet, brown, FILL.
					▨	🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, ~5% fines; moist, dark brown, FILL, 0.3' crushed stone at bottom.
10	S-2	5.0	3.19	0.0	▨	🟩		LEAN CLAY (CL); ~95% fines, non plastic, ~5% sand; dry, brown, FILL. WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, ~5% fines; moist, dark brown, FILL.
15	S-3	5.0	0	0.0				NO RECOVERY.
20	S-4	5.0	0.27	0.0	▨	🟩		WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, ~10% fines; wet, brown, tiny brick fragments likely cave in, poor recovery, only 0.27'.

WELL DETAILS



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BORING LOG
PAGE 2 of 2
B/MW-303(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
						🟩			
25	S-5	5.0	2.33	0.0		🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~65% sand, fine to medium, ~30% gravel, medium to coarse, angular, ~5% fines; moist, brown, trace reddish orange fine sand. WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to medium, ~15% gravel, fine to medium, angular, ~5% fines; moist, brown, trace reddish orange fine sand.	
30	S-6	5.0	1.55	0.0		🟩			
35	S-7	5.0	0.1	0.0				Poor Recovery. Only 0.1'.	
40	S-8	5.0	2.73	0.0		🟩		WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, brown, moderately dense. WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, gray, moderately dense.	
						🟩	B/MW-303(10) (43.75-44.75)	SILT (ML); ~95% fines, ~5% sand; wet, gray, dense.	
45								End of Boring at 45 feet. Monitoring well installed.	

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BORING LOG
PAGE 1 of 2
B-304(10)

GROUND SURFACE ELEVATION (FT): 29.12
LOCATION: West of Northeast Former Holder
NORTHING: 1418799.6619 **EASTING:** 709809.5631
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/28/2010 - 10/28/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	 PEN FT.	 REC FT.	 PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.9	0.0	▨	🟩		FILL, asphalt and concrete.
					▨	🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; dry, brown to yellowish brown, FILL, large subrounded gravel at 1.1', crushed angular stone and brick in shoe.
5	S-2	5.0	2.58	0.0	▨	🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; dry, brown and gray, FILL, crushed brick at 5.75' and between 8.75-10' with mortar.
10	S-3	5.0	3.06	0.0	▨	🟩		WIDELY GRADED SAND (SW); ~90% sand, ~5% gravel, ~5% fines; dry, brown and gray, FILL, scattered tiny brick fragments and mortar.
					▨	🟩		SILTY SAND (SM); ~70% sand, fine to medium, ~20% fines, ~10% gravel, fine to coarse; dry, light brown, FILL, brick fragments, layer of gray clay at 14.5', crushed stone and gravel at bottom.
15	S-4	5.0	4.5	0.0	▨	🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, ~5% fines; dry, brown and gray, FILL, scattered tiny brick fragments and mortar.
					⁘	🟩	B-304(10) (17.25-17.75)	WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, ~5% fines; wet, brown and gray, trace reddish orange fine sand.
20	S-5	5.0	1	0.0	⁘	🟩		

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BORING LOG
PAGE 2 of 2
B-304(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	SAMPLE INFO PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25	S-6	5.0	2.05	0.0	░	🟩	B-304(10) (28.75-29.5)	WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, gray, dense.
30								End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 2
B-305(10)

GROUND SURFACE ELEVATION (FT): 29.83
LOCATION: West of Northeast Former Holder
NORTHING: 1418791.5407 **EASTING:** 709834.6571
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/28/2010 - 10/28/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
0	S-1	5.0	3.88	0.0	▨	🟩		FILL, asphalt and concrete.
					▨	🟩		SILTY SAND (SM); ~50% sand, fine to coarse, ~40% fines, ~10% gravel; dry, brown, FILL, trace mortar and tiny brick fragments, crushed coarse cobble at 6-6.5'.
5	S-2	5.0	2.87	0.0	▨	🟩		
					▨	🟩		GRAVELLY LEAN CLAY WITH SAND (CL); ~65% fines, ~20% gravel, ~15% sand, fine to medium; dry, brown and gray, FILL, trace mortar and reddish orange fine sand.
10	S-3	5.0	1.28	0.0	▨	🟩		GRAVELLY LEAN CLAY WITH SAND (CL); ~65% fines, ~20% gravel, ~15% sand, fine to medium; moist, brown and gray, FILL.
					▨	🟩	B-305(10) (14-15)	SILTY SAND (SM); ~70% sand, fine to medium, ~20% fines, ~10% gravel; wet, black, FILL.
15	S-4	5.0	1.97	0.0	●	🟩		WIDELY GRADED GRAVEL WITH SILT AND SAND (GW); ~70% gravel, fine, ~20% sand, fine to medium, ~10% fines; wet, dark gray and olive.
20	S-5	5.0	2.45	0.0	⁘	🟩		WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, fine to coarse, ~10% fines; wet, light brown to brown.

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BORING LOG

PAGE 2 of 2

B-305(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟩		
25	S-6	5.0	1	0.0		🟩	B-305(10) (27-30)	NARROWLY GRADED GRAVEL (GP); ~85% gravel, coarse, ~10% sand, ~5% fines; wet, brown.
						🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, ~5% fines; wet, dark gray, moderately dense.
30								End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 1
B-306(10)

GROUND SURFACE ELEVATION (FT): 30.39
LOCATION: Within Northeast Former Holder Wall
NORTHING: 1418795.9445 **EASTING:** 709867.4791
TOTAL DEPTH (FT): 16.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/28/2010 - 10/28/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
0	S-1	5.0	2.9	0.0	▨	🟩		FILL, asphalt, concrete, and crusher run.
					▨	🟩		SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel; moist to wet, brown, FILL.
5	S-2	5.0	2.45	0.0	▨	🟩		
					▨	🟩		Wet, FILL, crushed bricks.
					▨	🟩		SILTY SAND (SM); ~80% sand, fine to medium, ~15% fines, ~5% gravel; wet, dark gray, FILL, wood chunk at 8.5'.
10	S-3	5.0	2.7	0.0	▨	🟩		WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, brown, FILL, crushed brick fragments at 10'.
					▨	🟩		CLAYEY SAND WITH GRAVEL (SC); ~60% sand, fine to medium, ~15% gravel, ~15% fines, low plasticity; wet, gray, FILL, crushed brick fragments at 14.5'.
15	S-4	1.0	1	0.0	▨	🟨	NLO	WIDELY GRADED SAND (SW); ~85% sand, fine to medium, ~10% gravel, ~5% fines; strong naphthalene-like odor, wet, dark gray, FILL, bottom 0.5' black stained, crushed brick fragments.

End of Boring at 16 feet.
Refusal at 16'
Fill with bentonite chips.

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FT. = FEET

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455 Winding Brook Road
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BORING LOG

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B-307(10)

GROUND SURFACE ELEVATION (FT): 30.62
LOCATION: Within Northeast Former Holder Wall
NORTHING: 1418767.8405 **EASTING:** 709871.21
TOTAL DEPTH (FT): 16.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/28/2010 - 10/28/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0	S-1	0.4 4.6	2.65	0.0 0.0	▨	🟩			FILL, asphalt and concrete, hand cleared to 0.4'.
					▨	🟩			SILTY SAND (SM); ~60% sand, fine to medium, ~30% fines, ~10% gravel; dry, brown, FILL.
					▨	🟩			Dry, FILL, bricks, mortar, black stained silty sand with burnt odor at 5'.
5	S-2	5.0	3.38	0.0	▨	🟨	NLO		WIDELY GRADED SAND WITH SILT (SW-SM); ~80% sand, fine to coarse, ~10% gravel, fine, ~10% fines; slight naphthalene-like odor, wet, dark gray, FILL, odor decreases with depth, some black stained portions, trace tiny brick fragments.
					▨	🟩		B-307(10) (7.6-7.9)	SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine to coarse, ~15% fines; wet, brown and gray, FILL.
10	S-3	5.0	2.78	0.0					
					▨	🟨	NLO	B-307(10) (13.5-14.75) and duplicate	SILTY SAND (SM); ~75% sand, fine to medium, ~15% fines, ~10% gravel, fine; slight naphthalene-like odor, wet, black, FILL, black stained, trace mortar.
15	S-4	1.0	0.65	0.0					
					▨	🟨	NLO		Slight naphthalene-like odor, red, FILL, brick.
					▨	🟧	NLO		NARROWLY GRADED SAND WITH SILT (SP-SM); ~90% sand, fine to medium, ~10% fines; slight naphthalene-like odor, wet, black, FILL, black stained, slight sheen, crushed brick fragments.

End of Boring at 16 feet.
Refusal at 16'
Fill with bentonite chips.

NOTES:

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BORING LOG

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B-308(10)

GROUND SURFACE ELEVATION (FT): 29.87
LOCATION: Within Southwest Former Holder Wall
NORTHING: 1418744.8909 **EASTING:** 709807.9068
TOTAL DEPTH (FT): 16.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/26/2010 - 10/26/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		2.0			▨	🟩			FILL, asphalt, concrete, and crusher run, hand and vacuum cleared to 2', brick fragments at 2.5'.
	S-1	3.0	2.55	0.0	▨	🟩			SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel; dry, brown, FILL.
5	S-2	5.0	0.85	0.0	▨	🟩			Dry, FILL, bricks.
					▨	🟩			LEAN CLAY (CL); ~100% fines, high plasticity; moist, FILL.
					▨	🟩		B-308(10) (9.5-10)	WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel; moist, FILL.
10	S-3	5.0	0	NA					NO RECOVERY.
15	S-4	1.0	0.3	0.0	▨	🟨	NLO	B-308(10) (15-16)	WIDELY GRADED GRAVEL WITH SAND (GW); ~60% gravel, fine to coarse, subangular, ~40% sand, fine to coarse; strong naphthalene-like odor, saturated, brown to dark gray, FILL, fine to coarse brick fragments.

End of Boring at 16 feet.
Refusal at 16'
Fill with bentonite chips.

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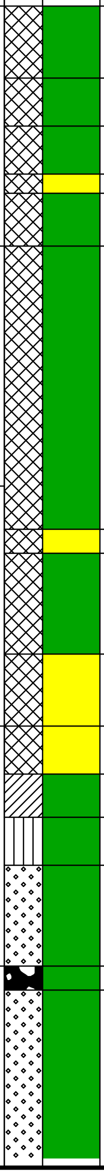
BORING LOG
PAGE 1 of 2
B-309(10)

GROUND SURFACE ELEVATION (FT): 31.97
LOCATION: South center parking lot
NORTHING: 1418675.0025 **EASTING:** 709867.9904
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/29/2010 - 10/29/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):



DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.83	0.0			FILL, asphalt, concrete, and crusher run. SILTY SAND WITH GRAVEL (SM); ~60% sand, fine to medium, ~25% fines, ~15% gravel; dry, brown, FILL, trace tiny brick fragments, trace clay. Dry, red and light gray, FILL, brick to 2.8' and crushed concrete/mortar to 3.5'. SILTY SAND WITH GRAVEL (SM); ~60% sand, fine to medium, ~25% fines, ~15% gravel; dry, FILL, trace black stain, ash, slight burnt odor.
5	S-2	5.0	2.4	0.0			FAT CLAY (CH); ~95% fines, high plasticity, ~5% sand; dry, brown gray, FILL. WIDELY GRADED SAND WITH SILT (SW-SM); ~85% sand, fine to coarse, ~10% fines, ~5% gravel; dry, FILL, trace thin layers of clay.
10	S-3	5.0	2.85	0.0	TLO	B-309(10) (14-15)	SILT (ML); ~85% fines, non plastic, ~10% sand, ~5% gravel; moist, dark gray, FILL, trace black stain at 10.9', slight burnt odor, coarse rounded gravel at 11.4'. WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, ~5% fines; moist, brown, FILL, coarse cobble at 13.5'. LEAN CLAY (CL); ~100% fines, non plastic; moderate tar-like odor, moist, FILL.
15	S-4	5.0	2.23	0.0	TLO		WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, ~5% fines; slight tar-like odor, moist, brown, FILL, black stained at 15.4'. LEAN CLAY (CL); ~100% fines, low plasticity; moist, gray. SILT (ML); ~90% fines, non plastic, ~10% sand; moist, light brown to brown. WIDELY GRADED SAND (SW); ~85% sand, fine to medium, ~10% gravel, ~5% fines; moist to wet, light brown to brown, trace reddish orange fine sand, less gravel at bottom.
20	S-5	5.0	2.32	0.0			Wet, coarse rounded gravel and crushed stone. WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, fine to coarse, subangular, ~5% fines; wet, brown, trace reddish orange fine sand.

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BORING LOG
PAGE 2 of 2
B-309(10)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25	S-6	5.0	1.88	0.0	⁘	🟩		B-309(10) (28.5-29.5)	WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, ~5% fines; wet, brown, moderately dense.
30									End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG

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B-310(10)

GROUND SURFACE ELEVATION (FT): 32.92
LOCATION: West of Bocce Courts
NORTHING: 1418586.1228 **EASTING:** 709817.491
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/25/2010 - 10/25/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		3.0		0.0	▩	🟩			Dry, FILL, asphalt and concrete, hand cleared.
					▩	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; dry, brown, FILL, fine to coarse brick fragments, hand and vacuum cleared to 3'.
	S-1	2.0	1.3	0.0	▩	🟩			
5	S-2	5.0	0.5	0.0	▩	🟨	TLO		WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; strong tar-like odor, dry, brown, FILL.
					▩	🟨	TLO		WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine, ~5% fines; strong tar-like odor, moist to wet, gray, FILL, tiny brick fragments, bricks bottom 0.5'.
10	S-3	5.0	3.25	0.9, 12.5, 25.0, 63.0	▩	🟨			
					▩	🟪	TLO	B-310(10) (11.5-12.25)	SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine, angular, ~15% fines; strong tar-like odor, saturated, FILL, black stained, tar coated, slight sheen.
					▩	🟨	TLO		WIDELY GRADED GRAVEL WITH SAND (GW); ~70% gravel, fine, angular, ~25% sand, fine to medium, ~5% fines; strong tar-like odor, moist, brown, FILL, tiny brick fragments, brick at 13.25'.
					▩	🟨	TLO	B-310(10) (14.25-15)	SILT (ML); ~90% fines, non plastic, ~10% sand; strong tar-like odor, moist, dark gray, FILL, tiny brick fragments, black stain at 15-15.25'.
15	S-4	5.0	3.3	2.7, 11.4, 2.5, 1.4		🟨			FILL.
					▥	🟨	TLO		SILT WITH SAND (ML); ~80% fines, non plastic, ~20% sand, fine; moderate tar-like odor, moist, brown to gray.
					⁚	🟨	TLO		SILTY SAND (SP-SM); ~80% sand, fine to medium, ~20% fines; strong tar-like odor, moist, black stained.
20	S-5	5.0	1.8	2.6, 1.3	⁘	🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; moderate tar-like odor, wet, brown and gray, trace reddish orange fine sand.

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BORING LOG
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B-310(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
					▒	🟨			
25	S-6	5.0	1.88	4.6, 2.3, 0.7	▒	🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; moderate tar-like odor, saturated, brown, trace reddish orange fine sand.
30	S-7	5.0	1.85	0.8, 1.4, 0.4	▒	🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; slight tar-like odor, saturated, brown and gray, macrocore sleeve has sheen, thin black stain/sheen at 34', black stain/trace blebs at 35'.
					▒	🟧	TLO		Strong tar-like odor.
35	S-8	5.0	2.2	0.0	▒	🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to coarse, ~25% gravel, fine to coarse, subrounded and subangular, ~5% fines; strong tar-like odor, saturated, brown to gray, trace reddish orange fine sand.
40	S-9	5.0	0.3	0.0	░	🟩			NARROWLY GRADED SAND (SP); ~95% sand, fine, ~5% fines; gray, recovery = shoe only, dense.
45								B-310(10) (44.75-45)	End of Boring at 45 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 2
B-311(10)

GROUND SURFACE ELEVATION (FT): 33.07
LOCATION: West of Bocce Courts
NORTHING: 1418583.7027 **EASTING:** 709830.6199
TOTAL DEPTH (FT): 40.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/25/2010 - 10/25/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		3.3		0.0	▩	🟩			FILL, asphalt and concrete, hand cleared.
					▩	🟩			FILL, crusher run and silty sand, hand and vacuum cleared to 3.3'.
	S-1	1.7	1.2	0.0	▩	🟩			SILTY SAND (SM); ~60% sand, fine to medium, ~40% fines; dry, brown, FILL.
5	S-2	5.0	2.87	0.0	▩	🟩			Dry, FILL, crushed mortar and concrete.
					▩	🟩			LEAN CLAY (CL); low plasticity; dry, FILL, stone at 6.75'.
					▩	🟩			Dry, FILL, crushed mortar, concrete, brick fragments, and sand.
					▩	🟩			SILT WITH GRAVEL (ML); ~75% fines, ~25% gravel; dry, gray to dark gray, FILL, coarse rounded gravel at 8.2, trace reddish orange fine sand.
10	S-3	5.0	2.6	0.6, 13.7, 20.0	▩	🟨	TLO		FAT CLAY (CL); ~90% fines, high plasticity, ~5% gravel, ~5% sand; moderate tar-like odor, moist, gray, FILL.
					▩	🟨	TLO		SILT WITH SAND (ML); ~75% fines, ~20% sand, fine to medium, ~5% gravel; moderate tar-like odor, moist, gray to dark gray, FILL, wood fragments.
					▩	🟧	NLO	B-311(10) (13-14)	SILT WITH SAND (ML); ~75% fines, ~20% sand, fine to medium, ~5% gravel; strong naphthalene-like odor, moist, FILL, black stained, slight sheen.
15	S-4	5.0	2.75	0.0	▩	🟨	TLO		WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, fine to medium, ~10% fines; slight tar-like odor, moist, light brown to reddish orange, FILL, trace fine gravel and brick fragments.
					▥	🟨	TLO		SILT WITH SAND (ML); ~85% fines, ~15% sand, fine; slight tar-like odor, moist, light brown.
					▨	🟨	TLO		LEAN CLAY (CL); ~100% fines, non plastic; slight tar-like odor, moist.
					⁘	🟨	TLO		WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; slight tar-like odor, moist, dark gray, black stained.
20	S-5	5.0	2.6	0.0	⁘	🟩		B-311(10) (20.75-22.75)	WIDELY GRADED SAND WITH SILT AND GRAVEL (SW); ~70% sand, fine to medium, ~20% gravel, fine to coarse, subangular and subrounded, ~10% fines; wet, brown and gray, layer of reddish orange fine sand at 22.5'.

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B-311(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
					▨	🟩 🟨	TLO		
25	S-6	5.0	2.35	0.0	▨	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; slight tar-like odor, wet, black stained. WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, ~35% gravel, fine to coarse, subangular and subrounded, ~5% fines; wet, brown and gray.
30	S-7	5.0	2.28	0.0	▨	🟩			
35	S-8	5.0	2.6	0.0	▨	🟩		B-311(10) (39-40)	WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, brown to gray, trace gravel, dense.
40									End of Boring at 40 feet. Fill with bentonite chips.

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PROJECT:	Troy Liberty Street
CITY/STATE:	Troy, New York
GEI PROJECT NUMBER:	093300-1-1113

BORING LOG

PAGE 1 of 2

B-312(10)

GROUND SURFACE ELEVATION (FT):	33.56	**LOCATION:**	Inside 1st Bocce Court
NORTHING: 1418584.9327	**EASTING:** 709848.1369	**TOTAL DEPTH (FT):**	40.00
DRILLED BY:	Zebra Environmental / Ethan Plank	**DATUM VERT. / HORZ.:**	MSL / NAD83
LOGGED BY:	Drew Blicharz	**DATE START / END:**	10/27/2010 - 10/27/2010
DRILLING DETAILS:	Geoprobe / 7720DT		
WATER LEVEL DEPTHS (FT):			

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.07	0.0	▨	🟩			FILL, asphalt. SANDY SILT (ML); ~70% fines, ~30% sand, fine to medium; dry, brown, FILL, fine to coarse gravel to 1.0'.
					▨	🟩			LEAN CLAY (CL); ~90% fines, high plasticity, ~10% sand; dry, gray, FILL, brick fragments.
5	S-2	5.0	2.84	0.0	▨	🟩			Dry, FILL, crushed brick and mortar. WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; dry, brown, FILL.
					▨	🟩			LEAN CLAY (CL); ~90% fines, high plasticity, ~10% sand; dry, brown and gray, FILL, sand layers.
10	S-3	5.0	3.12	0.0, 36.8, 240, 23	▨	🟨	TLO		SANDY SILT (ML); ~65% fines, ~30% sand, fine to medium, ~5% gravel, fine, subangular; strong tar-like odor, dry, brown, FILL.
					▨	🟨	TLO	B-312(10) (12.5-13.25)	WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, medium to coarse, ~10% fines; strong tar-like odor, dry, FILL, black stained, brick fragments and wood chips, brick at 13.25'.
					▨	🟩			SANDY SILT (ML); ~65% fines, ~30% sand, fine to medium, ~5% gravel; dry, dark gray to brown, FILL, crushed stone at 14.5' separates gray/brown material.
15	S-4	5.0	3.07	0.0	▨	🟨	SLO		SANDY SILT (ML); ~65% fines, ~30% sand, fine to medium, ~5% gravel; slight sulfur-like odor, dry, dark gray to brown, FILL, black material at 15.5', strange burnt odor, sulfur-like odor.
					▥	🟩			SILT (ML); ~90% fines, non plastic, ~10% sand, fine to medium; dry, light brown to reddish orange, FILL, black material at 16.6'.
					⁘	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, ~35% gravel, fine, subangular, ~5% fines; dry, brown, crushed stone at 20'.
20	S-5	5.0	1.47	0.0	⁘	🟩		B-312(10) (21-22.5)	WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~40% gravel, fine to coarse, subangular and subrounded, ~5% fines; moist to wet, brown to gray.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
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ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

GEI Consultants, Inc.
455 Winding Brook Road
Glastonbury, CT 06033
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CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-312(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	SAMPLE INFO PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25	S-6	5.0	2.12	0.0	▨	🟩			
					▨	🟩			NARROWLY GRADED SAND (SP); ~100% sand, fine to medium; moist, reddish orange. WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, subangular and subrounded, ~5% fines; wet, gray.
30	S-7	5.0	3.15	0.0	▨	🟩			
					▨	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet to saturated, brown to gray, trace fine gravel, cobbles at 36.75'.
35	S-8	5.0	3.5	0.0	▨	🟩			
					▨	🟩		B-312(10) (39-39.75)	WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, dark gray, moderately dense.
40									End of Boring at 40 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 1
B-313(10)

GROUND SURFACE ELEVATION (FT): 33.21
LOCATION: West of Bocce Courts
NORTHING: 1418574.7358 **EASTING:** 709817.8369
TOTAL DEPTH (FT): 15.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/26/2010 - 10/26/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		2.8		0.0	▨	🟩			Dry, FILL, asphalt and concrete, hand cleared.
					▨	🟩			SILTY SAND (SM); ~80% sand, ~15% fines, ~5% gravel; dry, FILL, crusher run gravel and silty sand, hand and vacuum cleared to 2.8'.
	S-1	2.2	0.8	0.0	▨	🟩			SILTY SAND (SM); ~80% sand, ~15% fines, ~5% gravel; moist, brown, FILL.
					▨	🟩			Dry, FILL, crushed brick.
5	S-2	5.0	2	0.0, 12.2	▨	🟨			SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine; wet, FILL, black stained, tiny brick fragments.
					▨	🟧	TLO	B-313(10) (7.5-9.5)	SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine; moderate tar-like odor, wet, FILL, black stained, sheen.
					▨	🟧	TLO		SILTY SAND (SM); ~70% sand, fine to coarse, ~25% fines, ~5% gravel, fine; moderate tar-like odor, wet, FILL, black stained, blebs, sheen, stringy wood fragments.
10	S-3	5.0	1.92	NA	▨	🟪	TLO		CLAYEY SAND (SC); ~60% sand, fine to coarse, ~35% fines, ~5% gravel, fine; strong tar-like odor, wet, FILL, sticky, black stained, coatings, blebs, sheen, tiny brick fragments.
					▨	🟨	TLO		SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine to coarse, ~15% fines; strong tar-like odor, moist, FILL, crushed brick and mortar at 11.8'.
					▨	🟨	TLO		SILT WITH SAND (ML); ~75% fines, ~20% sand, fine to medium, ~5% gravel; strong tar-like odor, moist, brown to dark gray, FILL, trace mortar.
					▨	🟧	TLO		SILT WITH SAND (ML); ~75% fines, ~20% sand, fine to medium, ~5% gravel; strong tar-like odor, moist, FILL, black stained and slight sheen.
15									End of Boring at 15 feet. Terminated because potentially located within tar well. Fill with bentonite chips.

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FT. = FEET

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CLIENT: National Grid		**BORING LOG**	
PROJECT: Troy Liberty Street		**PAGE** **1 of 2**	**B-314(10)**
CITY/STATE: Troy, New York			
GEI PROJECT NUMBER: 093300-1-1113			

GROUND SURFACE ELEVATION (FT): 33.22
LOCATION: West of Bocce Courts
NORTHING: 1418574.7378 **EASTING:** 709828.9239
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/25/2010 - 10/25/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		2.0		0.0	▩	🟩			FILL, asphalt and concrete, hand and vacuum cleared to 2'.
	S-1	3.0	2.65	0.0	▩	🟩			FILL, brick, and sand.
					▩	🟩			FILL, crushed concrete.
5	S-2	5.0	1.5	0.0	▩	🟩			
					▩	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; dry, brown to yellowish orange, FILL.
					▩	🟨	TLO		WIDELY GRADED SAND WITH SILT (SW); ~90% sand, fine to coarse, ~10% fines; slight tar-like odor, dry, brown, FILL, mortar, brick at 8.5'.
10	S-3	5.0	2.35	0.0	▩	🟨			
					▩	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; dry, light gray to brown, FILL.
					▩	🟨	TLO		SILTY SAND (SP-SM); ~80% sand, fine to medium, ~15% fines, ~5% gravel; slight tar-like odor, moist, FILL, black stained.
15	S-4	5.0	2.5	0.2, 1.2, 0.6, 0.2	⁘	🟨	TLO		SILTY SAND (SP-SM); ~85% sand, fine, ~15% fines; strong tar-like odor, moist, brown.
					⁘	🟧	TLO		SILTY SAND (SP-SM); ~75% sand, ~25% fines; strong tar-like odor, moist, black stained, trace sheen, strong odor.
					⁘	🟨	TLO		SILTY SAND (SP-SM); ~75% sand, fine, ~25% fines; strong tar-like odor, moist, brown.
					▥	🟧	TLO	B-314(10) (18-18.75)	SILT (ML); fine, subrounded, ~100% sand; strong tar-like odor, moist to wet, brown with black stained layers, slight sheen, trace layers silt and reddish orange fine sand.
20	S-5	5.0	1.93	0.0	⁘	🟨	TLO	B-314(10) (21-23)	WIDELY GRADED SAND WITH GRAVEL (SW); ~65% sand, ~30% gravel, fine, subrounded, ~5% fines; moderate tar-like odor, moist, black stained.

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CLIENT:	**National Grid**
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GEI PROJECT NUMBER:	**093300-1-1113**

BORING LOG

PAGE 2 of 2

B-314(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟨			
25	S-6	5.0	1.63	0.0		🟨	TLO		WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); ~50% gravel, fine to coarse, subangular and subrounded, ~40% sand, fine to coarse, ~10% fines; moderate tar-like odor, moist to wet, brown, trace black stained.
						🟨	TLO		WIDELY GRADED GRAVEL WITH SAND (GW); ~85% gravel, fine to coarse, subangular and subrounded, ~15% sand, fine to medium; slight tar-like odor, moist.
						🟩			WIDELY GRADED GRAVEL WITH SAND (GW); ~60% gravel, fine to coarse, subangular and subrounded, ~35% sand, fine to medium, ~5% fines; wet, brown.
30	S-7	5.0	2	0.0		🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, ~35% gravel, fine to coarse, subangular and subrounded, ~5% fines; slight tar-like odor, wet, brown, layers of fine reddish orange fine sand.
						🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to medium, ~25% gravel, fine to coarse, subangular and subrounded, ~5% fines; wet, brown, layers of fine reddish orange fine sand.
35	S-8	5.0	2.55	0.0		🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, ~35% gravel, fine to coarse, subangular and subrounded, ~5% fines; slight tar-like odor, wet, brown, layers of fine reddish orange fine sand.
						🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, brown to gray, trace gravel, moderately dense.
40	S-9	5.0	3.05	0.0		🟩			
						🟨	TLO		WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; slight tar-like odor, wet, brown to gray, trace gravel, moderately dense.
						🟩		B-314(10) (44-45)	SILT (ML); ~100% fines, non plastic; wet, gray, dense.
45									End of Boring at 45 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 2
B-315(10)

GROUND SURFACE ELEVATION (FT): 33.79
LOCATION: Inside 1st Bocce Court
NORTHING: 1418573.5406 **EASTING:** 709848.4589
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/27/2010 - 10/27/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.7	0.0	▩ ▥ ▨ ░	🟩		FILL, asphalt and crusher run. SANDY SILT (ML); ~70% fines, ~30% sand; dry, brown, FILL. LEAN CLAY (CL); ~100% fines, non plastic; dry, gray, FILL. SILTY SAND (SM); ~85% sand, ~15% fines; dry, brown, FILL, brick fragments and mortar.
5	S-2	5.0	3.2	0.0	░	🟩		SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine; dry to moist, brown and gray, FILL, clay layers, medium plasticity, trace brick fragments.
10	S-3	5.0	2.2	0.0	░	🟩		
15	S-4	5.0	2.16	0.0	░ ░ ● ░	🟨 🟩		SILTY SAND (SM); ~85% sand, fine to medium, ~15% fines; moist, FILL, trace black stained, ash, burnt odor. SILTY SAND (SM); ~85% sand, fine to medium, ~15% fines; moist, brown, FILL. Fine to medium; dry, white, FILL, stone and cobble. SILTY SAND (SM); ~75% sand, fine to medium, ~15% fines, ~10% gravel, fine, subrounded and subangular; moist, brown, FILL, trace brick fragments, mortar.
20	S-5	5.0	2.35	0.0	∘	🟩	B-315(10) (20.5-21.25)	WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to medium, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet, brown, trace reddish orange fine sand.

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TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

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SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-315(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25	S-6	5.0	1.25	0.0		🟩		WIDELY GRADED GRAVEL WITH SAND (GW); ~65% gravel, fine to coarse, subrounded and subangular, ~30% sand, fine to medium, ~5% fines; wet, brown, mostly coarse gravel, trace reddish orange fine sand.
30	S-7	5.0	1.65	0.0		🟩		
35	S-8	5.0	2.95	0.0		🟩		
						🟩		WIDELY GRADED SAND (SW); ~95% sand, ~5% fines; wet, dark gray, 0.3' layer brown to reddish orange fine sand at 37.5', moderately dense.
40	S-9	5.0	4	0.0		🟩		
						🟩	B-315(10) (44-45)	SILT (ML); ~100% fines, non plastic; wet, dark gray, dense.
45								End of Boring at 45 feet. Fill with bentonite chips.

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CLIENT: National Grid
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BORING LOG
PAGE 1 of 2
B-316(10)

GROUND SURFACE ELEVATION (FT): 33.35
LOCATION: West of Bocce Courts
NORTHING: 1418563.6688 **EASTING:** 709820.4538
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/26/2010 - 10/26/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0		0.0	▨	🟩			FILL, asphalt, hand cleared.
					▨	🟩			FILL, crusher run then brown, dry, silty sand with gravel, hand and vacuum cleared to 5'.
5	S-1	5.0	4.12	0.0	▨	🟩			LEAN CLAY (CL); ~95% fines, ~5% sand; moist, brown, FILL, layers reddish orange fine sand.
					▨	🟩			SILTY SAND (SM); ~75% sand, ~25% fines; dry, brown to light gray, FILL, mortar, brick bottom 0.25'.
					▨	🟩			SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel; dry, brown, FILL, trace mortar.
10	S-2	5.0	4	0.0	▨	🟩			LEAN CLAY (CL); ~100% fines, high plasticity; wet, gray, FILL.
					▨	🟨			SILT (ML); ~85% fines, ~10% sand, ~5% gravel; moist, brown, FILL, brick fragments 12.75-13', trace mortar, black ash.
					▨	🟨			SILT (ML); ~90% fines, ~10% sand; moist, FILL, black ash, 0.2' of mortar, burnt odor.
15	S-3	5.0	5	0.0	▨	🟨			SILT (ML); ~90% fines, ~10% sand; moist, brown, FILL, burnt odor.
					⁙	🟩			SILTY SAND (SM); ~60% sand, fine to medium, ~35% fines, ~5% gravel; moist, brown.
					▥	🟨	SLO	B-316(10) (18-18.25) B-316(10) (18.25-18.5)	SILT (ML); ~95% fines, ~5% sand, fine to medium; strong sulfur-like odor, moist, gray and brown, black stained, slight sheen, burnt odor.
					▥	🟩			SILT (ML); ~95% fines, ~5% sand; moist, gray and brown, trace reddish orange fine sand.
20	S-4	5.0	2.22	0.0	⁘	🟨	SLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to medium, angular, ~40% gravel, fine to coarse, ~5% fines; strong sulfur-like odor, moist, black stained.
					⁘	🟨	SLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, subangular, ~35% gravel, fine to coarse, ~5% fines; strong sulfur-like odor, moist, gray and

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455 Winding Brook Road
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(860) 368-5300

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG

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B-316(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟨			brown, trace black stained material.
25	S-5	5.0	2.3	0.0		🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, subangular and subrounded, ~35% gravel, fine to coarse, ~5% fines; wet, brown.
30	S-6	5.0	2.55	0.0		🟩			
35	S-7	5.0	3.33	0.0		🟩			
						🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to coarse, subangular and subrounded, ~35% gravel, fine to coarse, ~5% fines; wet.
						🟩			WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, ~5% fines; wet, brown to gray, gray at 42.5', moderately dense.
40	S-8	5.0	3.35	0.0		🟩			
						🟩		B-316(10) (43.75-44.5)	SILT (ML); ~90% fines, ~10% sand; wet, gray, dense.
45									End of Boring at 45 feet. Fill with bentonite chips.

NOTES:

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ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
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MLO = MUSTY LIKE ODOR

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BORING LOG
PAGE 1 of 2

B-317(10)

GROUND SURFACE ELEVATION (FT): 33.84
LOCATION: Inside 1st Bocce Court
NORTHING: 1418562.7017 **EASTING:** 709830.3368
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/27/2010 - 10/27/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
0	S-1	5.0	2.72	0.0	▨	🟩		FILL, asphalt. SILTY SAND (SM); ~80% sand, ~15% fines, ~5% gravel; dry, dark brown to light brown, FILL, black ash, crushed mortar, and brick fragments.
5	S-2	5.0	2.42	0.0	▨	🟩		NARROWLY GRADED GRAVEL (GP); ~100% gravel, coarse; dry, light gray, FILL. LEAN CLAY (CL); ~95% fines, ~5% sand; moist, gray, FILL. SILTY SAND (SM); ~85% sand, fine to medium, ~15% fines; moist, light gray, FILL, crushed mortar and bricks.
10	S-3	5.0	4.05	0.0	▨	🟩 🟨 🟩		LEAN CLAY (CL); ~95% fines, ~5% sand; moist, gray, FILL, trace brown fine sand. SILTY SAND (SM); ~60% sand, fine to medium, ~35% fines, ~5% gravel; moist, dark gray, FILL, black stained, ash, brick fragments. SILTY SAND (SM); ~70% sand, fine to medium, ~15% fines, ~10% gravel; moist, brown.
15	S-4	5.0	2.58	0.0		🟩	B-317(10) (17-17.75)	SILTY SAND (SM); ~65% sand, fine to medium, ~35% fines; brown. WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to medium, ~45% gravel, ~5% fines; moist to wet, brown.
20	S-5	5.0	2.3	0.0		🟩		

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FT. = FEET

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BORING LOG
PAGE 2 of 2
B-317(10)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
25	S-6	5.0	1.7	0.0	▨	🟩		WIDELY GRADED GRAVEL WITH SAND (GW); ~80% gravel, fine to coarse, subrounded and subangular, ~20% sand, fine to coarse, ~5% fines; wet to saturated, brown, trace reddish orange fine sand.
30	S-7	5.0	1.7	0.0	▨	🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet, brown.
					▨	🟩		WIDELY GRADED GRAVEL WITH SAND (GW); ~80% gravel, fine to coarse, subrounded and subangular, ~20% sand, fine to coarse, ~5% fines; wet to saturated, orange to light brown.
35	S-8	5.0	1.78	0.0	▨	🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet, brown.
40	S-9	5.0	2.25	0.0	▨	🟩		WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, brown to gray, moderately dense.
					▨	🟩	B-317(10) (44-44.5)	SILT (ML); ~100% fines; wet, gray, dense.
45								End of Boring at 45 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 2
B-318(10)

GROUND SURFACE ELEVATION (FT): 33.92
LOCATION: North of Bocce Courts
NORTHING: 1418565.0546 **EASTING:** 709848.9038
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/28/2010 - 10/28/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.08	0.0	▨	🟩			Dry, FILL, asphalt, concrete, and crusher run.
					▨	🟩			SILTY SAND WITH GRAVEL (SM); ~65% sand, ~20% gravel, ~15% fines; dry, brown, FILL, brick fragments, black ash 3.25-3.75' and 5'.
5	S-2	5.0	2.58	0.0					
					▨	🟩			LEAN CLAY (CL); ~95% fines, medium plasticity, ~5% sand; moist to wet, gray, FILL, tiny brick fragments, mortar 8.7-9.0'.
10	S-3	5.0	4.66	0.0					
					▨	🟩			LEAN CLAY WITH SAND (CL); ~70% fines, ~20% sand, ~10% gravel; wet, gray, FILL.
					▨	🟨		B-318(10) (12.8-13.25)	GRAVELLY SILT WITH SAND (ML); ~65% fines, ~20% gravel, fine, ~15% sand, fine; moist, dark gray to gray, FILL, black stained 12.5-13.25', burnt odor.
					▨	🟨	TLO		GRAVELLY SILT WITH SAND (ML); ~65% fines, ~20% gravel, fine, ~15% sand, fine to medium; slight tar-like odor, moist, brown and gray, FILL, weathered odor, wood fragment.
					▨	🟨	TLO		SILTY SAND (SM); ~65% sand, fine to medium, ~35% fines; slight tar-like odor, moist, brown, FILL, weathered odor.
15	S-4	5.0	2.72	0.0	░	🟩			SILTY SAND (SM); ~65% sand, fine to medium, ~35% fines; moist, brown.
					▥	🟩			SILT (ML); ~90% fines, ~10% sand; moist, gray.
					⁘	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to medium, ~45% gravel, fine to coarse, subrounded to angular, ~5% fines; wet, brown, trace reddish orange fine sand.
20	S-5	5.0	2	0.0					

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BORING LOG

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B-318(10)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25	S-6	5.0	2.2	0.0	▨	🟩		B-318(10) (27.8-30)	WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; wet, brown and gray, moderately dense, trace fine gravel.
30									End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 2
B-319(10)

GROUND SURFACE ELEVATION (FT): 33.44
LOCATION: West of Bocce Courts
NORTHING: 1418553.7719 **EASTING:** 709809.8968
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/26/2010 - 10/26/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0		5.0		0.0	▨	🟩			FILL, dry, brown, silty sand and gravel, hand and vacuum cleared to 5'.
5	S-1	5.0	0.5	0.0	▨	🟨	TLO	B-319(10) (5-10)	Slight tar-like odor, FILL, Poor recovery. Clay and tiny brick fragments. Rock stuck in shoe prevented recovery.
10	S-2	5.0	3.65	0.0	▨	🟩			SILTY SAND WITH GRAVEL (SM); ~65% sand, ~20% gravel, ~15% fines; wet to dry, brown, FILL, brick fragments at 12.5'.
15	S-3	5.0	2.1	0.0	░	🟨			SILTY SAND (SM); ~80% sand, ~15% fines, ~5% gravel; moist, black stained, strong strange burnt odor.
					▥	🟩			SILT WITH SAND (ML); ~85% fines, ~15% sand; moist, gray.
20	S-4	5.0	2.45	0.0	░	🟩		B-319(10) (20-21.5)	SILTY SAND WITH GRAVEL (SM); ~65% sand, fine to medium, ~20% gravel, fine, subrounded, ~15% fines; wet, brown.

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BORING LOG
PAGE 2 of 2
B-319(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	 PEN FT.	 REC FT.	 PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟩			WIDELY GRADED GRAVEL WITH SILT AND SAND (GW-GM); ~70% gravel, fine to coarse, subrounded to angular, ~20% sand, fine to coarse, ~10% fines; wet, brown and gray, trace layers of reddish orange fine sand, coarse gravel 35-38.5'.
25	S-5	5.0	2.15	0.0		🟩			
30	S-6	5.0	2.15	0.0		🟩			
35	S-7	5.0	1.6	0.0		🟩			
						🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% gravel; wet, brown, moderately dense.
40	S-8	5.0	3.25	0.0		🟩			
						🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% gravel; wet, gray, dense 1" silt varve at 43.7' and dense silt in shoe.
45								B-319(10) (44.25-44.75)	End of Boring at 45 feet. Fill with bentonite chips.

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PROJECT: Troy Liberty Street
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GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 2
B-320(10)

GROUND SURFACE ELEVATION (FT): 34.06
LOCATION: North of Bocce Courts
NORTHING: 1418553.7377 **EASTING:** 709832.2048
TOTAL DEPTH (FT): 35.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/27/2010 - 10/27/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.03	0.0	▨	🟩		FILL, asphalt. SILTY SAND (SM); ~70% sand, fine to medium, ~15% fines, ~5% gravel; dry, brown, FILL, 1.75-2.25' crushed concrete and mortar. SILTY SAND (SM); ~70% sand, fine to medium, ~15% fines, ~5% gravel; dry, brown and black, FILL. SILTY SAND (SM); ~70% sand, fine to medium, ~15% fines, ~5% gravel; dry, brown, FILL, brick fragments and mortar at 3.8-4.2', clay at 5'.
5	S-2	5.0	3.6	0.0	▨	🟩		FAT CLAY (CH); ~100% fines, high plasticity; moist, gray, FILL. FILL, crushed mortar and bricks. FAT CLAY WITH SAND (CH); ~85% fines, ~15% sand, fine; moist, gray, FILL.
10	S-3	5.0	2.23	0.0	▨	🟩 🟨		FAT CLAY (CH); ~100% fines; moist, gray, FILL. SILTY SAND (SM); ~85% sand, ~15% fines; moist, brown, FILL, brick fragments, trace black stained, burnt odor.
15	S-4	5.0	2.39	0.0	▨ ⁘	🟨 🟩	B-320(10) (15-16)	FAT CLAY (CH); ~95% fines, ~5% sand; moist, gray, FILL, trace black stained 15-15.5', burnt odor. FAT CLAY (CH); ~95% fines, ~5% sand; moist, gray with light pink, FILL. WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to medium, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; moist to wet, brown, trace fine reddish orange fine sand.
20	S-5	5.0	1.47	0.0	⁘	🟩		

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BORING LOG
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B-320(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
					⁘	🟩		
25	S-6	5.0	1.7	0.0	⁘	🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, ~35% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet, brown, trace fine reddish orange fine sand.
30	S-7	5.0	0	NA				NO RECOVERY.
35								End of Boring at 35 feet. Fill with bentonite chips.

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CLIENT: National Grid		**BORING LOG**	
PROJECT: Troy Liberty Street		**PAGE** 1 of 2	**B-321(10)**
CITY/STATE: Troy, New York			
GEI PROJECT NUMBER: 093300-1-1113			

GROUND SURFACE ELEVATION (FT): 34.09
LOCATION: Inside 1st Bocce Court
NORTHING: 1418553.7746 **EASTING:** 709849.7398
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/28/2010 - 10/28/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	3.42	0.0	▨	🟩			FILL, asphalt and concrete.
					▨	🟩			FILL, crusher run with sand, brown and black sand and gravel.
					▨	🟩			SILTY SAND WITH GRAVEL (SM); ~60% sand, ~20% gravel, ~20% fines; moist, light brown and brown, FILL, scattered crushed mortar fragments.
5	S-2	5.0	2	0.0	▨	🟨	NLO	B-321(10) (6-7)	SILTY SAND (SM); ~80% sand, ~20% fines; moderate naphthalene-like odor, moist, FILL, black stained, coarse crushed stone and brick at 7'.
									Apparent void in drilling between 7-9'.
					▨	🟩			Moist, FILL, two sections of mortar and brick.
10	S-3	5.0	3.7	0.0	▨	🟨	NLO		CLAYEY SAND (SC); ~50% sand, ~45% fines, ~5% gravel; moderate naphthalene-like odor, wet, brown to gray, FILL, tiny brick fragments.
					▨	🟩			FAT CLAY (CH); ~100% fines, high plasticity; wet, gray, FILL.
					▨	🟨	NLO	B-321(10) (11.4-12)	CLAYEY SAND (SC); ~50% sand, ~45% fines, ~5% gravel; moderate naphthalene-like odor, wet, gray, FILL, some black stained material and wood fragments.
					▨	🟨	NLO		FAT CLAY (CH); ~100% fines, high plasticity; slight naphthalene-like odor, wet, light gray, FILL, fractions of fine sand.
15	S-4	5.0	1.36	0.0	▨	🟨	NLO		SILTY SAND WITH GRAVEL (SM); ~60% sand, ~20% gravel, ~20% fines; slight naphthalene-like odor, wet, dark gray and brown, FILL, black wood chips at 14.5', crushed mortar, brick fragments at 16'.
					░	🟩			SILTY SAND (SM); ~85% sand, ~15% fines; moist, dark gray to light brown, coarse stone at 17', 2" brown silt layer.
20	S-5	5.0	1.07	0.0	⁘	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to medium, ~30% gravel, fine to coarse, subrounded, ~5% fines; wet, brown and gray, reddish orange fine sand and gravel at 21'.

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MLO = MUSTY LIKE ODOR

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BORING LOG
PAGE 2 of 2
B-321(10)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
					⁘	🟩			
25	S-6	5.0	1.38	0.0	⁘	🟩		B-321(10) (29-30)	WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to medium, ~45% gravel, fine to coarse, subrounded, ~5% fines; wet, brown and gray, reddish orange fine sand and gravel at 29'.
30									End of Boring at 30 feet. Fill with bentonite chips.

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IN. = INCHES
FT. = FEET

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BORING LOG
PAGE 1 of 1
B-322(10)

GROUND SURFACE ELEVATION (FT): 30.63
LOCATION: Within Southwest Former Holder Wall
NORTHING: 1418709.2317 **EASTING:** 709837.8836
TOTAL DEPTH (FT): 18.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/26/2010 - 10/26/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0	S-1	5.0	4	0.0	▨	🟩			FILL, asphalt and concrete.
					▨	🟩			NARROWLY GRADED SAND WITH GRAVEL (SP); ~50% sand, fine sand, ~45% gravel, ~5% fines; dry, light brown and gray, FILL.
					▨	🟩			Fine to medium; dry, brown, FILL.
					▨	🟩			Dry, red, FILL, bricks and mortar.
					▨	🟩			SILTY SAND (SM); ~70% sand, fine to medium, ~20% fines, ~10% gravel; dry, brown, FILL, crushed brick fragments between 5.25-5.75'.
5	S-2	5.0	3	0.0	▨	🟩			
					▨	🟩			SILTY SAND (SM); ~75% sand, fine to medium, ~15% fines, ~5% gravel; dry, dark gray to gray, FILL.
					▨	🟩			Dry, pink and red, FILL, crushed mortar and brick fragments.
					▨	🟨	TLO		SILTY SAND (SM); ~75% sand, fine to medium, ~15% fines, ~10% gravel; slight tar-like odor, moist, dark gray to black, FILL, ash.
10	S-3	5.0	2.58	0.0	▨	🟨	TLO		SILTY GRAVEL (GM); ~85% gravel, fine to coarse, subangular, ~15% fines; slight tar-like odor, wet, gray and red, FILL, fine to coarse brick fragments.
					▨	🟨	TLO	B-322(10) (12-13)	SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine, subangular, ~15% fines; slight tar-like odor, wet, dark gray, FILL.
					▨	🟨	TLO		WIDELY GRADED GRAVEL WITH SAND (GW); ~65% gravel, fine to coarse, subangular, ~30% sand, fine to medium, ~5% fines; slight tar-like odor, wet, brown, FILL, brick fragments.
15	S-4	3.0	1.3	0.0	▨	🟨			
					▨	🟨	TLO		Slight tar-like odor, wet, light yellow and red, FILL, crushed mortar and brick fragments.
					▨	🟨	TLO	B-322(10) (16.5-17.5)	SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine, subangular, ~15% fines; moderate tar-like odor, wet, brown, FILL, brick fragments, thin lens of black staining at 17'.

End of Boring at 18 feet.
Refusal at 18'
Fill with bentonite chips.

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BORING LOG

PAGE 1 of 2

B-323(10)

GROUND SURFACE ELEVATION (FT): 31.18
LOCATION: Adjacent to Tar Well between Former Holders
NORTHING: 1418762.878 **EASTING:** 709847.391
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/29/2010 - 10/29/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	SAMPLE INFO PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		15.0							Soils not sampled per NYSDEC concurrence. Goal was to characterize outside and below tar well floor.
5									
10									
15	S-1	5.0	1.75	0.0	▩	🟨	TLO		WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to medium, ~20% gravel, fine to coarse, subrounded and subangular, ~10% fines; slight tar-like odor, moist, dark gray, FILL, trace black stain.
					▩	🟩		B-323(10) (18.5-19.5)	WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to medium, ~20% gravel, fine to coarse, subrounded and subangular, ~10% fines; moist, gray and brown, FILL, crushed stone at 18'.
20	S-2	5.0	2.4	0.0	⁘	🟩			WIDELY GRADED SAND WITH SILT AND GRAVEL (SW-SM); ~70% sand, fine to medium, ~20% gravel, fine, angular, ~10% fines; wet, brown, large rounded gravel at 21'.
					⁘	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to coarse, ~5% fines; moist, brown, trace tiny brick fragments.

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BORING LOG
PAGE 2 of 2
B-323(10)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25	S-3	5.0	2.3	0.0	▨	🟩		B-323(10) (28.5-29.5)	WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, fine to coarse, subrounded, ~5% fines; wet, brown.
30									End of Boring at 30 feet. Fill with bentonite chips.

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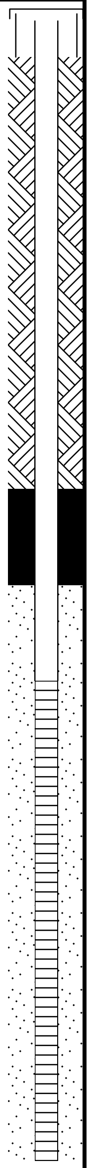
BORING LOG
PAGE 1 of 2

B/MW-324(10)

GROUND SURFACE ELEVATION (FT): 33.1
LOCATION: West of South Tar Well
NORTHING: 1418573.6191 **EASTING:** 709806.7446
TOTAL DEPTH (FT): 45.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 10/29/2010 - 10/29/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	SAMPLE INFO PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0	S-1	5.0	2.75	NA	▩	🟩			WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; dry to wet, brown, FILL, crushed brick at 2.4' and 3.6'.
5	S-2	5.0	3.38	NA	▩	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, fine to coarse, subrounded, ~5% fines; dry to wet, brown, FILL, trace brick fragments to 5.75'.
					▩	🟩			LEAN CLAY (CL); ~90% fines, ~10% sand; wet, gray, FILL.
					▩	🟨	TLO		WIDELY GRADED SAND WITH SILT (SW-SM); ~90% sand, fine to medium, ~10% fines; moderate tar-like odor, wet, dark gray and black, FILL, black stained, ash.
10	S-3	5.0	2.65	6.3, 100.0, 30.3	▩	🟨	TLO		
					▩	🟧	TLO		SILTY SAND (SM); ~75% sand, fine to medium, ~20% fines, ~5% gravel; strong tar-like odor, moist to wet, dark brown to black, FILL, slight to strong tar-like odor, black stain and sheen 11.75' to bottom, shoe=sheen, coatings, blebs.
					▩	🟪	TLO		Strong tar-like odor, FILL.
15	S-4	5.0	4.8	6.2, 5.1, 29.9, 13.5, 11.2	▩	🟪	TLO	B/MW-324(10) (15-15.25) B/MW-324(10) (15.25-16.5)	Strong tar-like odor. SILTY SAND (SM); ~75% sand, fine to medium, ~20% fines, ~5% gravel; strong tar-like odor, saturated, black, FILL, medium tar coated, blebs, heavy sheen.
					▩	🟧	TLO		SILTY SAND (SM); ~75% sand, ~20% fines, ~5% gravel; strong tar-like odor, wet, black, FILL, black stain and sheen.
					▩	🟩			Red, FILL, crushed brick.
					▩	🟧	TLO		SILTY SAND (SM); ~75% sand, ~20% fines, ~5% gravel; strong tar-like odor, wet to moist, black, FILL, black stain and sheen, layer of brown clay 17.4-17.6'.
					▨	🟧	TLO		LEAN CLAY (CL); ~95% fines, medium plasticity, ~5% sand; strong tar-like odor, moist, brown, FILL.
					░	🟨	TLO		NARROWLY GRADED SAND (SP); ~95% sand, fine, ~5% fines; strong tar-like odor, moist, black, FILL, black stain.
20	S-5	5.0	2.12	0.6, 1.2, 1.6, 2.0	░	🟨			
					⁘	🟨	TLO		WIDELY GRADED SAND WITH GRAVEL (SW);

WELL DETAILS



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BORING LOG
PAGE 2 of 2
B/MW-324(10)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)						
						🟨			~70% sand, ~25% gravel, ~5% fines; moderate tar-like odor, wet, black, crushed stone 20.5', black stain, moderate to slight tar odor, trace wood fragments.	
25	S-6	5.0	1.85	0.0		🟨				
						🟩	TLO		WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to medium, ~25% gravel, fine to medium, ~5% fines; slight tar-like odor, wet, black gray to gray, black stained to 27.3'.	
						🟩			WIDELY GRADED GRAVEL WITH SAND (GW); ~60% gravel, fine to coarse, ~35% sand, fine to medium, ~5% fines; wet, light brown to brown, trace layers of fine reddish orange sand.	
30	S-7	5.0	1.55	0.0		🟩				
35		5.0							Not sampled by accident.	
40	S-8	5.0	3.01	0.0		🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, brown, moderately dense.	
						🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, gray, moderately dense.	
						🟩		B/MW-324(10) (43.75-44.75) and a duplicate	SILT (ML); ~100% fines; moist, gray, dense.	
45									End of Boring at 45 feet. Monitoring well installed.	

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BORING LOG
PAGE 1 of 2
B-401(11)

GROUND SURFACE ELEVATION (FT): 32.88
LOCATION: Hill Street West of South Tar Well
NORTHING: 1418588.4427 **EASTING:** 709766.0762
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/14/2011 - 4/14/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0		0.0	▩	🟩			FILL, asphalt, concrete, cobblestone, silty sand with gravel, bricks, mortar, hand and vacuum cleared.
					▩	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~80% sand, fine to medium, ~15% gravel, fine to coarse, subrounded, ~5% fines; dry, brown, FILL, trace reddish orange fine sand.
5	S-1	5.0	3.43	0.0	▩	🟩			
					▩	🟩			FAT CLAY (CH); ~90% fines, high plasticity, ~10% sand, fine; moist, gray, FILL, layers of fine sand and silt within clay.
10	S-2	5.0	4.05	0.0	▩	🟩			SILTY SAND WITH GRAVEL (SM); ~65% sand, fine, ~20% fines, ~15% gravel, fine to coarse; moist to wet, gray, FILL.
					▩	🟩			WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, ~5% fines; wet, brown, FILL, clay and gravel between 12.1' and 12.5'.
					▩	🟩		B-401(11) (12.6-12.8) B-401(11) (12.8-13.3)	SILT WITH GRAVEL (ML); ~85% fines, ~15% gravel, fine, subrounded; moist to dry, gray, FILL, dense, tiny brick fragments.
15	S-3	5.0	4.05	0.0	▩	🟩			Moist, FILL, dark wood chips with burnt odor.
					▥	🟩			SILT (ML); ~90% fines, non plastic, ~5% gravel, fine, ~5% sand, fine; moist to wet, gray.
					▥	🟩			SILT (ML); fine, ~95% fines, non plastic, ~5% sand, fine; wet, gray.
					▥	🟩			SILT (ML); ~100% fines, low plasticity; moist, brown gray.
					⁘	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, gray, <5% fine gravel.
20	S-4	5.0	4.43	0.0	⁘	🟩			
					⁘	🟦	PLO	B-401(11) (21.9-22.5)	SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine to coarse, subrounded, ~15% fines; slight petroleum-like odor, wet, dark gray to black.
					⁘	🟩			SILTY SAND WITH GRAVEL (SM); ~65% sand, fine to

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BORING LOG

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B-401(11)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
25	S-5	5.0	2.65	0.0		🟩		B-401(11) (25-30) and B-401(11) (29-30)	medium, ~20% gravel, fine to coarse, subrounded and subangular, ~15% fines; wet, light brown to brown and gray. WIDELY GRADED GRAVEL WITH SAND (GW); ~75% gravel, fine to coarse, subrounded and subangular, ~20% sand, fine to coarse, ~5% fines; saturated, brown and gray, loose, gravel increases with depth until a little more sand at bottom.
30									End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG

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B-402(11)

GROUND SURFACE ELEVATION (FT):	32.54	**LOCATION:**	Northwest of South Tar Well
NORTHING:	1418594.9853 **EASTING:** 709804.3513	**TOTAL DEPTH (FT):**	35.00
DRILLED BY:	Zebra Environmental / Brian Ramos	**DATUM VERT. / HORZ.:**	MSL / NAD83
LOGGED BY:	Drew Blicharz	**DATE START / END:**	4/13/2011 - 4/13/2011
DRILLING DETAILS:	Geoprobe / 7720DT		
WATER LEVEL DEPTHS (FT):			

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0		0.0	▩	🟩			FILL, asphalt, concrete, cobblestone, silty sand with gravel, bricks, mortar, hand and vacuum cleared.
5	S-1	5.0	3.42	0.0	▩	🟩			SILTY SAND (SM); ~75% sand, fine to medium, ~20% fines, ~5% gravel, fine; moist, brown, FILL, tiny brick fragments.
					▩	🟩			FAT CLAY (CH); ~95% fines, ~5% sand; moist, gray with brown, FILL, layers of fine to medium sand.
10	S-2	5.0	3.15	0.0	▩	🟩			SILT WITH GRAVEL (ML); ~80% fines, ~20% gravel, fine to coarse; moist, gray, FILL, dark gray 10 to 10.1'.
					▩	🟩		B-402(11) (11.1-11.4) B-402(11) (11.4-11.8)	WIDELY GRADED SAND WITH GRAVEL (SW); ~65% sand, fine to coarse, ~30% gravel, fine to coarse, subrounded, ~5% fines; wet, brown, FILL, black wood chips with burnt odor at 11.9', trace reddish orange fine sand, mortar at 15'.
15	S-3	5.0	3.7	0.0	⁘	🟩			WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, gray, silt layer 15.8 to 16.1'.
					▨	🟩			FAT CLAY (CH); ~100% fines, high plasticity; wet, greenish gray, dense.
					░	🟩			SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine, subrounded, ~15% fines; wet, gray.
20	S-4	5.0	3.18	0.0	⁘	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~40% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet to saturated, brown and gray, black stained at 22 to 22.5'.
					⁘	🟦	PLO		Slight petroleum-like odor.
					⁘	🟩			

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CLO = CHEMICAL LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
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MLO = MUSTY LIKE ODOR

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-402(11)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
					▨	🟩		B-402(11) (24-25)	
25	S-5	5.0	5	0.0	▨	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); macrocore stuck in sampler, soils banged out into bucket.
30	S-6	5.0	5	0.0	▨	🟩			WIDELY GRADED SAND (SW); ~100% sand, fine to medium; brown and gray.
35					▨	🟩		B-402(11) (34.7-35)	NARROWLY GRADED SAND (SP); ~95% sand, fine, ~5% fines; gray to brown.

End of Boring at 35 feet.
Fill with bentonite chips.

NOTES:

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FT. = FEET

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BORING LOG

PAGE 1 of 2

B-403(11)

GROUND SURFACE ELEVATION (FT): 32.16
LOCATION: Southwest corner of parking lot
NORTHING: 1418622.887 **EASTING:** 709824.9053
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/12/2011 - 4/12/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0	S-1	5.0	2.27	0.0	▨	🟩			Dry, FILL, asphalt, concrete and crusher run, hand and vacuum cleared.
					▨	🟩			Dry, FILL, mortar, bricks, brown silty sand (fine to coarse) and fine to coarse gravel, crushed cobble.
5	S-2	5.0	1.9	0.0	▨	🟨	NLO	B-403(11) (7.4-7.9)	Slight naphthalene-like odor, dry, FILL, fine to medium sand, light brown, some black stained material, bricks.
					▨	🟨	NLO	B-403(11) (7.9-8.4)	Strong naphthalene-like odor, dry, FILL, fine to medium sand and gravel, black stained.
					▨	🟨	NLO		Slight naphthalene-like odor, dry, FILL, bricks and mortar, trace black stained material.
10	S-3	5.0	2.35	0.0	▨	🟨	NLO		SILT (ML); ~95% fines, ~5% gravel, fine; slight naphthalene-like odor, dry to moist, brown to light brown, FILL, brittle.
					▨	🟨	NLO		WIDELY GRADED SAND WITH SILT (SW-SM); ~85% sand, fine to medium, ~10% fines, ~5% gravel, fine; strong naphthalene-like odor, moist, FILL, black stained.
					▨	🟨	NLO		Slight naphthalene-like odor, dry, FILL, cobble and brick.
					▨	🟨	NLO		LEAN CLAY WITH SAND (CL); ~80% fines, low plasticity, ~15% sand, fine, ~5% gravel, fine; strong naphthalene-like odor, moist, brown and gray, FILL, black stained material 13.8-14.25'.
15	S-4	5.0	3.65	0.0	▨	🟨	NLO		WIDELY GRADED SAND (SW); ~85% sand, fine to medium, ~10% gravel, fine to coarse, ~5% fines; slight naphthalene-like odor, moist to wet, gray, FILL, trace brick fragments, trace black stained material at 17'.
					▨	🟨	NLO		SILT (ML); ~100% fines, low plasticity; slight naphthalene-like odor, wet, brown to light brown, FILL, black stained material at 18' and 20', trace black stained material in between.
20	S-5	5.0	1.35	0.0	░	🟩			WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~40% gravel, fine, ~5% fines; wet, light brown to brown, dark gray material at 25'.

NOTES:

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FT. = FEET

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BORING LOG
PAGE 2 of 2
B-403(11)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
						🟩			
25	S-6	5.0	1.62	0.0		🟩		B-403(11) (28-29) B-403(11) (29-30)	WIDELY GRADED GRAVEL WITH SAND (GW); ~55% gravel, fine to coarse, ~40% sand, fine to coarse, ~5% fines; wet, brown and dark brown, little dark gray material.
30									End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG

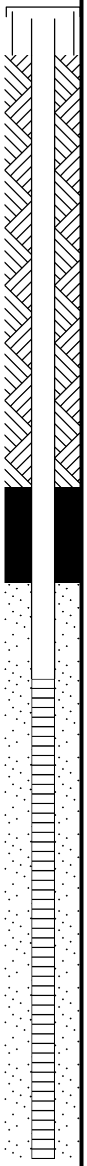
PAGE 1 of 2

B/MW-404(11)

GROUND SURFACE ELEVATION (FT): 33.33
LOCATION: Hill Street West of South Tar Well
NORTHING: 1418558.6354 **EASTING:** 709772.8932
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/13/2011 - 4/14/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		3.0		0.0		🟩		Dry, FILL, asphalt, cobblestone, hand and vacuum cleared.
	S-1	2.0	1.5	0.0		🟩		SANDY LEAN CLAY WITH GRAVEL (CL); ~60% fines, ~25% sand, fine to medium, ~15% gravel, fine to coarse, subrounded; dry to moist, light brown and brown, FILL, layers of brown and gray fine to medium sand, silty sand and silt, trace reddish orange fine sand.
5	S-2	5.0	3.78	0.0		🟩		
10	S-3	5.0	3.3	0.0		🟩		
						🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~60% sand, fine to medium, ~35% gravel, fine to coarse, subrounded, ~5% fines; dry to moist, brown and reddish brown, FILL. SILT (ML); ~85% fines, non plastic, ~10% gravel, fine, subrounded, ~5% sand, fine; dry to moist, gray, FILL, brittle. SILT (ML); ~95% fines, non plastic, ~5% sand, fine; moist to wet, light brown, soft, trace reddish orange fine sand, slightly higher sand content to 15.7', wet at 18'.
15	S-4	5.0	4.45	0.0		🟩	B/MW-404(11) (18-18.2) B/MW-404(11) (18.2-18.5)	WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, brown.
20	S-5	5.0	1.45	0.0		🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~40% gravel, fine to coarse, subrounded, ~5% fines; saturated, brown, loose.

WELL DETAILS



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BORING LOG
PAGE 2 of 2
B/MW-404(11)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
25	S-6	5.0	2.2	0.0	⁘	🟩	B/MW-404(11) (25-26.4)	WIDELY GRADED SAND (SW); ~95% sand, ~5% gravel, subrounded; wet, dark gray, loose.	
					●	🟩		WIDELY GRADED GRAVEL (GW); ~90% gravel, fine to coarse, rounded and subangular, ~5% sand, ~5% fines; saturated, brown and light brown, loose, sand and silt within gravel at bottom.	
30							B/MW-404(11) (29.5-30)	End of Boring at 30 feet.	

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BORING LOG
PAGE 1 of 2
B-405(11)

GROUND SURFACE ELEVATION (FT): 32.68
LOCATION: Hill Street West of South Tar Well
NORTHING: 1418573.2185 **EASTING:** 709770.9872
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/13/2011 - 4/13/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0				🟩		Dry, FILL, asphalt, cobblestone, hand and vacuum cleared.
						🟩		SILTY SAND WITH GRAVEL (SM); ~60% sand, fine to medium, ~25% fines, ~15% gravel, fine to coarse, subrounded; dry to moist, gray and brown, FILL, layers of light brown and brown moist clay, trace reddish orange fine sand.
5	S-1	5.0	1.78	0.0		🟩		
10	S-2	5.0	4.65	0.0		🟩		
						🟩		SILT (ML); ~80% fines, ~10% gravel, fine, ~10% sand, fine; dry to moist, brown, FILL, brittle.
						🟩		SILT (ML); ~90% fines, ~5% gravel, fine, subrounded, ~5% sand, fine; dry to moist, dark gray, FILL, brittle, dense, brick fragments at 12.25' and 15'.
15	S-3	5.0	4.15	0.0		🟩		SILT (ML); ~95% fines, ~5% sand; moist to wet, light gray, FILL.
						🟩	B-405(11) (17.3-17.5) B-405(11) (17.5-17.9)	WIDELY GRADED SAND WITH SILT (SW-SM); wet, wet at ~17.2, brown fine to medium sand enveloped by decreasing amount of gray silt.
						🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, subrounded, ~5% fines; wet, reddish brown.
20	S-4	5.0	3.45	0.0		🟩		WIDELY GRADED SAND (SW); fine to coarse, rounded, ~95% sand, fine to coarse, ~5% fines; wet, gray.
						🟩		SILTY SAND WITH GRAVEL (SM); ~45% sand, fine to coarse, ~40% gravel, fine to coarse, subrounded and subangular, ~15%

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DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
						🟩		fines; wet, reddish brown and brown.
25	S-5	5.0	1.27	0.0		🟩	B-405(11) (25-27)	WIDELY GRADED SAND (SW); ~100% sand, fine to coarse; wet, gray and brown.
						🟩		WIDELY GRADED GRAVEL (GW); fine to coarse, subrounded and subangular, ~100% sand; wet, gray.
30								End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG
PAGE 1 of 2
B-406(11)

GROUND SURFACE ELEVATION (FT): 32.16
LOCATION: Hill Street West of South Tar Well
NORTHING: 1418591.8444 **EASTING:** 709767.8605
TOTAL DEPTH (FT): 25.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/13/2011 - 4/13/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)			
0		3.5		0.0	▨	🟩	Dry, FILL, asphalt, cobblestone, hand and vacuum cleared.
	S-1	1.5	1.66	0.0	▨	🟩	SANDY LEAN CLAY (CL); ~50% fines, ~40% sand, fine to medium, ~10% gravel, fine, subrounded; wet to dry, gray and brown, FILL, trace reddish orange fine sand, black and white ash at 5'.
5	S-2	5.0	2.22	0.0	▨	🟩	WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; dry to moist, brown, FILL, two 0.3' layers of gray and yellowish orange lean clay between 8-10'.
10	S-3	5.0	0				Only shoe recovered 3 times. Rock in bottom of outer casing prevented sample collection..
15	S-4	5.0	0				
20	S-5	5.0	0				

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CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 2 of 2
B-406(11)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	SOIL / BEDROCK DESCRIPTION
25							End of Boring at 25 feet. Fill with bentonite chips.

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GEI PROJECT NUMBER:	093300-1-1113

BORING LOG

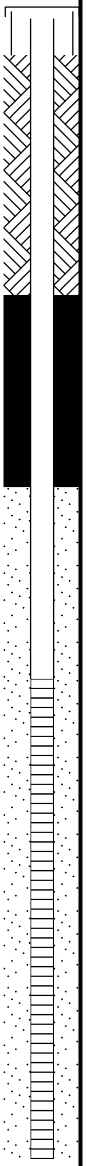
PAGE 1 of 2

B/PZ-407(11)

GROUND SURFACE ELEVATION (FT):	29.81	**LOCATION:**	Northwest of Northeast Former Holder
NORTHING: 1418816.8233	**EASTING:** 709849.1786	**TOTAL DEPTH (FT):**	30.00
DRILLED BY:	Zebra Environmental / Brian Ramos	**DATUM VERT. / HORZ.:**	MSL / NAD83
LOGGED BY:	Drew Blicharz	**DATE START / END:**	4/12/2011 - 4/12/2011
DRILLING DETAILS:	Geoprobe / 7720DT		
WATER LEVEL DEPTHS (FT):			

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0		0.0				Dry, FILL, asphalt, concrete and crusher run, hand cleared. Dry, FILL, brown silty sand with gravel, cobble, and brick fragments, vacuum cleared.
5	S-1	5.0	2	0.0				SILTY SAND WITH GRAVEL (SM); ~60% sand, fine to coarse, ~25% gravel, fine, rounded, ~15% fines; moist, brown, FILL, trace reddish orange fine sand.
								WIDELY GRADED GRAVEL WITH CLAY (GW-GC); ~75% gravel, fine, rounded, ~20% fines, ~5% sand, fine to coarse; moist, brown, FILL.
								SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to coarse, ~15% gravel, fine, subrounded, ~15% fines; dry, brown, FILL, cobble at 8.5', crushed mortar below, trace reddish orange fine sand.
10	S-2	5.0	3.45	0.0				WIDELY GRADED SAND WITH CLAY AND GRAVEL (SP-SC); ~80% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~10% fines; moist, gray, FILL, trace reddish orange fine sand.
								LEAN CLAY (CL); ~90% fines, medium plasticity, ~10% gravel, fine to coarse, subrounded; moist, gray, FILL, dense.
								LEAN CLAY (CL); ~85% fines, medium plasticity, ~10% sand, fine to medium, ~5% gravel, fine, subrounded; moist, brown to gray, FILL.
15	S-3	5.0	2.8	0.0			B/PZ-407(11) (16-16.4) B/PZ-407(11) (16.4-17.1)	WIDELY GRADED SAND WITH GRAVEL (SW); ~75% sand, fine to coarse, ~20% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet to saturated, brown and reddish orange.
								WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, subrounded, ~5% fines; saturated, gray to 20', brown and gray below, trace fine reddish orange sand, f-c angular gravel at 25'.
20	S-4	5.0	3.25	0.0				

WELL DETAILS



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BORING LOG

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B/PZ-407(11)

DEPTH FT.	SAMPLE INFO TYPE and NO.	SAMPLE INFO PEN FT.	SAMPLE INFO REC FT.	SAMPLE INFO PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
						🟩			
25	S-5	5.0	2.9	0.0		🟩		WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, subrounded, ~5% fines; saturated, gray.	
						🟩		WIDELY GRADED SAND (SW); fine, ~5%, ~95% sand, fine to coarse, ~5% fines; saturated, reddish brown.	
						🟩	B/PZ-407(11) (29-30)	WIDELY GRADED SAND (SW); ~90% sand, fine to coarse, ~5% gravel, fine, subrounded, ~5% fines; wet, brown and gray.	
30								End of Boring at 30 feet.	

NOTES:

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REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
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CrLO= CREOSOTE LIKE ODOR
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SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

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CITY/STATE: Troy, New York
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BORING LOG

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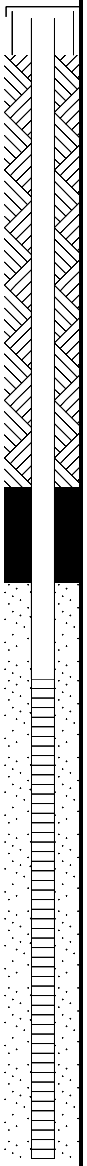
B/PZ-408(11)

GROUND SURFACE ELEVATION (FT): 31.87
LOCATION: Southeast of Northeast Former Holder
NORTHING: 1418758.7155 **EASTING:** 709932.5038
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/12/2011 - 4/12/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		5.0		0.0		🟩		Dry, FILL, asphalt, concrete and crusher run, hand cleared. Dry, FILL, brown to light brown fine to medium sand, gravel, 5% fines, cobbles, vacuum cleared.
5	S-1	5.0	0.95	0.0		🟩		SILTY SAND WITH GRAVEL (SM); ~70% sand, fine to medium, ~15% gravel, fine to coarse, subrounded, ~15% fines; dry to moist, dark brown to light brown, FILL, trace reddish orange fine sand, cobble at 14-15'.
10	S-2	5.0	2.15	0.0, 0.1		🟩		
15	S-3	5.0	2.6	0.0, 0.2		🟩		
						🟩	B/PZ-408(11) (15.75-16.5) B/PZ-408(11) (16.5-17.3)	WIDELY GRADED SAND (SW); ~85% sand, ~10% gravel, ~5% fines; wet, dark brown, trace reddish orange fine sand.
						🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, ~25% gravel, ~5% fines; wet to saturated, dark brown and gray, trace reddish orange fine sand, coarse gravel at 17.1'.
20	S-4	5.0	1.83	0.0		🟩		
						🟩	B/PZ-408(11) (22.7-23.25)	WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~40% gravel, fine to coarse, subrounded, ~5% fines; saturated, brown.

WELL DETAILS



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BORING LOG

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B/PZ-408(11)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
					▨	🟩	B/PZ-408(11) (23.25-25)		
25	S-5	5.0	0					NO RECOVERY, rods pushed through interval effortlessly, loose material.	
30								End of Boring at 30 feet.	

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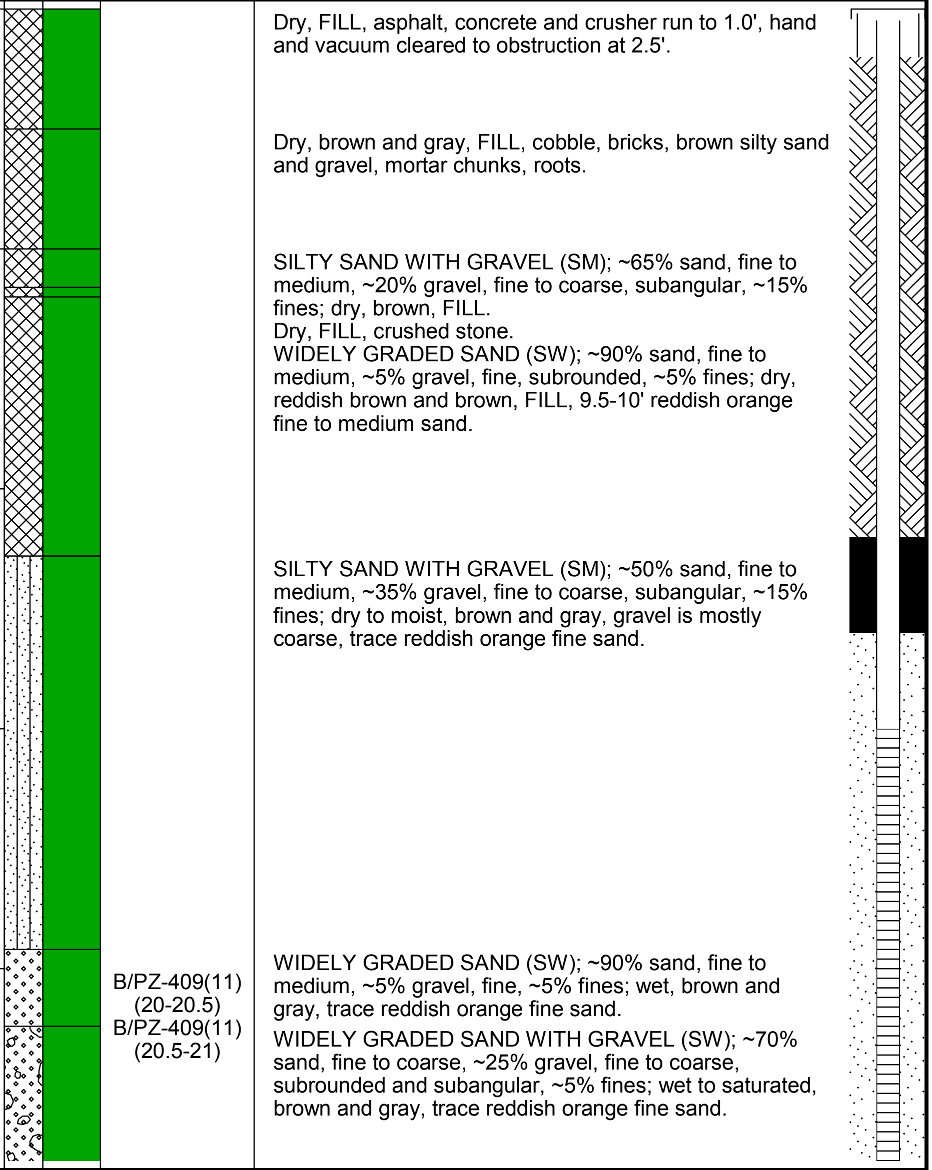
CITY/STATE:	Troy, New York
GEI PROJECT NUMBER:	093300-1-1113

BORING LOG

PAGE 1 of 2

B/PZ-409(11)

GROUND SURFACE ELEVATION (FT):	33.33	**LOCATION:**	East of Former Retort adjacent to stone wall
NORTHING:	1418656.4867	**EASTING:**	709931.7253
TOTAL DEPTH (FT):	30.00		
DRILLED BY:	Zebra Environmental / Brian Ramos	**DATUM VERT. / HORZ.:**	MSL / NAD83
LOGGED BY:	Drew Blicharz	**DATE START / END:**	4/12/2011 - 4/12/2011
DRILLING DETAILS:	Geoprobe / 7720DT		
WATER LEVEL DEPTHS (FT):			



DEPTH FT.	SAMPLE INFO: TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
0		5.0		0.0				Dry, FILL, asphalt, concrete and crusher run to 1.0', hand and vacuum cleared to obstruction at 2.5'. Dry, brown and gray, FILL, cobble, bricks, brown silty sand and gravel, mortar chunks, roots.	
5	S-1	5.0	3	0.0				SILTY SAND WITH GRAVEL (SM); ~65% sand, fine to medium, ~20% gravel, fine to coarse, subangular, ~15% fines; dry, brown, FILL. Dry, FILL, crushed stone. WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, fine, subrounded, ~5% fines; dry, reddish brown and brown, FILL, 9.5-10' reddish orange fine to medium sand.	
10	S-2	5.0	3.55	0.0				SILTY SAND WITH GRAVEL (SM); ~50% sand, fine to medium, ~35% gravel, fine to coarse, subangular, ~15% fines; dry to moist, brown and gray, gravel is mostly coarse, trace reddish orange fine sand.	
15	S-3	5.0	3.49	0.0					
20	S-4	5.0	3	0.0			B/PZ-409(11) (20-20.5) B/PZ-409(11) (20.5-21)	WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, fine, ~5% fines; wet, brown and gray, trace reddish orange fine sand. WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to coarse, ~25% gravel, fine to coarse, subrounded and subangular, ~5% fines; wet to saturated, brown and gray, trace reddish orange fine sand.	

NOTES:

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FT. = FEET

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OLO = ORGANIC LIKE ODOR
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DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
25	S-5	5.0	1.12	0.0		🟩			
30								End of Boring at 30 feet.	

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BORING LOG

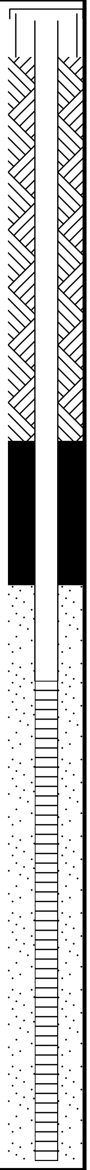
PAGE 1 of 2

B/PZ-410(11)

GROUND SURFACE ELEVATION (FT): 31.65
LOCATION: South of Southwest Former Holder
NORTHING: 1418668.8797 **EASTING:** 709837.9031
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/12/2011 - 4/12/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		2.0		0.0	▨	🟩		Dry, FILL, asphalt, concrete and crusher run, hand and vacuum cleared.
	S-1	3.0		0.0	▨	🟩		Dry, FILL, cobble, bricks, brown silty sand and gravel, clay.
5	S-2	5.0	3.07	0.0	▨	🟩		WIDELY GRADED SAND WITH SILT (SW); ~90% sand, fine to medium, ~10% fines; dry, brown, FILL. FAT CLAY (CL); ~95% fines, high plasticity, ~5% sand; moist, brown and gray, FILL, dense. WIDELY GRADED SAND WITH SILT (SW); ~90% sand, fine to medium, ~10% fines; dry, brown, FILL. FAT CLAY (CL); ~95% fines, high plasticity, ~5% sand; moist, brown and gray, FILL, tiny brick fragments, dense.
10	S-3	5.0	3.05	0.0	▨	🟩		CLAYEY SAND WITH GRAVEL (SC); ~50% sand, fine to medium, ~30% fines, ~20% gravel, fine to coarse, subrounded; moist, dark gray, FILL. FILL, bricks. LEAN CLAY (CL); ~85% fines, low plasticity, ~10% gravel, ~5% sand, fine; moist to wet, dark gray light gray, FILL.
15	S-4	5.0	3.93	0.0, 0.1	▨	🟩	B/PZ-410(11) (18.2-18.5) B/PZ-410(11) (18.5-18.8)	WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, fine, ~5% fines; wet, gray. WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, reddish brown.
20	S-5	5.0	2.93	0.0	⁘	🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~50% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded and subangular, ~5% fines; saturated, brown, trace reddish orange fine sand.

WELL DETAILS



NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL	ppm = PARTS PER MILLION	NLO = NAPHTHALENE LIKE ODOR	CrLO= CREOSOTE LIKE ODOR
REC = RECOVERY LENGTH OF SAMPLE	IN. = INCHES	PLO = PETROLEUM LIKE ODOR	OLO = ORGANIC LIKE ODOR
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)	FT. = FEET	TLO = TAR LIKE ODOR	SLO = SULFUR LIKE ODOR
		CLO = CHEMICAL LIKE ODOR	MLO = MUSTY LIKE ODOR
		ALO = ASPHALT LIKE ODOR	

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BORING LOG
PAGE 2 of 2
B/PZ-410(11)

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
25	S-6	5.0	2.5	0.0		🟩			
30							B/PZ-410(11) (29-30)		

End of Boring at 30 feet.

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BORING LOG

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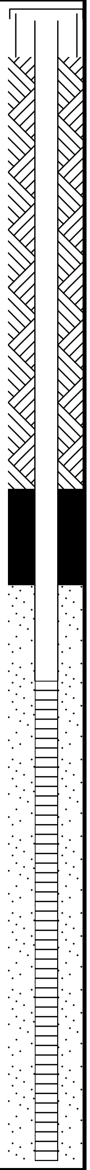
B/PZ-411(11)

GROUND SURFACE ELEVATION (FT): 30.61
LOCATION: Southwest of Southwest Former Holder
NORTHING: 1418687.389 **EASTING:** 709791.6188
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/13/2011 - 4/13/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO TYPE and NO.	PEN FT.	REC FT.	PID (ppm)	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
0		3.0		0.0			Dry, FILL, asphalt, concrete, cobblestone, hand and vacuum cleared to 2.5', crushed concrete and brick 2.5-4'.
	S-1	2.0	2.08	0.0			
							SILTY SAND (SM); ~80% sand, fine to medium, ~15% fines, ~5% gravel, fine to coarse, subrounded; dry, brown, FILL.
5	S-2	5.0	2.78	0.0			
							WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, fine to coarse, subrounded, ~5% fines; dry, brown, FILL.
							FAT CLAY (CH); ~100% fines, high plasticity; moist, gray, FILL.
							WIDELY GRADED SAND (SW); ~90% sand, fine to medium, ~5% gravel, fine to coarse, subrounded, ~5% fines; dry, brown, FILL.
10	S-3	5.0	2.35	0.0	PLO		FAT CLAY (CH); fine to coarse, ~5%, ~95% fines, high plasticity, ~5% sand, fine to medium; slight petroleum-like odor, moist, olive gray to gray, FILL, layers of dark gray material, trace brick fragments at 16'.
15	S-4	5.0	2.71	0.0			
					PLO	B/PZ-411(11) (16.8-17.8)	WIDELY GRADED SAND (SW); ~100% sand, fine to medium; slight petroleum-like odor, wet, gray.
					PLO	B/PZ-411(11) (17.8-18.8)	WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded, ~5% fines; slight petroleum-like odor, wet, dark gray to black.
20	S-5	5.0	2.08	0.0			
							WIDELY GRADED SAND WITH GRAVEL (SW); ~55% sand, fine to coarse, ~45% gravel, fine to coarse, subrounded, ~5% fines; wet, gray, trace reddish orange and yellowish orange fine sand.

WELL DETAILS



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BORING LOG
PAGE 2 of 2
B/PZ-411(11)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION	WELL DETAILS
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)						
25	S-6	5.0	2	0.0	░	🟩		B/PZ-411(11) (27.5-30)	WIDELY GRADED SAND WITH GRAVEL (SW); ~65% sand, fine to coarse, ~30% gravel, fine to coarse, subrounded and subangular, ~5% fines; saturated, light brown to brown.	
30									End of Boring at 30 feet.	

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BORING LOG

PAGE 1 of 2

B-412(11)

GROUND SURFACE ELEVATION (FT): 32.84
LOCATION: Hill Street West of South Tar Well
NORTHING: 1418588.0652 **EASTING:** 709792.245
TOTAL DEPTH (FT): 30.00
DRILLED BY: Zebra Environmental / Brian Ramos
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 4/14/2011 - 4/14/2011
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
0	S-1	5.0		0.0	▨	🟩		Asphalt, concrete, cobblestone, silty sand with gravel, bricks.
5	S-2	5.0	3.25	0.0	▨	🟩		SILTY SAND WITH GRAVEL (SM); ~75% sand, fine to medium, ~15% gravel, fine, subrounded and subangular, ~15% fines; dry, brown, cobble at 6.5'.
					▨	🟩		SILT (ML); ~90% fines, non plastic, ~10% sand, fine; moist, reddish brown and brown, brittle.
10	S-3	5.0	4.23	0.0	▨	🟩		SILT WITH GRAVEL (ML); ~80% fines, non plastic, ~20% gravel, fine, subrounded; moist, gray, fine reddish orange fine sand.
					▨	🟩		SILTY SAND WITH GRAVEL (SM); ~60% sand, fine to medium, ~20% gravel, fine, subrounded, ~20% fines; moist to wet, gray, trace clay, coarse gravel at 13.1'.
					▨	🟩		FAT CLAY WITH SAND (CL); ~60% fines, medium plasticity, ~20% sand, fine, ~5% gravel; moist to wet, reddish brown and brown, sand 14.1' to 14.5'.
15	S-4	5.0	3.48	0.0	⁘	🟩	B-412(11) (15-15.4) and a duplicate B-412(11) (15.4-16.2) and a duplicate	WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; wet, gray, <5% fine gravel.
					‖	🟩		SILT (ML); ~95% fines, non plastic, ~5% sand, fine; wet, greenish gray and light brown, brittle where moist.
20	S-5	5.0	0.6	0.0	⁘	🟩		WIDELY GRADED SAND (SW); ~95% sand, fine to medium, ~5% fines; saturated, gray, loose, low recoveries.

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BORING LOG

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B-412(11)

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
25	S-6	5.0	0.15	0.0	▨	🟩	B-412(11) (25-30)	
30								End of Boring at 30 feet. Fill with bentonite chips.

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BORING LOG

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2T1

GROUND SURFACE ELEVATION (FT): 32.51
LOCATION: West of South Tar Well
NORTHING: 1418573.7711 **EASTING:** 709800.8795
TOTAL DEPTH (FT): 20.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 12/7/2010 - 12/7/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)				
0	S-1	5.0		NA	▨	🟩		WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; dry to wet, brown, FILL.
5	S-2	5.0	1.58	0.0	▨	🟩		SILTY SAND (SM); ~80% sand, fine to coarse, ~15% fines, ~5% gravel, fine to coarse, subrounded; moist, brown, FILL, tiny brick fragments.
					▨	🟩		LEAN CLAY (CL); ~100% fines; wet, brown and gray, FILL, soft.
						🟩		FILL, NO RECOVERY, rock in shoe was pushed ~6.75 to 10.0'.
10	S-3	5.0	2.83	0.0	▨	🟩		LEAN CLAY (CL); ~90% fines, ~5% gravel, fine to coarse, subrounded, ~5% sand, fine to coarse; wet, gray, FILL.
					▨	🟩 🟨	2T1(13.5-14.5)	SILTY SAND (SM); ~75% sand, fine to coarse, ~15% fines, ~10% gravel, fine to coarse, subrounded; moist, gray, FILL, brown f-c sand, brick frags, and trace fine gravel between 11.4'-12.0', cobble at 13.2'. Trace black stains 13.5 - 15.0'.
15	S-4	5.0	1.65	0.0	▨	🟩		SILTY SAND (SM); ~75% sand, fine to coarse, ~15% fines, ~10% gravel, fine to coarse, subrounded; dry to moist, brown and gray, FILL, tiny brick fragments and coarse concrete fragments.
					⁘	🟩		WIDELY GRADED SAND WITH GRAVEL (SW); ~70% sand, fine to coarse, ~25% gravel, fine to coarse, subrounded, ~5% fines; dry to moist, dark gray and black, ALLUVIUM.
20								End of Boring at 20 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

GEI Consultants, Inc.
455 Winding Brook Road
Glastonbury, CT 06033
(860) 368-5300

CLIENT: National Grid
PROJECT: Troy Liberty Street
CITY/STATE: Troy, New York
GEI PROJECT NUMBER: 093300-1-1113

BORING LOG
PAGE 1 of 1
2T2

GROUND SURFACE ELEVATION (FT): 32.8
LOCATION: West of South Tar Well
NORTHING: 1418573.5192 **EASTING:** 709812.2677
TOTAL DEPTH (FT): 20.00
DRILLED BY: Zebra Environmental / Ethan Plank
DATUM VERT. / HORZ.: MSL / NAD83
LOGGED BY: Drew Blicharz
DATE START / END: 12/7/2010 - 12/7/2010
DRILLING DETAILS: Geoprobe / 7720DT
WATER LEVEL DEPTHS (FT):

DEPTH FT.	SAMPLE INFO				STRATA	VISUAL IMPACTS	ODOR	ANALYZED SAMPLE ID	SOIL / BEDROCK DESCRIPTION
	TYPE and NO.	PEN FT.	REC FT.	PID (ppm)					
0	S-1	5.0		NA	▨	🟩			WIDELY GRADED SAND (SW); ~85% sand, fine to coarse, ~10% gravel, fine to coarse, subrounded, ~5% fines; dry to wet, brown, FILL.
5	S-2	5.0	1.93	0.0	▨	🟦	PLO		SILTY SAND WITH GRAVEL (SM); ~60% sand, ~20% gravel, ~20% fines; slight petroleum-like odor, dry, brown, FILL. Brick fragments at 8.1'.
					▨	🟩			
					▨	🟩			Trace black stained soil.
10	S-3	5.0	1.7	0.0	▨	🟩			SILTY SAND WITH GRAVEL (SM); ~60% sand, ~20% gravel, ~20% fines; dry, brown, FILL, tiny brick fragments.
					▨	🟨	NLO		Slight naphthalene-like odor, black stained.
					▨	🟩			LEAN CLAY (CL); ~90% fines, ~5% gravel, ~5% sand; moist, gray.
					▨	🟨	NLO	2T2(13.5-14.5)	SILTY SAND WITH GRAVEL (SM); ~70% sand, ~15% gravel, ~15% fines; slight naphthalene-like odor, moist, dark gray, black stained (stronger weathered odor).
15	S-4	5.0	5	4.0, 4.6, 15.7, 31.9, 18.1				Difficult to see. It is now dark outside.	
					▨	🟪	NLO		LEAN CLAY WITH GRAVEL (CL); ~75% fines, ~15% gravel, ~10% sand; strong naphthalene-like odor, moist, dark gray, black stained (stronger weathered odor), scattered thin lenses of sheen, blebs, coatings.
					░	🟪	NLO		SILTY SAND (SM); ~60% sand, ~30% fines, ~10% gravel; strong naphthalene-like odor, moist, dark gray, black stained (stronger weathered odor), scattered thin lenses of sheen, blebs, coatings.
					▥	🟪	NLO		SILT WITH SAND (ML); ~80% fines, ~20% sand; strong naphthalene-like odor, moist, dark gray, black stained (stronger weathered odor), scattered thin lenses of sheen, blebs, coatings.
20									End of Boring at 20 feet. Fill with bentonite chips.

NOTES:

PEN = PENETRATION LENGTH OF SAMPLER OR CORE BARREL
REC = RECOVERY LENGTH OF SAMPLE
PID = PHOTOIONIZATION DETECTOR READING (JAR HEADSPACE)

ppm = PARTS PER MILLION
IN. = INCHES
FT. = FEET

NLO = NAPHTHALENE LIKE ODOR
PLO = PETROLEUM LIKE ODOR
TLO = TAR LIKE ODOR
CLO = CHEMICAL LIKE ODOR
ALO = ASPHALT LIKE ODOR

CrLO= CREOSOTE LIKE ODOR
OLO = ORGANIC LIKE ODOR
SLO = SULFUR LIKE ODOR
MLO = MUSTY LIKE ODOR

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B/MW-103(05)	B/MW-301(10)	B/MW-301(10)	B/MW-301(10)	B-310(10)	B-310(10)	B-310(10)	B-311(10)
Sample Name:				B/MW-103(05)(16-18)	B/MW-301(10)(18-19.25)	B/MW-301(10)(20.5-22)	B/MW-301(10)(33.8-35)	B-310(10)(11.5-12.25)	B-310(10)(14.25-15)	B-310(10)(44.75-45)	B-311(10)(13-14)
Start Depth:				16	18	20.5	33.8	11.5	14.25	44.75	13
End Depth:				18	19.25	22	35	12.25	15	45	14
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				12/1/2005	10/25/2010	10/25/2010	10/25/2010	10/25/2010	10/25/2010	10/25/2010	10/25/2010
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0098 J	0.28 U	0.0056 U	0.0057 U	22	15	NA	0.96
Toluene	108-88-3	0.7	500	0.0023 U	0.28 U	0.00017 J	0.0057 U	23	39	NA	0.43 J
Ethylbenzene	100-41-4	1	390	0.017 J	0.28 U	0.0056 U	0.0057 U	3.8	7.4	NA	3.9
Total Xylene	1330-20-7	0.26	500	0.0071 U	0.28 U	0.0056 U	0.0057 U	38	70	NA	4.5
Total BTEX	TBTEX	NE	NE	0.0268	ND	0.00017	ND	86.8	131.4	NA	9.79
Other VOCs (mg/kg)											
Styrene	100-42-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	11	0.13	0.019 U	0.004 J	180	57	0.0097 J	68
Acenaphthylene	208-96-8	100	500	10	0.019 U	0.019 U	0.019 U	540	320	0.041	20
Anthracene	120-12-7	100	500	16 J	0.019 U	0.019 U	0.019 U	890	220	0.0097 J	82
Benzo[g,h,i]perylene	191-24-2	100	500	2.8 J	0.019 UJ	0.019 UJ	0.019 UJ	240	100	0.0086 J	42
Fluoranthene	206-44-0	100	500	41	0.033	0.019 U	0.019 U	1,300	620	0.022	290
Fluorene	86-73-7	30	500	16.0 J	0.36	0.019 U	0.019 U	500	250	0.018 J	63
2-Methylnaphthalene	91-57-6	NE	NE	NA	0.019 U	0.019 U	0.019 U	540	360	0.11	23
Naphthalene	91-20-3	12	500	100	0.019 U	0.011 J	0.064	3,500	2,400	1.4	260
Phenanthrene	85-01-8	100	500	61	0.89	0.019 U	0.019 U	2,100	1,000	0.049	410
Pyrene	129-00-0	100	500	35	0.19	0.019 U	0.019 U	960	450	0.017 J	140
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	14 J	0.0089 J	0.019 U	0.019 U	510	210	0.013 J	75
Benzo[a]pyrene	50-32-8	1	1	11 J	0.019 U	0.019 U	0.019 U	490	200	0.011 J	75
Benzo[b]fluoranthene	205-99-2	1	5.6	14 J	0.019 U	0.019 U	0.019 U	480	170	0.011 J	59
Benzo[k]fluoranthene	207-08-9	0.8	56	5.5 J	0.019 U	0.019 U	0.019 U	140	53	0.0056 J	27
Chrysene	218-01-9	1	56	9.3	0.012 J	0.019 U	0.019 U	520	130	0.0071 J	53
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.44 J	0.019 UJ	0.019 UJ	0.019 UJ	10 U	1.1 U	0.019 U	0.95 UJ
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	2.3 J	0.019 UJ	0.019 UJ	0.019 UJ	230	100	0.0075 J	38
Total PAHs	TPAH	NE	NE	349.34	1.6239	0.011	0.068	13,120	6,640	1.7402	1725
Other SVOCs (mg/kg)											
1,1-Biphenyl	92-52-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	86-74-8	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	132-64-9	7	350	NA	0.11	0.019 U	0.019 U	510	260	0.025	56
2,4-Dimethylphenol	105-67-9	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol (o-Cresol)	95-48-7	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol (p-Cresol)	106-44-5	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	108-95-2	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
Metals (mg/kg)											
Aluminum	7429-90-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	13	16	NA	NA	NA	NA	NA	NA	NA	NA
Barium	7440-39-3	350	400	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	7.2	590	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	2.5	9.3	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	7440-70-2	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	7440-48-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	50	270	NA	NA	NA	NA	NA	NA	NA	NA
Iron	7439-89-6	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	63	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	7439-95-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	1,600	10,000	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.18	2.8	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	30	310	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	7440-09-7	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Silver	7440-22-4	2	1,500	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	7440-23-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	109	10,000	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide (mg/kg)											
Total Cyanide	57-12-5	27	27	0.571 U	NA	NA	NA	NA	NA	NA	NA
Other											
Percent Moisture (%)	MOIST	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Percent Solids (%)	SOLIDS	NE	NE	NA	90	88	91	84	73	88	71
Total Organic Carbon (mg/kg)	TOC	NE	NE	5,900	NA	NA	NA	NA	NA	NA	NA

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-311(10)	B-311(10)	B-312(10)	B-312(10)	B-312(10)	B-313(10)	B-314(10)	B-314(10)
Sample Name:				B-311(10)(20.75-22.75)	B-311(10)(39-40)	B-312(10)(12.5-13.25)	B-312 (10) (21-22.5)	B-312(10)(39-39.75)	B-313(10)(7.5-9.5)	B-314(10)(18-18.75)	B-314(10)(21-23)
Start Depth:				20.75	39	12.5	21	39	7.5	18	21
End Depth:				22.75	40	13.25	22.5	39.75	9.5	18.75	23
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				10/25/2010	10/25/2010	10/27/2010	10/27/2010	10/27/2010	10/26/2010	10/25/2010	10/25/2010
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0011 J	0.0057 U	0.0042 J	0.0058 U	0.0054 UJ	390	0.29 U	0.002 J
Toluene	108-88-3	0.7	500	0.0002 J	0.0057 U	0.0023 J	0.0058 U	0.0054 UJ	430	0.29 U	0.00096 J
Ethylbenzene	100-41-4	1	390	0.0055 U	0.0057 U	0.0055 J	0.0058 U	0.0054 UJ	78	0.29 U	0.0011 J
Total Xylene	1330-20-7	0.26	500	0.0055 U	0.0057 U	0.0083	0.0058 U	0.0054 UJ	480	0.29 U	0.004 J
Total BTEX	TBTEX	NE	NE	0.0013	ND	0.0203	ND	ND	1,378	ND	0.00806
Other VOCs (mg/kg)											
Styrene	100-42-5	NE	NE	NA	NA	NA	NA	NA	72	NA	NA
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	0.1	0.019 U	23	0.018 U	0.018 U	610	2.6	11
Acenaphthylene	208-96-8	100	500	0.038	0.019 U	3.4	0.018 U	0.018 U	3,400	3.1	11
Anthracene	120-12-7	100	500	0.014 J	0.019 U	21	0.018 U	0.018 U	4,000	5.8	22
Benzo[g,h,i]perylene	191-24-2	100	500	0.0072 J	0.019 UJ	9.7	0.018 U	0.018 U	1,000	2.5 J	28 J
Fluoranthene	206-44-0	100	500	0.063	0.006 J	50	0.018 U	0.018 U	5,700	12	140
Fluorene	86-73-7	30	500	0.011 J	0.019 U	14	0.018 U	0.018 U	2,600	5.7	22
2-Methylnaphthalene	91-57-6	NE	NE	0.0043 J	0.006 J	0.16	0.018 U	0.018 U	3,400	0.1	0.094 J
Naphthalene	91-20-3	12	500	0.058	0.091	2.2	0.014 J	0.018 U	23,000	1	0.83
Phenanthrene	85-01-8	100	500	0.024	0.009 J	69	0.018 U	0.018 U	10,000	22	96
Pyrene	129-00-0	100	500	0.058	0.019 U	35	0.018 U	0.018 U	4,500	9	100
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.013 J	0.019 U	19	0.018 U	0.018 U	2,200	4.3	51
Benzo[a]pyrene	50-32-8	1	1	0.011 J	0.019 U	20	0.007 J	0.018 U	2,100	4.6	51
Benzo[b]fluoranthene	205-99-2	1	5.6	0.012 J	0.019 U	14	0.0066 J	0.018 U	2,000	3.9	40
Benzo[k]fluoranthene	207-08-9	0.8	56	0.018 U	0.019 U	4	0.018 U	0.018 U	580	1.4	18
Chrysene	218-01-9	1	56	0.0075 J	0.019 U	12	0.018 U	0.018 U	2,100	3.6	31
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.018 UJ	0.019 UJ	0.097 U	0.018 U	0.018 U	240	0.1 UJ	0.48 UJ
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.0075 J	0.019 UJ	9.1	0.0045 J	0.018 U	950	2.4 J	27 J
Total PAHs	TPAH	NE	NE	0.4285	0.112	305.56	0.0321	ND	68,380	84	648.924
Other SVOCs (mg/kg)											
1,1-Biphenyl	92-52-4	NE	NE	NA	NA	NA	NA	NA	860	NA	NA
Carbazole	86-74-8	NE	NE	NA	NA	NA	NA	NA	1600	NA	NA
Dibenzofuran	132-64-9	7	350	0.0079 J	0.019 U	13	0.018 U	0.018 U	2,400	5.2	9.3
2,4-Dimethylphenol	105-67-9	NE	NE	NA	NA	NA	NA	NA	220	NA	NA
2-Methylphenol (o-Cresol)	95-48-7	0.33	500	NA	NA	NA	NA	NA	210	NA	NA
4-Methylphenol (p-Cresol)	106-44-5	0.33	500	NA	NA	NA	NA	NA	520	NA	NA
Phenol	108-95-2	0.33	500	NA	NA	NA	NA	NA	220	NA	NA
Metals (mg/kg)											
Aluminum	7429-90-5	NE	NE	NA	NA	NA	NA	NA	4,460	NA	NA
Arsenic	7440-38-2	13	16	NA	NA	NA	NA	NA	8.4	NA	NA
Barium	7440-39-3	350	400	NA	NA	NA	NA	NA	62.3	NA	NA
Beryllium	7440-41-7	7.2	590	NA	NA	NA	NA	NA	0.37 J	NA	NA
Cadmium	7440-43-9	2.5	9.3	NA	NA	NA	NA	NA	1.1 J	NA	NA
Calcium	7440-70-2	NE	NE	NA	NA	NA	NA	NA	4,540	NA	NA
Chromium	7440-47-3	NE	NE	NA	NA	NA	NA	NA	9.5	NA	NA
Cobalt	7440-48-4	NE	NE	NA	NA	NA	NA	NA	4.3	NA	NA
Copper	7440-50-8	50	270	NA	NA	NA	NA	NA	24.1	NA	NA
Iron	7439-89-6	NE	NE	NA	NA	NA	NA	NA	8,870	NA	NA
Lead	7439-92-1	63	1,000	NA	NA	NA	NA	NA	146	NA	NA
Magnesium	7439-95-4	NE	NE	NA	NA	NA	NA	NA	2,040	NA	NA
Manganese	7439-96-5	1,600	10,000	NA	NA	NA	NA	NA	309	NA	NA
Mercury	7439-97-6	0.18	2.8	NA	NA	NA	NA	NA	2.1 J	NA	NA
Nickel	7440-02-0	30	310	NA	NA	NA	NA	NA	8.2	NA	NA
Potassium	7440-09-7	NE	NE	NA	NA	NA	NA	NA	825	NA	NA
Silver	7440-22-4	2	1,500	NA	NA	NA	NA	NA	0.14 J	NA	NA
Sodium	7440-23-5	NE	NE	NA	NA	NA	NA	NA	126 J	NA	NA
Vanadium	7440-62-2	NE	NE	NA	NA	NA	NA	NA	9	NA	NA
Zinc	7440-66-6	109	10,000	NA	NA	NA	NA	NA	79.2	NA	NA
Total Cyanide (mg/kg)											
Total Cyanide	57-12-5	27	27	NA	NA	NA	NA	NA	58.3	NA	NA
Other											
Percent Moisture (%)	MOIST	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Percent Solids (%)	SOLIDS	NE	NE	90	88	87	94	94	66	83	89
Total Organic Carbon (mg/kg)	TOC	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-314(10)	B-315(10)	B-315(10)	B-316(10)	B-316(10)	B-316(10)	B-318(10)	B-318(10)
Sample Name:				B-314(10)(44-45)	B-315(10)(20.5-21.25)	B-315(10)(44-45)	B-316(10)(18-18.25)	B-316(10)(18.25-18.5)	B-316(10)(43.75-44.5)	B-318(10)(12.8-13.25)	B-318(10)(27.8-30)
Start Depth:				44	20.5	44	18	18.25	43.75	12.8	27.8
End Depth:				45	21.25	45	18.25	18.5	44.5	13.25	30
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				10/25/2010	10/27/2010	10/27/2010	10/26/2010	10/26/2010	10/26/2010	10/28/2010	10/28/2010
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0056 UJ	0.0056 U	0.0055 UJ	0.006 U	NA	0.0059 U	0.0093	0.0057 U
Toluene	108-88-3	0.7	500	0.0056 UJ	0.00034 J	R	0.006 U	NA	0.0059 U	0.0017 J	0.0057 U
Ethylbenzene	100-41-4	1	390	0.0056 UJ	0.0056 U	R	0.006 U	NA	0.0059 U	0.0016 J	0.0057 U
Total Xylene	1330-20-7	0.26	500	0.0056 UJ	0.00069 J	R	0.006 U	NA	0.0059 U	0.0039 J	0.0057 U
Total BTEX	TBTEX	NE	NE	ND	0.00103	ND	ND	NA	ND	0.0165	ND
Other VOCs (mg/kg)											
Styrene	100-42-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	0.019 U	0.018 U	0.019 U	NA	0.028	0.02 U	11	0.0075 J
Acenaphthylene	208-96-8	100	500	0.01 J	0.018 U	0.019 U	NA	0.013 J	0.02 U	2.3	0.019 U
Anthracene	120-12-7	100	500	0.019 U	0.018 U	0.019 U	NA	0.021 U	0.02 U	8.3	0.019 U
Benzo[g,h,i]perylene	191-24-2	100	500	0.019 UJ	0.012 J	0.019 U	NA	0.021 U	0.02 U	7.7	0.019 U
Fluoranthene	206-44-0	100	500	0.0092 J	0.0072 J	0.019 U	NA	0.021 U	0.02 U	32	0.019 U
Fluorene	86-73-7	30	500	0.019 U	0.018 U	0.019 U	NA	0.021 U	0.02 U	10	0.019 U
2-Methylnaphthalene	91-57-6	NE	NE	0.034	0.018 U	0.019 U	NA	0.021 U	0.02 U	0.092 J	0.019 U
Naphthalene	91-20-3	12	500	0.46	0.018 U	0.01 J	NA	0.021 U	0.02 U	1.2	0.021
Phenanthrene	85-01-8	100	500	0.012 J	0.018 U	0.019 U	NA	0.021 U	0.02 U	13	0.012 J
Pyrene	129-00-0	100	500	0.0063 J	0.0054 J	0.019 U	NA	0.021 U	0.02 U	24	0.019 U
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.019 U	0.01 J	0.019 U	NA	0.021 U	0.02 U	13	0.006 J
Benzo[a]pyrene	50-32-8	1	1	0.019 U	0.012 J	0.019 U	NA	0.021 U	0.02 U	14	0.019 U
Benzo[b]fluoranthene	205-99-2	1	5.6	0.019 U	0.01 J	0.019 U	NA	0.021 U	0.02 U	12	0.019 U
Benzo[k]fluoranthene	207-08-9	0.8	56	0.019 U	0.0047 J	0.019 U	NA	0.021 U	0.02 U	4.5	0.019 U
Chrysene	218-01-9	1	56	0.019 U	0.0051 J	0.019 U	NA	0.021 U	0.02 U	9.9	0.019 U
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.019 UJ	0.018 U	0.019 U	NA	0.021 U	0.02 U	0.25 U	0.019 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.019 UJ	0.01 J	0.019 U	NA	0.021 U	0.02 U	7.2	0.019 U
Total PAHs	TPAH	NE	NE	0.5315	0.0764	0.01	NA	0.041	ND	170.192	0.0465
Other SVOCs (mg/kg)											
1,1-Biphenyl	92-52-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	86-74-8	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	132-64-9	7	350	0.0063 J	0.018 U	0.019 U	NA	0.021 U	0.02 U	5.5	0.011 J
2,4-Dimethylphenol	105-67-9	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol (o-Cresol)	95-48-7	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol (p-Cresol)	106-44-5	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	108-95-2	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
Metals (mg/kg)											
Aluminum	7429-90-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	13	16	NA	NA	NA	NA	NA	NA	NA	NA
Barium	7440-39-3	350	400	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	7.2	590	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	2.5	9.3	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	7440-70-2	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	7440-48-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	50	270	NA	NA	NA	NA	NA	NA	NA	NA
Iron	7439-89-6	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	63	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	7439-95-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	1,600	10,000	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.18	2.8	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	30	310	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	7440-09-7	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Silver	7440-22-4	2	1,500	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	7440-23-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	109	10,000	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide (mg/kg)											
Total Cyanide	57-12-5	27	27	NA	NA	NA	NA	NA	NA	NA	NA
Other											
Percent Moisture (%)	MOIST	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Percent Solids (%)	SOLIDS	NE	NE	90	91	91	NA	77	84	68	88
Total Organic Carbon (mg/kg)	TOC	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-319(10)	B-319(10)	B-319(10)	B-321(10)	B-321(10)	B-321(10)	B-323(10)	B-323(10)
Sample Name:				B-319(10)(5-10)	B-319(10)(20-21.5)	B-319(10)(44.25-44.75)	B-321(10)(6-7)	B-321(10)(11.4-12)	B-321(10)(29-30)	B-323(10)(18.5-19.5)	B-323(10)(28.5-29.5)
Start Depth:				5	20	44.25	6	11.4	29	18.5	28.5
End Depth:				10	21.5	44.75	7	12	30	19.5	29.5
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				10/26/2010	10/26/2010	10/26/2010	10/28/2010	10/28/2010	10/28/2010	10/29/2010	10/29/2010
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.009	0.0056 U	0.0054 U	0.0074 U	0.058 J	0.0055 U	0.0054 U	0.0056 U
Toluene	108-88-3	0.7	500	0.012	0.0056 U	0.0054 U	0.00043 J	0.34 U	0.0055 U	0.0054 U	0.0056 U
Ethylbenzene	100-41-4	1	390	0.0058	0.0056 U	0.0054 U	0.0074 U	0.21 J	0.0055 U	0.0054 U	0.0056 U
Total Xylene	1330-20-7	0.26	500	0.038	0.0056 U	0.0054 U	0.0074 U	0.19 J	0.0055 U	0.0054 U	0.0056 U
Total BTEX	TBTEX	NE	NE	0.0648	ND	ND	0.00043	0.458	ND	ND	ND
Other VOCs (mg/kg)											
Styrene	100-42-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	0.038	0.024	0.018 U	1.7	2.9	0.0086 J	0.42	0.019 U
Acenaphthylene	208-96-8	100	500	0.099	0.018 U	0.018 U	1.3	0.041	0.019 U	0.08	0.019 U
Anthracene	120-12-7	100	500	0.48	0.018 U	0.018 U	4.6	0.45	0.019 U	0.2	0.019 U
Benzo[g,h,i]perylene	191-24-2	100	500	0.1	0.018 U	0.018 U	24	0.05	0.019 U	0.023	0.019 U
Fluoranthene	206-44-0	100	500	0.54	0.02	0.0078 J	32	0.32	0.019 U	0.42	0.019 U
Fluorene	86-73-7	30	500	0.13	0.018 U	0.018 U	1.4	1.7	0.019 U	0.39	0.019 U
2-Methylnaphthalene	91-57-6	NE	NE	0.061	0.018 U	0.018 U	1.1 J	1.7	0.019 U	0.017 J	0.019 U
Naphthalene	91-20-3	12	500	0.21	0.015 J	0.018 U	5.5	14	0.049	0.28	0.019 U
Phenanthrene	85-01-8	100	500	0.74	0.017 J	0.018 U	15	4.1	0.019 U	0.65	0.019 U
Pyrene	129-00-0	100	500	0.4	0.0082 J	0.0057 J	25	0.19	0.019 U	0.32	0.019 U
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.19	0.018 U	0.0089 J	20	0.038	0.0056 J	0.08	0.019 U
Benzo[a]pyrene	50-32-8	1	1	0.2	0.018 U	0.018 U	33	0.062	0.019 U	0.057	0.019 U
Benzo[b]fluoranthene	205-99-2	1	5.6	0.19	0.018 U	0.018 U	28	0.055	0.019 U	0.057	0.019 U
Benzo[k]fluoranthene	207-08-9	0.8	56	0.059	0.018 U	0.018 U	11	0.019 J	0.019 U	0.017 J	0.019 U
Chrysene	218-01-9	1	56	0.18	0.018 U	0.0043 J	16	0.032	0.019 U	0.058	0.019 U
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.019 U	0.018 U	0.018 U	1.3 U	0.017 J	0.019 U	0.018 U	0.019 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.098	0.018 U	0.018 U	22	0.046	0.019 U	0.024	0.019 U
Total PAHs	TPAH	NE	NE	3.715	0.0842	0.0267	241.6	25.72	0.0632	3.093	ND
Other SVOCs (mg/kg)											
1,1-Biphenyl	92-52-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Carbazole	86-74-8	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzofuran	132-64-9	7	350	0.11	0.0046 J	0.018 U	1.2 J	2	0.019 U	0.36	0.019 U
2,4-Dimethylphenol	105-67-9	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
2-Methylphenol (o-Cresol)	95-48-7	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
4-Methylphenol (p-Cresol)	106-44-5	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
Phenol	108-95-2	0.33	500	NA	NA	NA	NA	NA	NA	NA	NA
Metals (mg/kg)											
Aluminum	7429-90-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	13	16	NA	NA	NA	NA	NA	NA	NA	NA
Barium	7440-39-3	350	400	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	7.2	590	NA	NA	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	2.5	9.3	NA	NA	NA	NA	NA	NA	NA	NA
Calcium	7440-70-2	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Cobalt	7440-48-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	50	270	NA	NA	NA	NA	NA	NA	NA	NA
Iron	7439-89-6	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	63	1,000	NA	NA	NA	NA	NA	NA	NA	NA
Magnesium	7439-95-4	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	1,600	10,000	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.18	2.8	NA	NA	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	30	310	NA	NA	NA	NA	NA	NA	NA	NA
Potassium	7440-09-7	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Silver	7440-22-4	2	1,500	NA	NA	NA	NA	NA	NA	NA	NA
Sodium	7440-23-5	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	109	10,000	NA	NA	NA	NA	NA	NA	NA	NA
Total Cyanide (mg/kg)											
Total Cyanide	57-12-5	27	27	NA	NA	NA	NA	NA	NA	NA	NA
Other											
Percent Moisture (%)	MOIST	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA
Percent Solids (%)	SOLIDS	NE	NE	85	92	92	66	68	87	92	90
Total Organic Carbon (mg/kg)	TOC	NE	NE	NA	NA	NA	NA	NA	NA	NA	NA

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B/MW-324(10)	B/MW-324(10)	B/MW-324(10)	B/MW-324(10)	TP-104(05)	TP-104(05)	B-402(11)	B-402(11)
Sample Name:				B/MW-324(10)(15-15.25)	B/MW-324(10)(15.25-16.5)	B/MW-324(10)(43.75-44.75)	B/MW-324(10)(45-46)	TP-104(05)(Composite)	Dup-2005	B-402(11)(11.1-11.4)	B-402(11)(11.4-11.8)
Start Depth:				15	15.25	43.75	43.75	NA	NA	11.1	11.4
End Depth:				15.25	16.5	44.75	44.75	NA	NA	11.4	11.8
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				10/29/2010	10/29/2010	10/29/2010	10/29/2010	12/5/2005	12/1/2005	4/13/2011	4/13/2011
Parent Sample Code:							B/MW-324(10)(43.75-44.75)		TP-104(05)(Composite)		
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.73 J	NA	0.0058 U	0.0057 U	0.16 J	0.014 J	0.0056 U	NA
Toluene	108-88-3	0.7	500	0.5 J	NA	0.0058 U	0.0057 U	0.32 J	0.022 J	0.001 J	NA
Ethylbenzene	100-41-4	1	390	8.4	NA	0.0058 U	0.0057 U	0.41 J	0.065 J	0.0056 U	NA
Total Xylene	1330-20-7	0.26	500	7.6	NA	0.0058 U	0.0057 U	3.7 J	0.52 J	0.0056 U	NA
Total BTEX	TBTEX	NE	NE	17.23	NA	ND	ND	4.59	0.621	0.001	NA
Other VOCs (mg/kg)											
Styrene	100-42-5	NE	NE	1.3 U	NA	NA	NA	NA	NA	NA	NA
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	NA	340	0.018 U	0.02 U	5.6	2.9	NA	0.3 U
Acenaphthylene	208-96-8	100	500	NA	60	0.018 U	0.02 U	8.6	4.9	NA	0.017 J
Anthracene	120-12-7	100	500	NA	280	0.018 U	0.02 U	32	12	NA	0.3 U
Benzo[g,h,i]perylene	191-24-2	100	500	NA	79	0.018 U	0.02 U	4.3	2.2 J	NA	0.3 U
Fluoranthene	206-44-0	100	500	NA	610	0.0087 J	0.02 U	67	39	NA	0.3 U
Fluorene	86-73-7	30	500	NA	270	0.018 U	0.02 U	25	11	NA	0.3 U
2-Methylnaphthalene	91-57-6	NE	NE	NA	200	0.018 U	0.02 U	NA	NA	NA	0.01 J
Naphthalene	91-20-3	12	500	NA	660	0.011 J	0.019 J	31	26	NA	0.062 J
Phenanthrene	85-01-8	100	500	NA	850	0.0084 J	0.011 J	98	61	NA	0.3 U
Pyrene	129-00-0	100	500	NA	450	0.0056 J	0.02 U	61	33	NA	0.3 U
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	NA	230	0.0066 J	0.0067 J	22.0 J	10	NA	0.3 U
Benzo[a]pyrene	50-32-8	1	1	NA	220	0.018 U	0.02 U	17.0 J	9	NA	0.3 U
Benzo[b]fluoranthene	205-99-2	1	5.6	NA	220	0.018 U	0.02 U	23.0 J	10	NA	0.3 U
Benzo[k]fluoranthene	207-08-9	0.8	56	NA	89	0.018 U	0.02 U	8.2	4.6	NA	0.3 U
Chrysene	218-01-9	1	56	NA	170	0.018 U	0.02 U	18.0 J	8.2	NA	0.3 U
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	NA	19 J	0.018 U	0.02 U	0.61 J	0.71 J	NA	0.3 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	NA	72	0.018 U	0.02 U	3.6	1.9 J	NA	0.3 U
Total PAHs	TPAH	NE	NE	NA	4,819	0.0403	0.0367	424.91	236.41	NA	0.089
Other SVOCs (mg/kg)											
1,1-Biphenyl	92-52-4	NE	NE	NA	88	NA	NA	NA	NA	NA	NA
Carbazole	86-74-8	NE	NE	NA	81	NA	NA	NA	NA	NA	NA
Dibenzofuran	132-64-9	7	350	NA	230	0.018 U	0.02 U	NA	NA	NA	NA
2,4-Dimethylphenol	105-67-9	NE	NE	NA	23 U	NA	NA	NA	NA	NA	NA
2-Methylphenol (o-Cresol)	95-48-7	0.33	500	NA	23 U	NA	NA	NA	NA	NA	NA
4-Methylphenol (p-Cresol)	106-44-5	0.33	500	NA	44 U	NA	NA	NA	NA	NA	NA
Phenol	108-95-2	0.33	500	NA	23 U	NA	NA	NA	NA	NA	NA
Metals (mg/kg)											
Aluminum	7429-90-5	NE	NE	NA	12,700	NA	NA	NA	NA	NA	NA
Arsenic	7440-38-2	13	16	NA	4.7 J	NA	NA	NA	NA	NA	NA
Barium	7440-39-3	350	400	NA	94	NA	NA	NA	NA	NA	NA
Beryllium	7440-41-7	7.2	590	NA	0.7 J	NA	NA	NA	NA	NA	NA
Cadmium	7440-43-9	2.5	9.3	NA	1.6 U	NA	NA	NA	NA	NA	NA
Calcium	7440-70-2	NE	NE	NA	3,180	NA	NA	NA	NA	NA	NA
Chromium	7440-47-3	NE	NE	NA	14.7	NA	NA	NA	NA	NA	NA
Cobalt	7440-48-4	NE	NE	NA	6.3	NA	NA	NA	NA	NA	NA
Copper	7440-50-8	50	270	NA	9 J	NA	NA	NA	NA	NA	NA
Iron	7439-89-6	NE	NE	NA	22,700	NA	NA	NA	NA	NA	NA
Lead	7439-92-1	63	1,000	NA	15	NA	NA	NA	NA	NA	NA
Magnesium	7439-95-4	NE	NE	NA	5,010	NA	NA	NA	NA	NA	NA
Manganese	7439-96-5	1,600	10,000	NA	551	NA	NA	NA	NA	NA	NA
Mercury	7439-97-6	0.18	2.8	NA	0.15	NA	NA	NA	NA	NA	NA
Nickel	7440-02-0	30	310	NA	16.3	NA	NA	NA	NA	NA	NA
Potassium	7440-09-7	NE	NE	NA	1,360	NA	NA	NA	NA	NA	NA
Silver	7440-22-4	2	1,500	NA	0.35	NA	NA	NA	NA	NA	NA
Sodium	7440-23-5	NE	NE	NA	285	NA	NA	NA	NA	NA	NA
Vanadium	7440-62-2	NE	NE	NA	15.1	NA	NA	NA	NA	NA	NA
Zinc	7440-66-6	109	10,000	NA	67.1	NA	NA	NA	NA	NA	NA
Total Cyanide (mg/kg)											
Total Cyanide	57-12-5	27	27	NA	106	NA	NA	0.823	1.28	NA	NA
Other											
Percent Moisture (%)	MOIST	NE	NE	NA	NA	NA	NA	NA	NA	11.1	11
Percent Solids (%)	SOLIDS	NE	NE	NA	74	95	84	NA	NA	88.9	89
Total Organic Carbon (mg/kg)	TOC	NE	NE	NA	NA	NA	NA	12,000	10,000	NA	NA

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-402(11)	B-402(11)
Sample Name:				B-402(11)(24-25)	B-402(11)(34.7-35)
Start Depth:				24	34.7
End Depth:				25	35
Depth Unit				ft	ft
Sample Date:				4/13/2011	4/13/2011
Parent Sample Code:					
BTEX (mg/kg)					
Benzene	71-43-2	0.06	44	0.0015 J	0.0054 U
Toluene	108-88-3	0.7	500	0.00029 J	0.00018 J
Ethylbenzene	100-41-4	1	390	0.0061 U	0.0054 U
Total Xylene	1330-20-7	0.26	500	0.0061 U	0.0054 U
Total BTEX	TBTEX	NE	NE	0.00179	0.00018
Other VOCs (mg/kg)					
Styrene	100-42-5	NE	NE	NA	NA
Non-carcinogenic PAHs (mg/kg)					
Acenaphthene	83-32-9	20	500	0.42	0.29 U
Acenaphthylene	208-96-8	100	500	0.22	0.29 U
Anthracene	120-12-7	100	500	0.27	0.29 U
Benzo[g,h,i]perylene	191-24-2	100	500	0.33 U	0.29 U
Fluoranthene	206-44-0	100	500	2.2	0.29 U
Fluorene	86-73-7	30	500	0.44	0.29 U
2-Methylnaphthalene	91-57-6	NE	NE	0.12 J	0.29 U
Naphthalene	91-20-3	12	500	0.52	0.029 J
Phenanthrene	85-01-8	100	500	0.29	0.29 U
Pyrene	129-00-0	100	500	1.8	0.29 U
Carcinogenic PAHs (mg/kg)					
Benz[a]anthracene	56-55-3	1	5.6	0.33 U	0.29 U
Benzo[a]pyrene	50-32-8	1	1	0.33 U	0.29 U
Benzo[b]fluoranthene	205-99-2	1	5.6	0.33 U	0.29 U
Benzo[k]fluoranthene	207-08-9	0.8	56	0.33 U	0.29 U
Chrysene	218-01-9	1	56	0.33 U	0.29 U
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.33 U	0.29 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.33 U	0.29 U
Total PAHs	TPAH	NE	NE	6.28	0.029
Other SVOCs (mg/kg)					
1,1-Biphenyl	92-52-4	NE	NE	NA	NA
Carbazole	86-74-8	NE	NE	NA	NA
Dibenzofuran	132-64-9	7	350	NA	NA
2,4-Dimethylphenol	105-67-9	NE	NE	NA	NA
2-Methylphenol (o-Cresol)	95-48-7	0.33	500	NA	NA
4-Methylphenol (p-Cresol)	106-44-5	0.33	500	NA	NA
Phenol	108-95-2	0.33	500	NA	NA
Metals (mg/kg)					
Aluminum	7429-90-5	NE	NE	NA	NA
Arsenic	7440-38-2	13	16	NA	NA
Barium	7440-39-3	350	400	NA	NA
Beryllium	7440-41-7	7.2	590	NA	NA
Cadmium	7440-43-9	2.5	9.3	NA	NA
Calcium	7440-70-2	NE	NE	NA	NA
Chromium	7440-47-3	NE	NE	NA	NA
Cobalt	7440-48-4	NE	NE	NA	NA
Copper	7440-50-8	50	270	NA	NA
Iron	7439-89-6	NE	NE	NA	NA
Lead	7439-92-1	63	1,000	NA	NA
Magnesium	7439-95-4	NE	NE	NA	NA
Manganese	7439-96-5	1,600	10,000	NA	NA
Mercury	7439-97-6	0.18	2.8	NA	NA
Nickel	7440-02-0	30	310	NA	NA
Potassium	7440-09-7	NE	NE	NA	NA
Silver	7440-22-4	2	1,500	NA	NA
Sodium	7440-23-5	NE	NE	NA	NA
Vanadium	7440-62-2	NE	NE	NA	NA
Zinc	7440-66-6	109	10,000	NA	NA
Total Cyanide (mg/kg)					
Total Cyanide	57-12-5	27	27	NA	NA
Other					
Percent Moisture (%)	MOIST	NE	NE	18.6	8.1
Percent Solids (%)	SOLIDS	NE	NE	81.4	91.9
Total Organic Carbon (mg/kg)	TOC	NE	NE	NA	NA

Table A-1
Subsurface Soil Analytical Results in Vicinity of Tar Wells - RI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Notes:

The 2005 and 2006 data reported in this table are gathered from the 2006 EA Engineering Data Usability Summary Report (DUSR).

mg/kg - milligrams/kilogram or parts per million (ppm)
BTEX - benzene, toluene, ethylbenzene, and xylenes
VOCs - volatile organic compounds
PAHs - polycyclic aromatic hydrocarbons
SVOCs - semivolatile organic compounds

Total BTEX and Total PAHs are calculated using detects only.

6 NYCRR - New York State Register and Official Compilation of Codes, Rules and Regulations of the State of New York
6 NYCRR 375 SCO UNRESTRICTED USE - regulatory comparison against NYCRR, Chapter IV, Part 375-6 Unrestricted Use Soil Cleanup Objectives
6 NYCRR 375 SCO RESTRICTED USE COMM - regulatory comparison against NYCRR, Chapter IV, Part 375-6 Restricted Use Commercial Soil Cleanup Objectives

NE - not established
NA - not analyzed
ND - not detected; total concentration is listed as ND because no compounds were detected in the group

Gray shading indicates that the detected result value exceeds established 6 NYCRR SCO UNRESTR
Yellow shading indicates that the detected result value exceeds established 6 NYCRR SCO RES COMM

Data Qualifiers:

J - estimated value
U - indicates not detected at or above the reporting limit shown.
UJ - not detected at or above the reporting limit shown and the reporting limit is estimated
R - rejected

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-501(13)	B-501(13)	B-501(13)	B-501(13)	B-502(13)	B-502(13)	B-502(13)	B-503(13)
Sample Name:				B-501(13)9-10	B-501(13)12-14	B-501(13)15-17	B-501(13)18-20	B-502(13)9.5-10	B-502(13)11-12	B-502(13)19-20	B-503(13)8-9
Start Depth:				9	12	15	18	9.5	11	19	8
End Depth:				10	14	17	20	10	12	20	9
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/11/2013	3/11/2013	3/11/2013	3/11/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.066	0.25 J	0.00064 J	0.00032 J	0.00073 J	0.0015 J	0.0011 UJ	0.00052 J
Toluene	108-88-3	0.7	500	0.081	0.28 J	0.00085 U	0.000088 J	0.0011 J	0.00049 J	0.0003 J	0.0007 J
Ethylbenzene	100-41-4	1	390	0.51	0.68 J	0.00032 J	R	0.00066 J	0.00047 J	0.0011 UJ	0.002 J
Total Xylene	1330-20-7	0.26	500	1.1	2.2 J	0.001 J	R	0.002 J	0.0016 J	0.0033 UJ	0.0053 J
Total BTEX	TBTEX	NE	NE	1.757	3.41	0.00196	0.000408	0.00449	0.00406	0.0003	0.00852
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	1.2	0.79	0.36 U	NA	1.1	0.53	0.37 U	2.1
Acenaphthylene	208-96-8	100	500	0.99	0.58	0.36 U	NA	0.33 J	0.59	0.37 U	2.4
Anthracene	120-12-7	100	500	1.6	1.2	0.36 U	NA	0.75	2.3	0.37 U	7.4
Benzo[g,h,i]perylene	191-24-2	100	500	0.74	0.33 J	0.36 U	NA	0.17 J	1.7	0.37 U	3
Fluoranthene	206-44-0	100	500	2.7	1.7	0.36 U	NA	1.4	6.4	0.37 U	12
Fluorene	86-73-7	30	500	2.6	1.6	0.082 J	NA	1.3	1.4	0.37 U	6.5
Naphthalene	91-20-3	12	500	0.97	2.6	0.24 J	NA	0.39 J	0.65	0.37 U	0.94 J
Phenanthrene	85-01-8	100	500	4.2	3.7	0.082 J	NA	2.1	4.8	0.056 J	20
Pyrene	129-00-0	100	500	3	1.8	0.36 U	NA	1	4.5	0.031 J	11
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	1.7	1.1	0.036 U	NA	0.52	4	0.037 U	9
Benzo[a]pyrene	50-32-8	1	1	1.5	0.74	0.036 U	NA	0.42	3.7	0.037 U	6.2
Benzo[b]fluoranthene	205-99-2	1	5.6	1.5	0.75	0.036 U	NA	0.41	3.7	0.037 U	5.5
Benzo[k]fluoranthene	207-08-9	0.8	56	0.83	0.39	0.036 U	NA	0.2	1.5	0.037 U	2.9
Chrysene	218-01-9	1	56	1.6	0.99	0.36 U	NA	0.5	3.8	0.37 U	8.1
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.22	0.11	0.036 U	NA	0.04 U	0.55	0.037 U	1.4
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.76	0.33	0.036 U	NA	0.2	1.9	0.037 U	3.2
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	26.11	18.71	0.404	NA	10.79	42.02	0.087	101.64

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-503(13)	B-503(13)	B-504(13)	B-504(13)	B-504(13)	B-505(13)	B-505(13)	B-505(13)
Sample Name:				B-503(13)14.5-15	B-503(13)18-19	B-504(13)6-8	B-504(13)11.5-12	B-504(13)18.5-19.5	B-505(13)8-9	B-505(13)13-15	B-505(13)18-19
Start Depth:				14.5	18	6	11.5	18.5	8	13	18
End Depth:				15	19	8	12	19.5	9	15	19
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/12/2013	3/12/2013	3/12/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0011 UJ	0.0011 UJ	0.0013 J	0.035 J	0.0068 J	0.001 U	0.0033	0.00065 J
Toluene	108-88-3	0.7	500	0.00026 J	0.00032 J	0.00037 J	0.001 J	0.00034 J	0.001 U	0.00032 J	0.00016 J
Ethylbenzene	100-41-4	1	390	0.0011 UJ	0.0011 UJ	0.0012 UJ	0.0018 J	0.0011 J	0.001 U	0.00056 J	0.00097 U
Total Xylene	1330-20-7	0.26	500	0.0032 UJ	0.0033 UJ	0.0037 UJ	0.0036 J	0.0011 J	0.0031 U	0.00086 J	0.0029 U
Total BTEX	TBTEX	NE	NE	0.00026	0.00032	0.00167	0.0414	0.00934	ND	0.00504	0.00081
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	0.39 U	0.37 U	0.35 J	0.23 J	0.13 J	0.43 U	0.29 J	1.2
Acenaphthylene	208-96-8	100	500	0.39 U	0.37 U	0.055 J	0.62	0.37 U	0.43 U	0.38 U	0.12 J
Anthracene	120-12-7	100	500	0.39 U	0.37 U	0.12 J	0.45 U	0.34 J	0.43 U	0.38 U	0.37 U
Benzo[g,h,i]perylene	191-24-2	100	500	0.39 U	0.37 U	0.18 J	0.45 U	0.37 U	0.43 U	0.38 U	0.37 U
Fluoranthene	206-44-0	100	500	0.39 U	0.37 U	0.62	0.45 U	0.14 J	0.43 U	0.42	0.37 U
Fluorene	86-73-7	30	500	0.39 U	0.37 U	0.28 J	0.11 J	0.76	0.43 U	0.18 J	0.37 U
Naphthalene	91-20-3	12	500	0.39 U	0.37 U	0.13 J	1.4	0.38	0.068 J	0.11 J	0.37 U
Phenanthrene	85-01-8	100	500	0.39 U	0.37 U	0.27 J	0.45 U	0.63	0.079 J	0.065 J	0.37 U
Pyrene	129-00-0	100	500	0.39 U	0.37 U	0.59	0.45 U	0.098 J	0.43 U	0.35 J	0.37 U
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.039 U	0.037 U	0.47	0.045 U	0.037 U	0.043 U	0.038	0.037 U
Benzo[a]pyrene	50-32-8	1	1	0.039 U	0.037 U	0.4	0.045 U	0.037 U	0.043 U	0.024 J	0.037 U
Benzo[b]fluoranthene	205-99-2	1	5.6	0.039 U	0.037 U	0.45	0.045 U	0.037 U	0.043 U	0.027 J	0.037 U
Benzo[k]fluoranthene	207-08-9	0.8	56	0.039 U	0.037 U	0.21	0.045 U	0.037 U	0.043 U	0.013 J	0.037 U
Chrysene	218-01-9	1	56	0.39 U	0.37 U	0.46	0.45 U	0.37 U	0.43 U	0.38 U	0.37 U
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.039 U	0.037 U	0.053	0.045 U	0.037 U	0.043 U	0.038 U	0.037 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.039 U	0.037 U	0.17	0.045 U	0.037 U	0.043 U	0.038 U	0.037 U
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	ND	ND	4.808	2.36	2.478	0.147	1.517	1.32

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-506(13)	B-506(13)	B-506(13)	B-507(13)	B-507(13)	B-507(13)	B-508(13)	B-508(13)
Sample Name:				B-506(13)9.5-10	B-506(13)12-13	B-506(13)19.5-20	B-507(13)9.5-10	B-507(13)14-15	B-507(13)18.5-19	B-508 (13) 9.5-10	B-508 (13) 12.5-15
Start Depth:				9.5	12	19.5	9.5	14	18.5	9.5	12.5
End Depth:				10	13	20	10	15	19	10	15
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/14/2013	3/15/2013	3/15/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.012 J	0.37 J	0.00075 J	0.0021 J	0.14 J	0.00078 J	0.00045 J	0.028 J
Toluene	108-88-3	0.7	500	0.0035 J	0.13 J	0.00039 J	0.0013 J	0.11 J	0.0011 UJ	0.00037 J	0.0043 J
Ethylbenzene	100-41-4	1	390	0.032 J	2.5 J	0.00025 J	0.0052 J	0.58 J	0.0011 UJ	0.0011 UJ	0.012 J
Total Xylene	1330-20-7	0.26	500	0.021 J	2.2 J	0.0032 UJ	0.0027 J	1.2 J	0.0033 UJ	0.0033 UJ	0.011 J
Total BTEX	TBTEX	NE	NE	0.0685	5.2	0.00139	0.0113	2.03	0.00078	0.00082	0.0553
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	15 J	0.42 U	0.16 J	0.44 U	1.1	0.4 U	0.78 U	1.7 J
Acenaphthylene	208-96-8	100	500	33	0.42 U	0.37 U	0.44 U	1.4	0.4 U	0.5 J	1.9
Anthracene	120-12-7	100	500	140	0.21 J	0.047 J	0.44 U	3	0.4 U	3.6	14
Benzo[g,h,i]perylene	191-24-2	100	500	67	0.062 J	0.37 U	0.44 U	1.8	0.4 U	6.1	5.3
Fluoranthene	206-44-0	100	500	220	0.4 J	0.087 J	0.44 U	8.8	0.4 U	15	23
Fluorene	86-73-7	30	500	46	0.055 J	0.37 U	0.44 U	2.4	0.4 U	0.22 J	2.9
Naphthalene	91-20-3	12	500	18 U	1.5	0.061 J	0.49	3.1	0.26 J	0.78 U	14
Phenanthrene	85-01-8	100	500	280	0.36 J	0.098 J	0.44 U	8.4	0.4 U	5.8	21
Pyrene	129-00-0	100	500	180	0.35 J	0.071 J	0.44 U	6.3	0.4 U	11	22
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	88	0.15	0.037	0.044 U	3.4	0.04 U	6.9	9.5
Benzo[a]pyrene	50-32-8	1	1	89	0.14	0.03 J	0.044 U	3.4	0.04 U	7.6	10
Benzo[b]fluoranthene	205-99-2	1	5.6	77	0.14	0.028 J	0.044 U	3.1	0.04 U	7.5	9.8
Benzo[k]fluoranthene	207-08-9	0.8	56	38	0.057	0.013 J	0.044 U	1.2	0.04 U	3.1	4.4
Chrysene	218-01-9	1	56	110	0.17 J	0.37 U	0.44 U	2.7	0.4 U	7	10
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	17	0.019 J	0.037 U	0.044 U	0.44	0.04 U	1.5	0.95
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	63	0.063	0.015 J	0.044 U	1.9	0.04 U	6.4	5.4
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	1463	3.676	0.647	0.49	52.44	0.26	82.22	155.85

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-508(13)	B-509(13)	B-509(13)	B-509(13)	B-510(13)	B-510(13)	B-510(13)	B-511(13)
Sample Name:				B-508 (13) 19.5-20	B-509 (13) 9-10	B-509 (13) 11-14	B-509 (13) 16.5-17.5	B-510 (13) 5-10	B-510 (13) 11-12	B-510 (13) 15-20	B-511 (13) 5-7.5
Start Depth:				19.5	9	11	16.5	5	11	15	5
End Depth:				20	10	14	17.5	10	12	20	7.5
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/15/2013	3/15/2013	3/15/2013	3/15/2013	3/15/2013	3/15/2013	3/15/2013	3/15/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.00072 J	0.00062 J	0.019 J	0.0011 UJ	0.0023 J	0.0027 J	0.001 UJ	0.00031 J
Toluene	108-88-3	0.7	500	0.001 J	0.00037 J	0.0044 J	0.0011 UJ	0.0006 J	0.0019 J	0.0002 J	0.00053 J
Ethylbenzene	100-41-4	1	390	0.037 J	0.0012 UJ	0.0048 J	0.0011 UJ	0.0011 UJ	0.0013 J	0.001 UJ	0.0011 UJ
Total Xylene	1330-20-7	0.26	500	0.065 J	0.0037 UJ	0.045 J	0.0032 UJ	0.0033 UJ	0.0014 J	0.0031 UJ	0.0034 UJ
Total BTEX	TBTEX	NE	NE	0.10372	0.00099	0.0732	ND	0.0029	0.0073	0.0002	0.00084
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	4.7	0.075 J	22	0.41 U	0.24 J	10	0.39 U	0.37 U
Acenaphthylene	208-96-8	100	500	1.4 J	0.45	61	0.082 J	0.084 J	11	0.39 U	0.05 J
Anthracene	120-12-7	100	500	18	1	120	0.24 J	0.44	39	0.39 U	0.37 U
Benzo[g,h,i]perylene	191-24-2	100	500	11	2.9	51	0.24 J	1.1	19	0.39 U	0.5
Fluoranthene	206-44-0	100	500	40	5.9	190	0.84	2.7	96	0.12 J	0.55
Fluorene	86-73-7	30	500	8.2	0.13 J	85	0.061 J	0.21 J	9.4	0.39 U	0.37 U
Naphthalene	91-20-3	12	500	12	0.16 J	9.8 J	0.41 U	0.23 J	1.4 J	0.39 U	0.061 J
Phenanthrene	85-01-8	100	500	52	1.2	340	0.28 J	2	72	0.076 J	0.13 J
Pyrene	129-00-0	100	500	35	4.8	180	0.73	2.1	79	0.098 J	0.8
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	17	3.6	83	0.39	1.7	36	0.051	0.46
Benzo[a]pyrene	50-32-8	1	1	17	4.5	79	0.39	1.9	34	0.05	0.76
Benzo[b]fluoranthene	205-99-2	1	5.6	17	4.6	72	0.42	1.9	28	0.053	0.84
Benzo[k]fluoranthene	207-08-9	0.8	56	6.9	1.6	39	0.19	0.82	15	0.023 J	0.37
Chrysene	218-01-9	1	56	16	3.7	83	0.38 J	1.7	34	0.39 U	0.53
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	1.8	0.78	8.3	0.034 J	0.3	4.9	0.039 U	0.12
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	11	3.2	49	0.25	1.2	21	0.021 J	0.55
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	269	38.595	1472.1	4.527	18.624	509.7	0.492	5.721

Validated

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-511(13)	B-511(13)	B-512(13)	B-512(13)	B-512(13)	B-513(13)	B-513(13)	B-513(13)
Sample Name:				B-511 (13) 11-13	B-511 (13) 19-20	B-512 (13) 9-10	B-512 (13) 12.5-13.5	B-512 (13) 15-16	B-513(13)9-10	B-513(13)13-14	B-513(13)15.5-16.5
Start Depth:				11	19	9	12.5	15	9	13	15.5
End Depth:				13	20	10	13.5	16	10	14	16.5
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/15/2013	3/15/2013	3/15/2013	3/15/2013	3/15/2013	3/18/2013	3/18/2013	3/18/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0043 J	0.00023 J	0.017 J	0.0055 J	0.00024 J	0.0011 UJ	0.8 J	0.49 J
Toluene	108-88-3	0.7	500	0.0016 J	0.00036 J	0.00099 J	0.00052 J	0.00051 J	0.00036 J	1.1 J	0.42 J
Ethylbenzene	100-41-4	1	390	0.00068 J	0.0011 UJ	0.001 UJ	0.0012 UJ	0.0011 UJ	0.00025 J	4.2 J	0.45 J
Total Xylene	1330-20-7	0.26	500	0.0018 J	0.0032 UJ	0.0031 UJ	0.0035 UJ	0.0032 UJ	0.0034 UJ	7.2 J	0.84 J
Total BTEX	TBTEX	NE	NE	0.00838	0.00059	0.01799	0.00602	0.00075	0.00061	13.3	2.2
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	5.3	0.37 U	0.37 U	0.26 J	0.38 U	0.084 J	11	7.6
Acenaphthylene	208-96-8	100	500	0.96	0.37 U	0.37 U	0.41 U	0.38 U	0.44	18	7.9
Anthracene	120-12-7	100	500	0.98	0.37 U	0.37 U	0.056 J	0.38 U	1.3	27	15
Benzo[g,h,i]perylene	191-24-2	100	500	0.19 J	0.37 U	0.37 U	0.41 U	0.38 U	1.6	9.7	6.7
Fluoranthene	206-44-0	100	500	1.6	0.37 U	0.37 U	0.066 J	0.38 U	4.5	45	31
Fluorene	86-73-7	30	500	6.2	0.37 U	0.37 U	0.074 J	0.38 U	0.21 J	21	12
Naphthalene	91-20-3	12	500	2.3	0.37 U	0.081 J	0.069 J	0.38 U	0.29 J	54	16
Phenanthrene	85-01-8	100	500	5.2	0.37 U	0.37 U	0.41 U	0.38 U	1.9	79	53
Pyrene	129-00-0	100	500	1.6	0.37 U	0.37 U	0.052 J	0.38 U	5.6	47	32
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.46	0.037 U	0.037 U	0.041 U	0.038 U	2.4	16	11
Benzo[a]pyrene	50-32-8	1	1	0.35	0.037 U	0.037 U	0.024 J	0.038 U	2.7	16	12
Benzo[b]fluoranthene	205-99-2	1	5.6	0.33	0.037 U	0.037 U	0.028 J	0.038 U	2.5	16	11
Benzo[k]fluoranthene	207-08-9	0.8	56	0.18	0.037 U	0.037 U	0.041 U	0.038 U	1.3	6.6	5
Chrysene	218-01-9	1	56	0.43 J	0.37 U	0.37 U	0.41 U	0.38 U	2.4	15	9.1
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.054	0.037 U	0.037 U	0.041 U	0.038 U	0.43	2.1	1.4
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.23	0.037 U	0.037 U	0.041 U	0.038 U	1.7	9	6.5
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	26.364	ND	0.081	0.629	ND	29.354	392.4	237.2

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-513(13)	B-514(13)	B-514(13)	B-514(13)	B-515(13)	B-515(13)	B-515(13)	B-515(13)
Sample Name:				B-513(13)24.5-25.0	B-514(13)12-13	B-514(13)15.5-16.0	B-514(13)20.0-21.5	B-515(13)9-10	B-515(13)12.6-12.8	B-515(13)18.5-19	B-515(13)23-23.5
Start Depth:				24.5	12	15.5	20	9	12.6	18.5	23
End Depth:				25	13	16	21.5	10	12.8	19	23.5
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/18/2013	3/18/2013	3/18/2013	3/18/2013	3/12/2013	3/12/2013	3/12/2013	3/12/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0053 J	0.09 J	17 J	0.11 J	0.0091	0.0045	0.00016 J	NA
Toluene	108-88-3	0.7	500	0.00049 J	0.013 J	38 J	0.026 J	0.0002 J	0.00019 J	0.001 U	NA
Ethylbenzene	100-41-4	1	390	0.0013 J	0.086 J	55 J	0.078 J	0.00038 J	0.00082 U	0.001 U	NA
Total Xylene	1330-20-7	0.26	500	0.002 J	0.12 J	160 J	0.17 J	0.0033 U	0.0024 U	0.0031 U	NA
Total BTEX	TBTEX	NE	NE	0.00909	0.309	270	0.384	0.00968	0.00469	0.00016	NA
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	0.48	1.3	9.7 J	2.3	0.4 U	0.059 J	0.086 J	0.59
Acenaphthylene	208-96-8	100	500	0.38 U	0.22 J	48	4.6	0.4 U	0.05 J	0.4 U	0.083 J
Anthracene	120-12-7	100	500	0.14 J	0.16 J	41	6.1	0.4 U	0.092 J	0.4 U	0.061 J
Benzo[g,h,i]perylene	191-24-2	100	500	0.38 U	0.099 J	18 J	3.2	0.4 U	0.36 U	0.4 U	0.41 U
Fluoranthene	206-44-0	100	500	0.5	0.26 J	91	14	0.4 U	0.18 J	0.11 J	0.46
Fluorene	86-73-7	30	500	0.56	1.1	40	5.7	0.4 U	0.14 J	0.4 U	0.19 J
Naphthalene	91-20-3	12	500	0.43	6.3	250	17	0.052 J	0.12 J	0.4 U	0.065 J
Phenanthrene	85-01-8	100	500	0.27 J	1.5	150	22	0.4 U	0.14 J	0.4 U	0.052 J
Pyrene	129-00-0	100	500	0.27 J	0.29 J	85	15	0.4 U	0.16 J	0.084 J	0.45
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.038 U	0.12	32	5.4	0.04 U	0.036 U	0.04 U	0.041 U
Benzo[a]pyrene	50-32-8	1	1	0.019 J	0.15	35	5.1	0.04 U	0.036 U	0.04 U	0.041 U
Benzo[b]fluoranthene	205-99-2	1	5.6	0.018 J	0.15	29	4.9	0.04 U	0.036 U	0.04 U	0.041 U
Benzo[k]fluoranthene	207-08-9	0.8	56	0.038 U	0.041 U	17	2.1	0.04 U	0.036 U	0.04 U	0.041 U
Chrysene	218-01-9	1	56	0.38 U	0.13 J	27	5.2	0.4 U	0.36 U	0.4 U	0.41 U
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.038 U	0.027 J	3.6	0.73	0.04 U	0.036 U	0.04 U	0.041 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.038 U	0.096	16	3.1	0.04 U	0.036 U	0.04 U	0.041 U
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	2.687	11.902	892.3	116.43	0.052	0.941	0.28	1.951

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-516(13)	B-516(13)	B-516(13)	B-516(13)	B-517(13)	B-517(13)	B-518(13)	B-518(13)
Sample Name:				B-516(13)7.5-8.0	B-516(13)14-15	B-516(13)18.25-18.75	B-516(13)22.5-23	B-517(13)11-12	B-517(13)24.5-25.0	B-518(13)5-7.5	B-518(13)14.5-16
Start Depth:				7.5	14	18.25	22.5	11	24.5	5	14.5
End Depth:				8	15	18.75	23	12	25	7.5	16
Depth Unit				ft	ft	ft	ft	ft	ft	ft	ft
Sample Date:				3/18/2013	3/18/2013	3/18/2013	3/18/2013	3/18/2013	3/18/2013	3/18/2013	3/18/2013
Parent Sample Code:											
BTEX (mg/kg)											
Benzene	71-43-2	0.06	44	0.0012 UJ	0.00046 J	0.063 J	0.0013 J	9.4 J	0.0011 J	0.0011 UJ	0.005 J
Toluene	108-88-3	0.7	500	0.0012 UJ	0.00026 J	0.00075 J	0.00022 J	29 J	0.00027 J	0.0011 UJ	0.00036 J
Ethylbenzene	100-41-4	1	390	0.0012 UJ	0.00072 J	0.012 J	0.00026 J	43 J	0.00043 J	0.0011 UJ	0.00067 J
Total Xylene	1330-20-7	0.26	500	0.0035 UJ	0.0025 J	0.017 J	0.003 UJ	290 J	0.0034 UJ	0.0032 UJ	0.0033 UJ
Total BTEX	TBTEX	NE	NE	ND	0.00394	0.09275	0.00178	371.4	0.0018	ND	0.00603
Non-carcinogenic PAHs (mg/kg)											
Acenaphthene	83-32-9	20	500	0.42 U	0.12 J	1.5	0.82	14 J	0.62	0.36 U	0.86 J
Acenaphthylene	208-96-8	100	500	0.42 U	0.41 U	0.24 J	0.1 J	42	0.39 U	0.36 U	0.47 J
Anthracene	120-12-7	100	500	0.42 U	0.41 U	0.28 J	0.12 J	95	0.24 J	0.36 U	0.38 UJ
Benzo[g,h,i]perylene	191-24-2	100	500	0.42 U	0.41 U	0.4 U	0.37 U	39	0.39 U	0.15 J	0.38 UJ
Fluoranthene	206-44-0	100	500	0.42 U	0.41 U	0.4 U	0.51	160	0.73	0.097 J	0.38 UJ
Fluorene	86-73-7	30	500	0.42 U	0.08 J	2.8	0.22 J	66	0.54	0.36 U	1.3 J
Naphthalene	91-20-3	12	500	0.42 U	0.24 J	1.1	0.29 J	310	0.43	0.36 U	0.4 J
Phenanthrene	85-01-8	100	500	0.42 U	0.17 J	2	0.11 J	270	0.15 J	0.06 J	1.3 J
Pyrene	129-00-0	100	500	0.42 U	0.037 J	0.4 U	0.27 J	160	0.46	0.11 J	0.38 UJ
Carcinogenic PAHs (mg/kg)											
Benz[a]anthracene	56-55-3	1	5.6	0.042 U	0.041 U	0.04 U	0.037 U	64	0.039 U	0.11	0.038 UJ
Benzo[a]pyrene	50-32-8	1	1	0.042 U	0.041 U	0.0091 J	0.037 U	64	0.039 U	0.21	0.038 UJ
Benzo[b]fluoranthene	205-99-2	1	5.6	0.042 U	0.041 U	0.01 J	0.037 U	58	0.039 U	0.19	0.038 UJ
Benzo[k]fluoranthene	207-08-9	0.8	56	0.042 U	0.041 U	0.04 U	0.037 U	27	0.039 U	0.11	0.038 UJ
Chrysene	218-01-9	1	56	0.42 U	0.41 U	0.4 U	0.37 U	56	0.39 U	0.11 J	0.38 UJ
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	0.042 U	0.041 U	0.04 U	0.037 U	8.8	0.039 U	0.038	0.038 UJ
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	0.042 U	0.041 UJ	0.04 U	0.037 U	35	0.039 U	0.17	0.038 UJ
Total PAHs (mg/kg)											
Total PAH 16	TPAH16	NE	500	ND	0.647	7.9391	2.44	1468.8	3.17	1.355	4.33

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	6 NYCRR 375 SCO UNRESTRICTED USE	6 NYCRR 375 SCO RESTRICTED USE COMM	B-518(13)	B-518(13)
Sample Name:				B-518(13)25-30	B-51813)21-22
Start Depth:				25	21
End Depth:				30	22
Depth Unit				ft	ft
Sample Date:				3/18/2013	3/18/2013
Parent Sample Code:				B-518(13)14.5-16	
BTEX (mg/kg)					
Benzene	71-43-2	0.06	44	0.023 J	0.062 J
Toluene	108-88-3	0.7	500	0.0013 J	0.00087 J
Ethylbenzene	100-41-4	1	390	0.00089 J	0.0018 J
Total Xylene	1330-20-7	0.26	500	0.0028 J	0.02 J
Total BTEX	TBTEX	NE	NE	0.02799	0.08467
Non-carcinogenic PAHs (mg/kg)					
Acenaphthene	83-32-9	20	500	13 J	0.7
Acenaphthylene	208-96-8	100	500	3.3 J	0.082 J
Anthracene	120-12-7	100	500	16 J	0.1 J
Benzo[g,h,i]perylene	191-24-2	100	500	14 J	0.42 U
Fluoranthene	206-44-0	100	500	50 J	0.22 J
Fluorene	86-73-7	30	500	11 J	0.63
Naphthalene	91-20-3	12	500	0.72 J	0.096 J
Phenanthrene	85-01-8	100	500	15 J	0.78
Pyrene	129-00-0	100	500	56 J	0.17 J
Carcinogenic PAHs (mg/kg)					
Benz[a]anthracene	56-55-3	1	5.6	21 J	0.062
Benzo[a]pyrene	50-32-8	1	1	23 J	0.064
Benzo[b]fluoranthene	205-99-2	1	5.6	20 J	0.056
Benzo[k]fluoranthene	207-08-9	0.8	56	8.9 J	0.028 J
Chrysene	218-01-9	1	56	18 J	0.072 J
Dibenz[a,h]anthracene	53-70-3	0.33	0.56	3.2 J	0.042 U
Indeno[1,2,3-cd]pyrene	193-39-5	0.5	5.6	14 J	0.032 J
Total PAHs (mg/kg)					
Total PAH 16	TPAH16	NE	500	287.12	3.092

Table A-2
Subsurface Soil Analytical Results in Vicinity of Tar Wells - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Notes:

The 2005 and 2006 data reported in this table are gathered from the 2006 EA Engineering Data Usability Summary Report (DUSR).

mg/kg - milligrams/kilogram or parts per million (ppm)
BTEX - benzene, toluene, ethylbenzene, and xylenes
VOCs - volatile organic compounds
PAHs - polycyclic aromatic hydrocarbons
SVOCs - semivolatile organic compounds

Total BTEX and Total PAHs are calculated using detects only.

6 NYCRR - New York State Register and Official Compilation of Codes, Rules and Regulations of the State of New York
6 NYCRR 375 SCO UNRESTRICTED USE - regulatory comparison against NYCRR, Chapter IV, Part 375-6 Unrestricted Use Soil Cleanup Objectives
6 NYCRR 375 SCO RESTRICTED USE COMM - regulatory comparison against NYCRR, Chapter IV, Part 375-6 Restricted Use Commercial Soil Cleanup Objectives

NE - not established
NA - not analyzed
ND - not detected; total concentration is listed as ND because no compounds were detected in the group

Gray shading indicates that the detected result value exceeds established 6 NYCRR SCO UNRESTR
Yellow shading indicates that the detected result value exceeds established 6 NYCRR SCO RES COMM

Data Qualifiers:

J - estimated value
U - indicates not detected at or above the reporting limit shown.
UJ - not detected at or above the reporting limit shown and the reporting limit is estimated
R - rejected

Table A-3
Pre- and Waste Characterization Analytical Results - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	EPA 40 CFR 261	PRE CHAR	PRE CHAR	PRE CHAR	PRE CHAR	WASTE
Sample Name:			Pre Char 1	Pre Char 2	Pre Char 3	Pre Char 4 Waste 2	Waste 1
Sample Date:			3/20/2013	3/20/2013	3/18/2013	3/18/2013	3/20/2013
BTEX (mg/kg)							
Benzene	71-43-2	NA	**9.2**	**270**	**0.33**	**9**	**190**
Toluene	108-88-3	NA	**13**	**300**	**0.15**	**44**	**200**
Ethylbenzene	100-41-4	NA	**1.3**	**26**	**0.3**	**26**	**20**
m,p-Xylene	108383/106423	NA	**15**	**290**	**0.43**	**150**	**200**
o-Xylene	95-47-6	NA	**5.6**	**110**	**0.16**	**49**	**75**
Other VOCs (mg/kg)							
Acetone	67-64-1	NA	0.59 U	12 U	0.53 U	1.3 U	10 U
Bromochloromethane	74-97-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Bromodichloromethane	75-27-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Bromoform	75-25-2	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Bromomethane	74-83-9	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
2-Butanone (Methyl ethyl ketone)	78-93-3	NA	0.59 U	12 U	0.53 U	1.3 U	10 U
Carbon disulfide	75-15-0	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Carbon tetrachloride	56-23-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Chlorobenzene	108-90-7	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Chloroethane	75-00-3	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Chloroform	67-66-3	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Chloromethane	74-87-3	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Cyclohexane	110-82-7	NA	**0.15**	2.4 U	0.11 U	0.26 U	**0.81 J**
1,2-Dibromo-3-chloropropane	96-12-8	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Dibromochloromethane	124-48-1	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,2-Dibromoethane (EDB)	106-93-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,2-Dichlorobenzene	95-50-1	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,3-Dichlorobenzene	541-73-1	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,4-Dichlorobenzene	106-46-7	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Dichlorodifluoromethane (Freon 12)	75-71-8	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,1-Dichloroethane	75-34-3	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,2-Dichloroethane	107-06-2	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,1-Dichloroethene	75-35-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
cis-1,2-Dichloroethene	156-59-2	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
trans-1,2-Dichloroethene	156-60-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,2-Dichloropropane	78-87-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
cis-1,3-Dichloropropene	10061-01-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
trans-1,3-Dichloropropene	10061-02-6	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,4-Dioxane	123-91-1	NA	5.9 U	120 U	5.3 U	13 U	100 U
2-Hexanone	591-78-6	NA	0.59 U	12 U	0.53 U	1.3 U	10 U
Isopropyl benzene	98-82-8	NA	**0.1 J**	**1.5 J**	**0.031 J**	**1.5**	**1.1 J**
Methyl acetate	79-20-9	NA	0.23 U	4.8 U	0.21 U	0.52 U	4 U
Methyl tert-butyl ether (MTBE)	1634-04-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
4-Methyl-2-pentanone (MIBK)	108-10-1	NA	0.59 U	12 U	0.53 U	1.3 U	10 U
Methylcyclohexane	108-87-2	NA	**0.39**	**3.9**	**0.17**	**19**	**2.7**
Methylene chloride	75-09-2	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Styrene	100-42-5	NA	**5.7**	**120**	**0.016 J**	**34**	**75**
1,1,2,2-Tetrachloroethane	79-34-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Tetrachloroethene (PCE)	127-18-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon-113)	76-13-1	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,2,3-Trichlorobenzene	87-61-6	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,2,4-Trichlorobenzene	120-82-1	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,1,1-Trichloroethane	71-55-6	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
1,1,2-Trichloroethane	79-00-5	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Trichloroethene (TCE)	79-01-6	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Trichlorofluoromethane (Freon 11)	75-69-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U
Vinyl chloride	75-01-4	NA	0.12 U	2.4 U	0.11 U	0.26 U	2 U

Table A-3
Pre- and Waste Characterization Analytical Results - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	EPA 40 CFR 261	PRE CHAR	PRE CHAR	PRE CHAR	PRE CHAR	WASTE
Sample Name:			Pre Char 1	Pre Char 2	Pre Char 3	Pre Char 4 Waste 2	Waste 1
Sample Date:			3/20/2013	3/20/2013	3/18/2013	3/18/2013	3/20/2013
TCLP VOCs (mg/L)							
Benzene	71-43-2	0.5	NA	NA	NA	**0.096**	**8.5**
2-Butanone (Methyl ethyl ketone)	78-93-3	200	NA	NA	NA	0.05 U	0.1 U
Carbon tetrachloride	56-23-5	0.5	NA	NA	NA	0.01 U	0.02 U
Chlorobenzene	108-90-7	100	NA	NA	NA	0.01 U	0.02 U
Chloroform	67-66-3	6	NA	NA	NA	0.01 U	0.02 U
1,2-Dichloroethane	107-06-2	0.5	NA	NA	NA	0.01 U	0.02 U
1,1-Dichloroethene	75-35-4	0.7	NA	NA	NA	0.01 U	0.02 U
Tetrachloroethene (PCE)	127-18-4	0.7	NA	NA	NA	0.01 U	0.02 U
Trichloroethene (TCE)	79-01-6	0.5	NA	NA	NA	0.01 U	0.02 U
Vinyl chloride	75-01-4	0.2	NA	NA	NA	0.01 U	0.02 U
1,4-Dichlorobenzene	106-46-7	7.5	NA	NA	NA	0.04 U	1 U
Other SVOCs (mg/kg)							
Acenaphthene	83-32-9	NA	**40 J**	**61 J**	**2.6**	**43 J**	**140 J**
Acenaphthylene	208-96-8	NA	**210**	**320**	**5.1**	**84**	**840**
Acetophenone	98-86-2	NA	54 U	120 U	1.9 U	44 U	240 U
Anthracene	120-12-7	NA	**210**	**350**	**11**	**150**	**1100**
Atrazine	1912-24-9	NA	54 U	120 U	1.9 U	44 U	240 U
Benz[a]anthracene	56-55-3	NA	**150**	**260**	**9.4**	**78**	**570**
Benzaldehyde	100-52-7	NA	54 U	120 U	1.9 U	44 U	240 U
Benzo[a]pyrene	50-32-8	NA	**130**	**250**	**9.1**	**76**	**520**
Benzo[b]fluoranthene	205-99-2	NA	**130**	**220**	**8.2**	**67**	**490**
Benzo[g,h,i]perylene	191-24-2	NA	**81**	**150**	**5.5**	**46**	**290**
Benzo[k]fluoranthene	207-08-9	NA	**54**	**110**	**4**	**34**	**210**
1,1-Biphenyl	92-52-4	NA	**57**	**85 J**	**1.8 J**	**29 J**	**230 J**
Bis(chloroisopropyl)ether	108-60-1	NA	54 U	120 U	1.9 U	44 U	240 U
Bis(2-chloroethyl)ether	111-44-4	NA	5.4 U	12 U	0.19 U	4.4 U	24 U
Bis(2-chloroethoxy)methane	111-91-1	NA	54 U	120 U	1.9 U	44 U	240 U
Bis(2-ethylhexyl)phthalate	117-81-7	NA	54 U	54 U	1.9 U	44 U	240 U
4-Bromophenyl phenyl ether	101-55-3	NA	54 U	120 U	1.9 U	44 U	240 U
Butyl benzyl phthalate	85-68-7	NA	54 U	120 U	1.9 U	44 U	240 U
Caprolactam	105-60-2	NA	54 U	120 U	1.9 U	44 U	240 U
Carbazole	86-74-8	NA	**76**	**130**	**3.9**	**42 J**	**410**
4-Chloro-3-methylphenol	59-50-7	NA	54 U	120 U	1.9 U	44 U	240 U
4-Chloroaniline	106-47-8	NA	54 U	54 U	1.9 U	44 U	240 U
2-Chloronaphthalene	91-58-7	NA	54 U	120 U	1.9 U	44 U	240 U
2-Chlorophenol	95-57-8	NA	54 U	120 U	1.9 U	44 U	240 U
4-Chlorophenyl phenyl ether	7005-72-3	NA	54 U	120 U	1.9 U	44 U	240 U
Chrysene	218-01-9	NA	**140**	**260**	**9.6**	**87**	**600**
Dibenz[a,h]anthracene	53-70-3	NA	**19**	**38**	**1.3**	**11**	**73**
Dibenzofuran	132-64-9	NA	**170**	**260**	**5.9**	**82**	**700**
3,3-Dichlorobenzidine	91-94-1	NA	110 U	250 U	4 U	90 U	480 U
2,4-Dichlorophenol	120-83-2	NA	54 U	120 U	1.9 U	44 U	240 U
Diethyl phthalate	84-66-2	NA	54 U	120 U	1.9 U	44 U	240 U
Dimethyl phthalate	131-11-3	NA	54 U	120 U	1.9 U	44 U	240 U
2,4-Dimethylphenol	105-67-9	NA	**36 J**	**53 J**	1.9 U	44 U	**190 J**
Di-n-butyl phthalate	84-74-2	NA	54 U	120 U	1.9 U	44 U	240 U
4,6-Dinitro-2-methylphenol	534-52-1	NA	160 U	370 U	5.9 U	130 U	720 U
2,4-Dinitrophenol	51-28-5	NA	160 U	370 U	5.9 U	130 U	720 U
2,4-Dinitrotoluene	121-14-2	NA	11 U	25 U	0.4 U	9 U	48 U
2,6-Dinitrotoluene	606-20-2	NA	11 U	25 U	0.4 U	9 U	48 U
Di-n-octyl phthalate	117-84-0	NA	54 U	120 U	1.9 U	44 U	240 U
Fluoranthene	206-44-0	NA	**340**	**640**	**21**	**200**	**1400**
Fluorene	86-73-7	NA	**200**	**290**	**7.1**	**91**	**790**

Table A-3
Pre- and Waste Characterization Analytical Results - PDI Data
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Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Location Name:	CAS no.	EPA 40 CFR 261	PRE CHAR	PRE CHAR	PRE CHAR	PRE CHAR	WASTE
Sample Name:			Pre Char 1	Pre Char 2	Pre Char 3	Pre Char 4 Waste 2	Waste 1
Sample Date:			3/20/2013	3/20/2013	3/18/2013	3/18/2013	3/20/2013
Hexachlorobenzene	118-74-1	NA	5.4 U	12 U	0.19 U	4.4 U	24 U
Hexachlorobutadiene	87-68-3	NA	11 U	25 U	0.4 U	9 U	48 U
Hexachlorocyclopentadiene	77-47-4	NA	54 U	120 U	1.9 U	44 U	240 U
Hexachloroethane	67-72-1	NA	5.4 U	12 U	0.19 U	4.4 U	24 U
Indeno[1,2,3-cd]pyrene	193-39-5	NA	**75**	**150**	**5.5**	**43**	**280**
Isophorone	78-59-1	NA	54 U	120 U	1.9 U	44 U	240 U
2-Methylnaphthalene	91-57-6	NA	**210**	**340**	**2.8**	**60**	**980**
2-Methylphenol (o-Cresol)	95-48-7	NA	**30 J**	**41 J**	1.9 U	44 U	**180 J**
4-Methylphenol (p-Cresol)	106-44-5	NA	**73**	**100 J**	1.9 U	44 U	**470**
Naphthalene	91-20-3	NA	**770**	**1200**	**10**	**230**	**4000**
2-Nitroaniline	88-74-4	NA	110 U	250 U	4 U	90 U	480 U
3-Nitroaniline	99-09-2	NA	110 U	250 U	4 U	90 U	480 U
4-Nitroaniline	100-01-6	NA	110 U	250 U	4 U	90 U	480 U
Nitrobenzene	98-95-3	NA	5.4 U	12 U	0.19 U	4.4 U	24 U
2-Nitrophenol	88-75-5	NA	54 U	120 U	1.9 U	44 U	240 U
4-Nitrophenol	100-02-7	NA	160 U	370 U	5.9 U	130 U	720 U
N-Nitrosodi-n-propylamine	621-64-7	NA	5.4 U	12 U	0.19 U	4.4 U	24 U
N-Nitrosodiphenylamine	86-30-6	NA	54 U	120 U	1.9 U	44 U	240 U
Pentachlorophenol	87-86-5	NA	160 U	370 U	5.9 U	130 U	720 U
Phenanthrene	85-01-8	NA	**670**	**1100**	**27**	**400**	**2500**
Phenol	108-95-2	NA	**45 J**	**69 J**	1.9 U	44 U	**410**
Pyrene	129-00-0	NA	**310**	**500**	**23**	**230**	**1000**
1,2,4,5-Tetrachlorobenzene	95-94-3	NA	54 U	120 U	1.9 U*	44 U*	240 U
2,3,4,6-Tetrachlorophenol	58-90-2	NA	54 U	120 U	1.9 U	44 U	240 U
2,4,5-Trichlorophenol	95-95-4	NA	54 U	120 U	1.9 U	44 U	240 U
2,4,6-Trichlorophenol	88-06-2	NA	54 U	120 U	1.9 U	44 U	240 U
TCLP SVOCs (mg/L)							
2,4-Dinitrotoluene	121-14-2	0.13	NA	NA	NA	0.008 U	0.2 U
Hexachlorobenzene	118-74-1	0.13	NA	NA	NA	0.004 U	0.1 U
Hexachlorobutadiene	87-68-3	0.5	NA	NA	NA	0.008 U	0.2 U
Hexachloroethane	67-72-1	3	NA	NA	NA	0.004 U	0.1 U
2-Methylphenol (o-Cresol)	95-48-7	200	NA	NA	NA	**0.044**	**8.3**
Nitrobenzene	98-95-3	2	NA	NA	NA	0.004 U	0.1 U
Pentachlorophenol	87-86-5	100	NA	NA	NA	0.12 U	3 U
2,4,5-Trichlorophenol	95-95-4	400	NA	NA	NA	0.04 U	1 U
2,4,6-Trichlorophenol	88-06-2	2	NA	NA	NA	0.04 U	1 U
3,4-Methylphenol (m,p-Cresol)	108394/106445	NA	NA	NA	NA	**0.095**	**19**
Pyridine	110-86-1	5	NA	NA	NA	0.04 U	1 U
PCBs (mg/kg)							
Aroclor 1016	12674-11-2	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1221	11104-28-2	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1232	11141-16-5	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1242	53469-21-9	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1248	12672-29-6	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1254	11097-69-1	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1260	11096-82-5	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1262	37324-23-5	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Aroclor 1268	11100-14-4	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
Total PCBs	1336-36-3	NA	0.08 U	0.086 U	0.079 U	0.089 U	0.074 U
TCLP Pesticides (mg/L)							
gamma-BHC	58-89-9	NA	NA	NA	NA	0.0005 U	0.0005 U
Chlordane (Alpha & Gamma)	57-74-9	0.03	NA	NA	NA	0.005 U	0.005 U
Endrin	72-20-8	0.02	NA	NA	NA	0.0005 U	0.0005 U
Heptachlor	76-44-8	0.008	NA	NA	NA	0.0005 U	0.0005 U

Table A-3
Pre- and Waste Characterization Analytical Results - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Unvalidated

Location Name:	CAS no.	EPA 40 CFR 261	PRE CHAR	PRE CHAR	PRE CHAR	PRE CHAR	WASTE
Sample Name:			Pre Char 1	Pre Char 2	Pre Char 3	Pre Char 4 Waste 2	Waste 1
Sample Date:			3/20/2013	3/20/2013	3/18/2013	3/18/2013	3/20/2013
Heptachlor epoxide	1024-57-3	0.008	NA	NA	NA	0.0005 U	0.0005 U
Methoxychlor	72-43-5	10	NA	NA	NA	0.0005 U*	0.0005 U*
Toxaphene	8001-35-2	0.5	NA	NA	NA	0.005 U	0.005 U
TCLP Herbicides (mg/L)							
2,4-D	94-75-7	10	NA	NA	NA	0.017 U	0.017 U
Silvex	93-72-1	1	NA	NA	NA	0.017 U	0.017 U
Metals (mg/kg)							
Antimony	7440-36-0	NA	2.4 U	2.3 U	2.4 U	2.5 U	2.1 U
Aluminum	7429-90-5	NA	**11600**	**9690**	**14000**	**11800**	**9250**
Arsenic	7440-38-2	NA	**9.4**	**15**	**8.3**	**5.9**	**15.2**
Barium	7440-39-3	NA	**116**	**139**	**159**	**100**	**100**
Beryllium	7440-41-7	NA	**0.69**	**0.53**	**0.73**	**0.62**	**0.48**
Cadmium	7440-43-9	NA	1.2 U	1.1 U	1.2 U	1.3 U	1 U
Calcium	7440-70-2	NA	**15400**	**40000**	**15100**	**74800**	**24200**
Chromium	7440-47-3	NA	**15.4**	**20.1**	**17.4**	**17.6**	**13.1**
Chromium (VI)	18540-29-9	NA	NA	NA	NA	2.7 U	2.3 U
Cobalt	7440-48-4	NA	**10.8 J**	**7.2 J**	**10.3 J**	**7.5 J**	**7.5 J**
Copper	7440-50-8	NA	**28**	**142**	**24.3**	**39.3**	**29**
Iron	7439-89-6	NA	**29800**	**21100**	**26700**	**25900**	**20800**
Lead	7439-92-1	NA	**85.2**	**252**	**34.8**	**40.4**	**115**
Magnesium	7439-95-4	NA	**6300**	**5850**	**5780**	**8600**	**7130**
Manganese	7439-96-5	NA	**685**	**480**	**1190**	**709**	**834**
Mercury	7439-97-6	NA	**0.25**	**0.26**	**0.019 J**	**0.95**	**0.18**
Nickel	7440-02-0	NA	**23.1**	**18.2**	**24.6**	**20.3**	**18.1**
Potassium	7440-09-7	NA	**1650**	**1600**	**1420**	**1970**	**1420**
Selenium	7782-49-2	NA	2.4 U	2.3 U	2.4 U	2.5 U	2.1 U
Silver	7440-22-4	NA	2.4 U	2.3 U	2.4 U	2.5 U	2.1 U
Sodium	7440-23-5	NA	**1650**	**329 J**	**270 J**	1260 U	1040 U
Thallium	7440-28-0	NA	2.4 U	2.3 U	2.4 U	2.5 U	2.1 U
Vanadium	7440-62-2	NA	**19.9**	**17.6**	**19.4**	**19.4**	**25.4**
Zinc	7440-66-6	NA	**75.5**	**115**	**72.9**	**73.2**	**77.7**
TCLP Metals (mg/L)							
Arsenic	7440-38-2	5	NA	NA	NA	0.025 U	**0.0894**
Barium	7440-39-3	100	NA	NA	NA	**1.29**	**0.716 J**
Cadmium	7440-43-9	1	NA	NA	NA	0.025 U	0.025 U
Chromium	7440-47-3	5	NA	NA	NA	0.05 U	0.05 U
Lead	7439-92-1	5	NA	NA	NA	0.025 U	**0.055**
Mercury	7439-97-6	0.2	NA	NA	NA	0.0002 U	**0.00026**
Selenium	7782-49-2	1	NA	NA	NA	0.05 U	0.05 U
Silver	7440-22-4	5	NA	NA	NA	0.05 U	0.05 U
Cyanides (mg/kg)							
Total Cyanide	57-12-5	NA	**0.63**	**0.45**	**0.21**	**2.3**	**18.4**
Cyanide Reactivity	REAC-CN	NA	NA	NA	NA	25 U	25 U
Other							
British Thermal Units (btu)	BTU	NA	DNF	DNF	DNF	DNF	**5070**
Corrosivity (pH) (s.u.)	CORROS	NA	NA	NA	NA	**8.29 HF**	**9.21 HF**
Diesel Range Organics (mg/kg)	DRO	NA	**4700**	**800**	**180**	**3400**	**7300**
Extractable Organic Halides (mg/kg)	EOX	NA	NA	NA	NA	66.8 U	55.6 U
Gasoline Range Organics (mg/kg)	GRO	NA	**170**	**820**	**3.5**	**1900 ***	**2000 ***
Ignitibility (mm/sec)	IGNIT	NA	NA	NA	NA	2.2 U	2.2 U
Sulfide Reactivity (mg/kg)	REAC-HS	NA	NA	NA	NA	20 U	20 U

Table A-3
Pre- and Waste Characterization Analytical Results - PDI Data
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

Notes:
Analytes in blue are not detected in any sample
Data for these sampling events have not been validated. Qualifiers are Lab Qualifiers.
mg/kg - milligrams/kilogram or parts per million (ppm)
mg/L - milligrams/liter
btu - British thermal units
S.U. - Standard Units
mm/sec - millimeters per second

BTEX - benzene, toluene, ethylbenzene, and xylenes
TCLP- toxicity characteristics leaching procedure
VOCs - volatile organic compounds
SVOCs - semivolatile organic compounds
PCBs - polychlorinated biphenyls

40 CFR Part 261 - Regulatory Determination on Wastes from the Combustion of Fossil Fuels

NA - not analyzed or not applicable

Bolding indicates a detected concentration
Gray shading and bolding indicates that the detected result value exceeds the EPA 40 CFR 261

Laboratory Qualifiers:
J - estimated value
R - rejected
U - indicates not detected to the reporting limit
* - Duplicate analysis not within control limits
DNF - "Did Not Fire". There was no measurable heat content in the sample. This is equivalent to a result of "Not Detected".
HF - indicate pH was performed in the laboratory outside the 15 minute timeframe.

Appendix B

Remedial Alternative Cost Estimates

Appendix B-1
Preliminary Cost Estimate
Tar Well Excavation
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

GEI Consultants, Inc. (GEI) has prepared this preliminary cost estimate to complete the tar well excavation at the Troy former MGP site. GEI's estimate is based on published RS Means Cost Data, Vendor Costs, and on GEI's project experience. In order to prepare this estimate, GEI made basic assumptions as to actual site conditions that should be encountered; specific decisions and costs by other design professionals to be engaged by the contractor; the means, materials, methods of construction, and schedule the contractor will use/determine; and various other factors (see Assumptions). An actual contractor's bid price to perform this work may vary from this estimate based on variances in the above-mentioned assumptions. This estimate is based on excavating each tar well separately. We estimate that the northern well will require a 221 ft^2 excavation to a depth of 20 ft, the southern well will require a 1,659 ft^2 excavation to a depth of 20 ft, and that groundwater will be encountered.

Remedial Component	Unit	Unit Price	Quantity	Total Cost
DESIGN AND OVERSIGHT				
Consultant Design Fees				
1 Engineering Design, Contract Drawings	Lump Sum	$ 57,100.00	1.00	$ 57,100.00
2 Combined Remedial Action Work Plan and Alternatives Analysis	Lump Sum	$ 33,225.00	1.00	$ 33,225.00
3 Final Engineer Report	Lump Sum	$ 22,200.00	1.00	$ 22,200.00
4 Site Management Plan	Lump Sum	$ 17,200.00	1.00	$ 17,200.00
5 Legal Fees (Deed Restriction/Property Access)	Lump Sum	$ 10,000.00	1.00	$ 10,000.00
			Subtotal	**$ 139,725.00**
			% Total Capital Costs	9%
Construction Management				
1 Office Support/Weekly EOR Site Visits	Week	$ 2,624.00	10.00	$ 26,240.00
2 Various Office Support/Pre/Post Construction Work	Lump Sum	$ 18,590.00	1.00	$ 18,590.00
3 Construction Oversight	Day	$ 1,450.00	50.00	$ 72,500.00
4 CAMP Technician	Day	$ 1,090.00	50.00	$ 54,500.00
5 CAMP Equipment Rental	Lump Sum	$ 16,000.00	1.00	$ 16,000.00
6 Confirmation Sampling (hazardous/non hazardous)	Lump Sum	$ 5,000.00	1.00	$ 5,000.00
7 Vibration Monitoring Equipment	Month	$ 500.00	2.00	$ 1,000.00
			Subtotal	**$ 193,830.00**
			% Total Capital Costs	13%
CONSTRUCTION COMPONENTS				
Site Preparation				
1 Mobilization of Excavation Equipment	Lump Sum	$ 35,000.00	1.00	$ 35,000.00
2 Survey and Layout Work	Lump Sum	$ 10,000.00	1.00	$ 10,000.00
3 Facilities and Site Control	Lump Sum	$ 60,000.00	1.00	$ 60,000.00
4 Demolition	Square Yard	$ 5.90	4161.33	$ 24,551.87
5 Relocate Utility Pole and Overhead Wires	Lump Sum	$ 3,000.00	1.00	$ 3,000.00
Earthwork				
1 Excavation	Cubic Yard	$ 43.26	1393.00	$ 60,266.75
2 Transportation and Disposal - Soil - Thermal Desorption	Ton	$ 82.15	2270.00	$ 186,474.87
3 Transportation and Disposal - Soil - Hazardous	Ton	$ 120.00	97.00	$ 11,640.00
4 Backfill (Burrow, Compaction, and Grading)	Ton	$ 27.80	2368.00	$ 65,823.58
5 Excavation Support - Sheet Pile	Square Foot	$ 35.00	6690.00	$ 234,150.00
Dewatering				
1 Dewatering and Water Treatment System - Equipment	Lump Sum	$ 150,000.00	1.00	$ 150,000.00
2 Dewatering and Water Treatment System - Operation and POTW Discharge	1,000 Gallons	$ 64.43	1200.00	$ 77,317.09
Restoration				
1 Asphalt	Square Yard	$ 13.78	4161.33	$ 57,343.17
			Subtotal	$ 975,567.34
General Conditions				
1 Ancillary cost of work items (e.g. health & safety oversight, bottled water, permit fees, PPE) generally taken as 10% of the subtotal cost of the construction work.	Lump Sum	$ 97,556.73	1.00	$ 97,556.73
			Subtotal with General Conditions	**$ 1,073,124.07**
			% Total Capital Costs	70%
OM&M				
1 Annual Reports *Future Value*	Lump Sum	$ 8,148.00	30.00	$ 244,440.00
Present Value Assuming a 5% Discount Rate Over a 30 Year Period				**$125,254.73**
			% Total Capital Costs	8%
COST SUMMARY				
Total Capital Costs				$ 1,531,933.80
Capital Costs Contingency			20%	$ 306,386.76
			TOTAL COST	**$ 1,838,320.56**
			TOTAL COST (Rounded)	**$ 1,839,000.00**

GEI Consultants

		Project: Troy - Liberty Street	Page:
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Subject:	Consultant Costs	Approved:	By:

Field Oversight Costs and Office Support (before and after construction is completed)

	Labor Rate	Hours	Total for Project
Project Engineer/Geologist/Scientist	$100.00	112	$11,200.00
Engineer/Geologist/Scientist	$70.00	20	$1,400.00
Senior Project Manager	$153.00	30	$4,590.00
Support	$70.00	20	$1,400.00
			$18,590.00

Field Oversight Costs*

Engineering Oversight	**Labor Rate**	**Hours/Day**	**Total Per Day**
Project Engineer/Geologist/Scientist	$100.00	12	$1,200.00
Expenses - Hotel, Miles, and Per Diem			$250.00
			$1,450.00

CAMP Technician	**Labor Rate**	**Hours/Day**	**Total Per Day**
Engineer/Geologist/Scientist	$70.00	12	$840.00
Expenses - Hotel, Miles, and Per Diem			$250.00
			$1,090.00

Office Support	**Labor Rate**	**Hours/Week**	**Total Per Week**
Senior Project Manager	$153.00	12	$1,836.00
Project Manager	$115.00	2	$230.00
Staff Engineer/Geologist/Scientist	$77.00	4	$308.00
Expenses - Hotel, Miles, and Per Diem (assuming 1 site visit per week)			$250.00
			$2,624.00

CAMP Equipment Rental**	**Rental Rate**	**Period**	**#**	**Cost**
US Environmental	$8,000	1 month	2	$16,000
3 setups, backup				
				$16,000

* Based on a 10 hour day.

** Based on recent GEI price quotes received from AirLogics

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Page:
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By: C. Pray
Client: National Grid
Checked:
By:
Subject: Annual Report Costs
Approved:
By:

Annual Report Costs

Field Engineer*	**Labor Rate**	**Hours/Day**	**Total Per Event**
Staff Engineer/Geologist/Scientist	$105.00	20	$2,100.00
Analytical Costs	**Per Sample**	**# Wells**	**Total Per Event**
Sample analysis	$400.00	6	$2,400.00
Data Preparation	**Labor Rate**	**Hours**	**Total Per Event**
Data validation	$85.00	6	$510.00
Data management	$69.00	2	$138.00
			$648.00
Annual report	**Lump Sum**	**Quantity**	**Total Per Event**
Generating and distributing	$3,000.00	1	$3,000.00

Total Cost Per Event
$8,148.00

* Based on two 10 hour days to sample the wells.

Appendix B-1
Preliminary Cost Estimate
Tar Well Excavation
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

GEI Consultants, Inc. (GEI) has prepared this preliminary cost estimate to complete the tar well excavation at the Troy former MGP site. GEI's estimate is based on published RS Means Cost Data, Vendor Costs, and on GEI's project experience. In order to prepare this estimate, GEI made basic assumptions as to actual site conditions that should be encountered; specific decisions and costs by other design professionals to be engaged by the contractor; the means, materials, methods of construction, and schedule the contractor will use/determine; and various other factors (see Assumptions). An actual contractor's bid price to perform this work may vary from this estimate based on variances in the above-mentioned assumptions. This estimate is based on excavating each tar well separately. We estimate that the northern well will require a 221 ft^2 excavation to a depth of 20 ft, the southern well will require a 1,659 ft^2 excavation to a depth of 20 ft, and that groundwater will be encountered.

Assumptions

GENERAL

Unit cost data from RS Means 2012, estimated prices consider location and standard union labor rates. RS Means data has been supplemented with GEI previous project experience and bids received for similar work in surrounding areas.

CONSULTANT DESIGN AND OVERSIGHT COSTS

GEI unit rates from the National Grid rate schedule were used as typical costs for design, report preparation and oversight costs.
These rates are intended to reflect industry rates and not those of a specific consultant.

CAMP Equipment Rental - Cost estimated from subcontractor quote.
Costs include AirLogics Light CAMP stations. Costs assumes 4 stations.

Confirmation Sampling - Cost based on current lab pricing.
Assumes one sample per location (total of 4) per week for 10 weeks plus 4 QA/QC samples.

SITE PREPARATION

Mobilization - Cost based on GEI previous project experience.

Survey and Site Layout Work - Cost based on GEI previous project experience.

Facilities and Site Control - Cost based on GEI previous project experience.

Pump/Empty Tar Wells - Assumes a total of 2,000 gallons of tar will be removed from both wells, and that any recovered product can be disposed off at an off-site liquid waste disposal facility as non-hazardous waste.

Demolition - Unit rate based on RS Means.

EARTHWORK

Excavation - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation.

Transportation and Disposal - Soil - Thermal Desorption - Costs based on recent contractor pricing for 2011; increased by 4% for each year due to inflation.
Assuming 1.7 tons per cubic yard of soil

Transportation and Disposal - Soil - Hazardous - Cost based on recent contractor pricing.
Assuming ~35% of the Northern Tar well excavation will have to be disposed of as hazardous material based on pre-char performed during PDI.
Assuming 1.7 tons per cubic yard of soil

Backfill - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation.
Assuming 1.7 tons per cubic yard of soil

Excavation Support -Sheet Pile - Cost basis obtained from contractor bids submitted for similar work. Assumes excavation will be as prescribed above, square footage increased by 50% to account for embedment.

DEWATERING

Dewatering and Water Treatment System - Equipment - Cost based on GEI previous project experience.

Dewatering and Water Treatment System - Operation and POTW Discharge - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation, and assume 24,000 gallons of water per day of operation.

RESTORATION

Asphalt - Unit rate based on RS Means.

GENERAL CONDITIONS

Assumes 10% of total cost of construction.

OPERATIONS MAINTENANCE AND MONITORING

Annual Report - Assuming 1 sampling, analysis, and report per year with the annual inspection and certification consisting of verifying the existence of the pavement only.

GEI Consultants

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Northern Tar Well

Well Diameter	10	FT		
Excavation Area	221	SF		
Excavation Perimeter	61	FT		
Excavation Depth	20	FT		
Excavation Volume	4420	CF	163.7	CY
Sheet Pile	1830	SF		
Depth to Water	15	FT BGS		

Southern Tar Well

Well Diameter	12	FT		
Excavation Perimeter	162	SF		
Excavation Area	1659	SF		
Excavation Depth	20	FT		
Excavation Volume	33180	CF	1228.9	CY
Sheet Pile	4860	SF		
Depth to Water	15	FT BGS		

Total Volume of Excavated Soil	1392.6	CY
Total Weight of Excavated Soil	2367.4	TON
Total Volume of Excavated Soil (Haz)	57	CY
Total Weight of Excavated Soil (Haz)	97	TON
Total Volume of Excavated Soil (Non-Haz)	1335	CY
Total Weight of Excavated Soil (Non-Haz)	2270	TON
Total Sheet Pile Square Footage	6690	SF

Appendix B-2
Preliminary Cost Estimate
Tar Well Excavation
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

GEI Consultants, Inc. (GEI) has prepared this preliminary cost estimate to complete the tar well excavation at the Troy former MGP site. GEI's estimate is based on published RS Means Cost Data, Vendor Costs, and on GEI's project experience. In order to prepare this estimate, GEI made basic assumptions as to actual site conditions that should be encountered; specific decisions and costs by other design professionals to be engaged by the contractor; the means, materials, methods of construction, and schedule the contractor will use/determine; and various other factors (see Assumptions). An actual contractor's bid price to perform this work may vary from this estimate based on variances in the above-mentioned assumptions. The estimate is based on removing all soils that exceed the Unrestricted Use SCO. This estimate is based on excavating each area separately.

Remedial Component	Unit	Unit Price	Quantity	Total Cost
DESIGN AND OVERSIGHT				
Consultant Design Fees				
1 Engineering Design, Contract Drawings	Lump Sum	$ 150,000.00	1.00	$ 150,000.00
2 Combined Remedial Action Work Plan and Alternatives Analysis	Lump Sum	$ 33,225.00	1.00	$ 33,225.00
3 Final Engineer Report	Lump Sum	$ 27,000.00	1.00	$ 27,000.00
4 Site Management Plan	Lump Sum	$ 21,000.00	1.00	$ 21,000.00
5 Legal Fees (Deed Restriction/Property Access)	Lump Sum	$ 10,000.00	1.00	$ 10,000.00
Subtotal				**$ 241,225.00**
% Total Capital Costs				2%
Construction Management				
1 Office Support/Weekly EOR Site Visits	Week	$ 3,848.00	123.00	$ 473,304.00
2 Various Office Support/Pre/Post Construction Work	Lump Sum	$ 18,920.00	1.00	$ 18,920.00
3 Construction Oversight	Day	$ 1,450.00	612.00	$ 887,400.00
4 CAMP Technician	Day	$ 1,090.00	612.00	$ 667,080.00
5 CAMP Equipment Rental	Lump Sum	$ 31,000.00	1.00	$ 31,000.00
6 Confirmation Sampling	Each	$ 320.00	588.00	$ 188,160.00
Subtotal				**$ 2,265,864.00**
% Total Capital Costs				19%
CONSTRUCTION COMPONENTS				
Site Preparation				
1 Mobilization of Excavation Equipment	Lump Sum	$ 500,000.00	1.00	$ 500,000.00
2 Survey and Layout Work	Lump Sum	$ 150,000.00	1.00	$ 150,000.00
3 Facilities and Site Control	Lump Sum	$ 1,000,000.00	1.00	$ 1,000,000.00
4 Demolition	Square Yard	$ 5.90	4275.67	$ 25,226.43
Earthwork				
1 Excavation	Cubic Yard	$ 43.26	17987.00	$ 778,189.57
2 Transportation and Disposal - Soil - Thermal Desorption	Ton	$ 82.15	30579.00	$ 2,511,989.01
3 Transportation and Disposal - Soil - Hazardous	Ton	$ 120.00	66.00	$ 7,920.00
4 Backfill (Burrow, Compaction, and Grading)	Ton	$ 27.80	30579.00	$ 850,008.13
5 Excavation Support - Sheet Pile	Square Foot	$ 35.00	47693.00	$ 1,669,255.00
Dewatering				
1 Dewatering and Water Treatment System - Equipment	Lump Sum	$ 150,000.00	1.00	$ 150,000.00
2 Dewatering and Water Treatment System - Operation and POTW Discharge	1,000 Gallons	$ 64.43	14688.00	$ 946,361.24
Restoration				
1 Asphalt	Square Yard	$ 13.78	4275.67	$ 58,918.69
Subtotal				$ 8,647,868.07
General Conditions				
1 Ancillary cost of work items (e.g. health & safety oversight, bottled water, permit fees, PPE) generally taken as 10% of the subtotal cost of the construction work.	Lump Sum	$ 864,786.81	1.00	$ 864,786.81
Subtotal with General Conditions				**$ 9,512,654.88**
% Total Capital Costs				78%
OM&M				
1 Annual Reports *Future Value*	Lump Sum	$ 8,148.00	30.00	$ 244,440.00
Present Value Assuming a 5% Discount Rate Over a 30 Year Period				**$125,254.73**
% Total Capital Costs				1%
COST SUMMARY				
Total Capital Costs				$ 12,144,998.61
Capital Costs Contingency			20%	$ 2,428,999.72
TOTAL COST				**$ 14,573,998.33**
TOTAL COST (Rounded)				**$ 14,574,000.00**

GEI Consultants

Appendix B-2
Preliminary Cost Estimate
Tar Well Excavation
Troy (Liberty Street) Non-Owned Former MGP Site
Troy, New York

GEI Consultants, Inc. (GEI) has prepared this preliminary cost estimate to complete the tar well excavation at the Troy former MGP site. GEI's estimate is based on published RS Means Cost Data, Vendor Costs, and on GEI's project experience. In order to prepare this estimate, GEI made basic assumptions as to actual site conditions that should be encountered; specific decisions and costs by other design professionals to be engaged by the contractor; the means, materials, methods of construction, and schedule the contractor will use/determine; and various other factors (see Assumptions). An actual contractor's bid price to perform this work may vary from this estimate based on variances in the above-mentioned assumptions. The estimate is based on removing all soils that exceed the Unrestricted Use SCO. This estimate is based on excavating each area separately.

Assumptions

GENERAL

Unit cost data from RS Means 2012, estimated prices consider location and standard union labor rates. RS Means data has been supplemented with GEI previous project experience and bids received for similar work in surrounding areas.

CONSULTANT DESIGN AND OVERSIGHT COSTS

GEI unit rates from the National Grid rate schedule were used as typical costs for design, report preparation and oversight costs.
These rates are intended to reflect industry rates and not those of a specific consultant.

CAMP Equipment Rental - Cost estimated from subcontractor quote.
Costs include AirLogics Light CAMP stations. Costs assumes 4 stations.

Confirmation Sampling - Cost based on current lab pricing.
Assumes one sample per location (total of 4) per week for 9 weeks plus 4 QA/QC samples.

SITE PREPARATION

Mobilization - Cost based on GEI previous project experience.

Survey and Site Layout Work - Cost based on GEI previous project experience.

Facilities and Site Control - Cost based on GEI previous project experience.

Pump/Empty Tar Wells - Assumes a total of 2,000 gallons of tar will be removed from both wells, and that any recovered product can be disposed off at an off-site liquid waste disposal facility as non-hazardous waste.

Demolition - Unit rate based on RS Means.

EARTHWORK

Excavation - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation.

Transportation and Disposal - Soil - Thermal Desorption - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation.
Assuming 1.7 tons per cubic yard of soil.

Transportation and Disposal - Soil - Hazardous - Cost based on recent contractor pricing.
Assuming ~35% of the Northern Tar well excavation will have to be disposed of as hazardous material based on pre-char performed during PDI.
Assuming 1.7 tons per cubic yard of soil.

Backfill - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation.
Assuming 1.7 tons per cubic yard of soil

Excavation Support -Sheet Pile - Cost basis obtained from contractor bids submitted for similar work. Assumes excavation will be as prescribed above, square footage increased by 50% to account for embedment.

DEWATERING

Dewatering and Water Treatment System - Equipment - Cost based on GEI previous project experience.

Dewatering and Water Treatment System - Operation and POTW Discharge - Cost based on recent contractor pricing for 2011; increased by 4% for each year due to inflation, and assume 24,000 gallons of water per day of operation.

RESTORATION

Asphalt - Unit rate based on RS Means.

GENERAL CONDITIONS

Assumes 10% of total cost of construction.

OPERATIONS MAINTENANCE AND MONITORING

Annual Report - Assuming 1 sampling, analysis, and report per year with the annual inspection and certification consisting of verifying the existence of the pavement only.

GEI Consultants

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By: A. Royko
Client: National Grid
Checked:
By:
Subject: Volumes
Approved:
By:

Area A - Holders and Northern Tar Well

Excavation Perimeter	527	FT		
Excavation Area	14394	FT		
Excavation Depth	20	FT		
Excavation Volume	287880	CF	10662	CY
Sheet Pile	15810	SF		
Depth to Water	15	FT BGS		

Area B - Condenser Area

Excavation Perimeter	400	FT		
Excavation Area	6441	FT		
Excavation Depth	10	FT		
Excavation Volume	64410	CF	2385.6	CY
Sheet Pile	6000	SF		
Depth to Water	15	FT BGS		

Area C - Southern Tar Well and Bocce Courts

Excavation Perimeter	162	FT		
Excavation Area	1659	FT		
Excavation Depth	25	FT		
Excavation Volume	41475	CF	1536.1	CY
Sheet Pile	6075	SF		
Depth to Water	15	FT BGS		

Area D - Hill Street Excavation

Excavation Perimeter	146	FT		
Excavation Area	1029	FT		
Excavation Depth	30	FT		
Excavation Volume	30870	CF	1143.3	CY
Sheet Pile	6570	SF		
Depth to Water	15	FT BGS		

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Area E - Northern Spot Excavation

Excavation Perimeter	155	FT		
Excavation Area	1495	FT		
Excavation Depth	12	FT		
Excavation Volume	17940	CF	664.44	CY
Sheet Pile	2790	SF		
Depth to Water	15	FT BGS		

Area F - Deep Excavation between Holders

Excavation Perimeter	199	FT		
Excavation Area	1231	FT		
Excavation Depth	35	FT		
Excavation Volume	43085	CF	1595.7	CY
Sheet Pile	10448	SF		
Depth to Water	15	FT BGS		

Total Volume of Excavated Soil	17987	CY
Total Weight of Excavated Soil	30579	TON
Total Sheet Pile Square Footage	47693	SF

ALTERNATIVES ANALYSIS/REMEDIAL ACTION WORK PLAN
TROY (LIBERTY STREET) NON-OWNED
FORMER MGP SITE
TROY, NEW YORK
AUGUST 2013

Appendix C

Health and Safety Plan (electronic only)

Geotechnical
Environmental and
Water Resources
Engineering

Health and Safety Plan

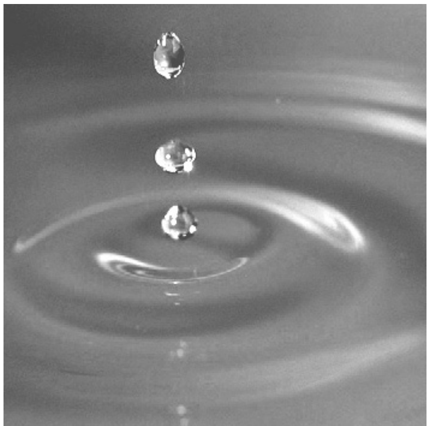
Alternatives Analysis/Remedial Action Work Plan
Troy (Liberty Street) Non-Owned
Former MGP Site
Rensselaer County
Troy, New York

Submitted To:
National Grid Company
300 Erie Boulevard West
Syracuse, New York 13202

Submitted By:
GEI Consultants, Inc., PC
455 Winding Brook Drive
Glastonbury, CT 06033
860-368-5300

June 2013
Project # 093300-2-1201

Jerry Zak
Project Manager



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Figures

Appendices

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Abbreviations and Acronyms

ACGIH	American Conference of Governmental Industrial Hygienists
BTEX	Benzene, Toluene, Ethylbenzene, Total Xylenes
CAMP	Community Air Monitoring Plan
CHSO	Corporate Health and Safety Officer
CMS	Chip Measurement System
CNS	Central Nervous System
CRZ	Contamination Reduction Zone
DOT	Department of Transportation
EZ	Exclusion Zone
FID	Flame Ionization Detector
GEI	GEI Consultants, Inc.
HASP	Health and Safety Plan
LEL	Lower Explosive Limit
MGP	Manufactured Gas Plant
MSDS	Material Safety Data Sheet
MSL	
NAPL	Non-aqueous Phase Liquid
NYSDEC	New York State Department of Environmental Conservation
OSHA	Occupational Health and Safety Administration
PAHs	Polycyclic Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PDI	Pre-Design Investigation
PEL	Permissible Exposure Level
PID	Photoionization Detector
PM	Project Manager
PPE	Personal Protective Equipment
SSO	Site Safety Officer
SVOC	Semivolatile Organic Compound
SZ	Support Zone
VOC	Volatile Organic Compound
WNV	West Nile Virus

1. Background Information

1.1 Purpose

Environmental Consultant	GEI Consultants, Inc., PC 455 Winding Brook Drive Glastonbury, CT 06033 860-368-5300
Project Name	Troy (Liberty Street) Non-Owned Former Manufactured Gas Plant (MGP) Site Rensselaer County Troy, New York

This Health and Safety Plan (HASP) establishes policies and procedures to protect GEI personnel from the potential hazards posed by Pre-Design Investigation (PDI) activities at the Troy (Liberty Street) Non-Owned Former Manufactured Gas Plant (MGP) site (the Site). Reading of this HASP is required of all on-site GEI Consultants, Inc. (GEI) personnel and GEI subcontractors. The plan identifies measures to minimize accidents and injuries, which may result from project activities or adverse weather conditions.

1.2 Project Description

GEI will supervise/conduct/direct the following general tasks:

- Site survey.
- Utility mark-outs.
- Excavation and backfill activities.
- Dewatering.
- Restoration activities.
- Confirmation sampling, if required.
- Soil borings, if required.
- Subsurface soil sampling, if required.
- Monitoring well and piezometer installation, if required.
- Monitoring well and piezometer decommissioning, if required.
- Well development, if required.
- Groundwater sampling, if required.

Field activities are expected to require ten weeks to complete. Site-specific procedures are provided in this stand-alone HASP and are in accordance with the National Grid corporate requirements for MGP sites.

1.3 Site Description

The Site location is presented in Figure 1. Historic features and previous sampling locations are presented in Figure 2 along with the proposed excavations. The Site consists of three separate parcels owned by the City of Troy. For the purposes of this HASP, the word “Site” refers to all three parcels.

The Site primarily consists of paved and unoccupied land in an urban residential/light commercial setting. It is bordered on all sides by city streets: Liberty Street on the north, 5th Avenue on the east, Washington Street on the south, and Hill Street on the west.

The Site is flat or nearly so. The elevation is approximately 35 feet above mean sea level (MSL). It is used for a farmer’s market during the summer. Two bocce courts are present in the southern portion of the Site. The courts are used and maintained by a local community group, the Little Italy Association.

The gas works on Liberty Street in Troy were constructed in 1848 by the Troy Gas Light Company, south of the city center. The gas plant consisted of coal storage sheds, a retort house, a purification house, a condenser room, offices, and two subsurface gas holders approximately 55 feet in diameter, with aboveground iron guide frames. In 1874, a gas holder was built by the Troy Gas Light Company three blocks south, on Jefferson Street. Gas from Liberty Street was likely sent to that holder for storage. The boiler room with attendant exhauster at Liberty Street was likely used to push the gas to Jefferson Street.

The configuration of the Liberty Street plant apparently did not change between 1848 and 1889, when it was shut down. The Liberty Street plant was replaced by a newer gas works on Smith Avenue in Troy in the late 1880s, concurrent with the merger of Troy Gas Light with two other gas companies (Troy Citizen’s Gas Company and Troy Fuel Gas Company) to form the Troy Gas Company.

After the Liberty Street gas plant operation ceased, within 10 years it was demolished and the City of Troy took possession of it in July 1899, using the property as an open-air market. This use continues today.

2. Statement of Safety and Health Policy

GEI is committed to providing a safe and healthy work environment for its employees. To do so, GEI has established an organizational structure and a Corporate Health and Safety Program to promote the following objectives:

- Reduce the risk of injury, illness, and loss of life to GEI employees.
- Maintain compliance with federal, state, and other applicable safety regulations; and minimize GEI employees’ work exposure to potential physical, chemical, biological, and radiological hazards.

3. Hazard/Risk Analysis

The Site is open and paved, in an urban residential/light commercial setting. It is easily accessible to trespassers. As such, several general Site safety measures will be implemented and adhered to as follow:

- GEI subcontractors will not be allowed to perform any work at the Site without GEI oversight.
- Excavations will not be left open overnight unless there is a full-time watchman at the Site. If excavations are left open and a watchman is required, excavations will also be cordoned off with caution tape and cones. If test pits are left open, but no watchman is available, excavations will be covered with heavy steel road plates.
- Temporary fencing will be positioned around the decontamination pad, waste storage, and equipment storage areas. Steel drums, roll-off containers, and polyethylene tanks will be stored in this area.

Physical hazards associated with heavy equipment and excavation operations are present. The heavy equipment associated with this project will include excavation and material removal equipment such as an excavator, backhoe, pile driving equipment, large trucks, and drill rig. Some of the hazards associated with this equipment include crushing of limbs, slipping, tripping, or falling, and heavy lifting. A portable or walk-behind saw may be used to saw-cut the asphalt. Hazards associated with operating the saw include dust, lacerations and broken bones.

Utility clearance in the vicinity of the excavations will be performed in accordance with the Contract Documents. Utility clearance activities include, but are not limited to: a public utility mark-out performed by Dig Safely New York (East Syracuse, New York) prior to the remediation and a private utility mark-out performed on site. Pre-excavation at the perimeter of the excavation to identity utilities that cross into the excavation may be necessary. If borings are performed, each soil boring location will be cleared to a 5-foot depth using a hand-auger or soil knife and vacuum truck before drilling begins.

All personnel with associated business at the Site are required to comply with this HASP.

Smoking is prohibited at or in the vicinity of hazardous operations or materials.

The hazards for this operation are listed in the following Activity Hazard Analysis and Site Hazards sections.

3.1 Personal Safety

Field activities have the potential to take site workers into areas which may pose a risk to personal safety. The following websites (sources) were researched on April 7, 2011 to identify potential crime activity in the area of the project:

- www.crimereports.com
- www.cityrating.com/crimestatistics.asp
- www.crimemapping.com

Recent crime has not been reported in the area. The results of the crime search are located in Appendix A. The crime mapping website does not currently track crime in New York State.

To protect yourself, take the following precautions:

- Use the buddy system (teams of a minimum of two persons present)
- Let the Site Safety Officer (SSO) know when you begin work in these areas and when you leave
- Call in regularly
- Pay attention to what is going on around you
- If you arrive in an area and it does not look safe to get out of your vehicle, lock the doors and drive off quickly but safely

Site workers must not knowingly enter into a situation where there is the potential for physical and violent behaviors to occur. If site workers encounter hostile individuals or a confrontation develops in the work area, suspend work activities, immediately leave the area of concern, and contact local 911 for assistance. Notify the SSO and Corporate Health and Safety Officer (CHSO) of any incidents once you are out of potential danger.

In the event of an emergency, prompt communications with local emergency responders is essential. At least one charged and otherwise functioning cell phone to facilitate emergency communications will be on site. Confirmation of cellular phone operation and site worker safety will be confirmed at the start, mid-point, and near the end of each working day.

3.2 Activity Hazard Analysis

The potential hazards for this project have been categorized into site and activity hazards. Site hazards are those hazards associated with site conditions, and activity hazards are associated with GEI on-site activities. The potential hazards and control measures established to reduce the risk of injury or illness are identified in the following tables. Safe operating procedures established for routine hazards and common site conditions are included in the table below.

3.2.1 Activity Hazard Analysis Table

SITE HAZARDS	
Potential Hazard	**Control Measures**
Construction Safety	▪ Identify yourself and your work location to heavy equipment operators, so they may incorporate you into their operations. Coordinate hand signals with operators. ▪ Stay Alert! Pay attention to equipment backup alarms and swing radii. ▪ Wear a high visibility vest when working near equipment or motor vehicle traffic. ▪ Position yourself in a safe location when filling out logs and talking with the contractor. ▪ Notify the contractor immediately if any problems arise. ▪ Do not stand or sit under suspended loads or near any pressurized equipment lines. ▪ Use equipment only for work it is designed to accomplish.
Physical Injury	▪ Wear steel-toed work boots in good condition with non-slip soles. ▪ Maintain good visibility of the work area. ▪ Avoid walking on uneven or debris ridden ground surfaces. ▪ Do not wear loose fitting clothing when operating equipment.
Noise	▪ Wear hearing protection when near loud noises. ▪ Wear hearing protection whenever you need to raise your voice above normal conversational speech due to a loud noise source; this much noise indicates the need for protection.
Heat Stress	▪ Increase water intake while working. ▪ Increase number of rest breaks and/or rotate workers in shorter work shifts. Rest in cool, dry areas. ▪ Watch for signs and symptoms of heat exhaustion and fatigue. ▪ In the event of heat stroke, bring the victim to a cool environment, call for help, and initiate first aid procedures. ▪ See Heat Stress Guidelines in Appendix D.
Vehicular Traffic	▪ Wear traffic safety vest at all times. ▪ Use cones, flags, barricades, and caution tape to define work area. ▪ Use a "spotter" to locate oncoming vehicles. ▪ Use vehicle to block work area. ▪ Engage police detail if needed.

SITE HAZARDS	
Potential Hazard	**Control Measures**
Utilities	▪ Check that underground utilities have been clearly identified before any intrusive activities, and that professional utility locating services, property owner(s), or utility companies have provided these mark-outs. ▪ Utilities are to be considered live or active until documented otherwise. ▪ For overhead utilities within 50 feet, determine with the utility company the appropriate safe distance. Minimum distance for clearance is based on voltage of the line. ▪ An observer will be established when operating drilling rigs, excavators, or backhoes near overhead utilities.

ACTIVITY HAZARDS		
Activity	**Potential Hazards**	**Protective Equipment**
Entering Construction Site	Heavy equipment, dust, noise.	Work clothing, hardhat, orange safety vest, steel-toed, steel-shank boots, safety glasses, latex/neoprene gloves, and earplugs (or ear muffs).
Excavation, Saw-cutting, Drilling, Asphalt Resurfacing	Heavy equipment, dust, noise.	In addition to the Personal Protective Equipment (PPE) listed above for "Entering Construction Site:" work gloves and face shield (as necessary).
PPE is the *initial level of protection* based on the activity hazards and site conditions which have been identified. *Upgrades to respiratory protection may be required based on the designated action levels.* General on site provisions shall include: extra nitrile, leather, and/or Kevlar gloves, extra protective coveralls (e.g. Tyvek®) with boot covers, drinking water and electrolyte fluids, reflective vest, first aid kit, hearing protection and washing facilities.		

If Site conditions suggest the existence of a situation more hazardous than anticipated, the site personnel shall evacuate the immediate area. The hazard, the level of precautions, and the PPE shall then be reevaluated with the assistance and approval of the GEI CHSO (Robin DeHate) and the Project Manager.

3.2.2 Handling Drums and Containers

Regulations for handling drums and containers are specified by Occupational Health and Safety Administration (OSHA) 29 CFR 1910.120(j). Potential hazards associated with handling drums include vapor generation, fire, explosions, and possible physical injury. Handling of drums/containers during the site investigation and remediation activities may be necessary. If drum/container handling is necessary, it will be performed in accordance with all applicable regulations. Steel drums will be stored within temporary fencing until they can be properly removed and disposed of. Steel drums will be clearly marked to indicate source of material (test pit or boring location), the generator (National Grid), and nature of the contents (hazardous or non-hazardous, based on field scientist observations, until analytical test results are known).

3.2.3 Electrical Hazards

Electrical hazards are serious physical hazards that can be encountered when working near electrical lines. Measures to mitigate exposure to overhead and subsurface electrical transmission and distribution lines should be considered as follow:

- Contact Dig Safely New York for identify and mark out of underground public utilities along all streets surrounding the Site.
- Mark out of underground transmission/distribution lines on site by private survey/mark out personnel.
- Use hand digging tools or a vacuum truck with an air knife to clear the top 5 feet of soils prior to drilling.
- If necessary, perform a pre-excavation at the perimeter of the excavation to identity utilities that cross into the excavation.
- Maintain a minimum clearance of 16 feet from bus bars, transformer/capacitor electrodes and overhead transmission/distribution lines.
- Maintain a minimum offset of 3 feet from marked underground transmission/distribution lines.
- Be cognizant of the weather. Stop work immediately and vacate the work area in the event lightning is observed or thunder is heard. Work can resume only after 30 minutes have passed since last thunderclap.

3.2.4 Precautions for Working in Confined Spaces

The work plan for remedial investigation does not propose any type of confined space entry. However, if any work in confined spaces is required, it will be performed in accordance with 29 CFR 1910.146 (effective April 15, 1993), as applicable. Confined space work will not be performed without first notifying and receiving approval from the GEI CHSO, or without a confined space entry permit.

3.3 Evaluation of Potential Chemical Hazards

The characteristics of compounds at the Site are discussed below for information purposes. Adherence to the safety and health guidelines in this HASP should reduce the potential for exposure to the compounds discussed below.

3.3.1 Volatile Organic Compounds (VOCs)

VOCs, such as benzene, toluene, ethyl benzene, and xylene (BTEX) are present as soil and groundwater contaminants and in some cases chemical components in non-aqueous phase liquids (NAPL) such as oil or tar within soils and abandoned pipelines. These compounds generally have a depressant effect on the central nervous system (CNS), may cause chronic liver and kidney damage, and some are suspected human carcinogens. Benzene is a known human carcinogen. Acute exposure may include headache, dizziness, nausea, and skin and eye irritation. The primary route of exposure to VOCs is through inhalation and, therefore, respiratory protection is the primary control against exposure to VOCs.

3.3.2 Coal Tar and Coal Tar Products

Coal tar products typically contain semivolatile organic compounds (SVOCs). SVOCs consist of a mixture of acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(k)fluorethene, benz(a)pyrene, benzo(e)pyrene, benzo(g,h,i)peryline, chrysene, dibenz(a,h)anthracene, fluoranthene, fluorene, indeno(1,2,3cd)pyrene, 2-methyl naphthalene, naphthalene, phenanthrene, phenols, and pyrene.

Coal tar products, petroleum products, and other SVOCs are present or potentially present at the Site within impacted soil and groundwater and as NAPL. Petroleum products may also be present in the soil and groundwater.

Coal tar products such as those listed above may cause contact dermatitis. Direct contact can be irritating to the skin and produce itching, burning, swelling and redness. Direct contact or exposure to the vapors may be irritating to the eyes. Conjunctivitis may result from prolonged exposure. If ingested, coal tar is considered to be toxic.

Naphthalene is an eye and skin irritant and can cause nausea, headache, fever, anemia, liver damage, vomiting, convulsions and coma. Poisoning may occur by ingestion of large doses, inhalation or skin absorption.

Exposure to high levels of SVOCs may increase the risk of cancer including lung, kidney and skin cancer. However, high levels of exposure to these compounds are not anticipated during work activities conducted at the Site.
The major route of exposure for SVOCs during work activities is through direct contact. Exposure is most likely to occur when handling soil samples. Exposure through direct contact is possible and will be minimized through the use of appropriate PPE. Inhalation of SVOCs may occur when the soil is disturbed causing respirable and nuisance dust particles to become airborne or through the volatilization of naphthalene. Air monitoring will be conducted during intrusive field work at upwind and downwind perimeters and in the work zone. If levels of VOCs or dust exceed a safe level, as established in the Community Air Monitoring Plan (CAMP) section of the New York State Department of Environmental Conservation (NYSDEC) and New York State Department of Health (NYSDOH)-approved work plan, work will halt and engineering controls will be applied to reduce VOC and/or dust concentrations to an acceptable level. If an acceptable level cannot be maintained, soil disturbing activities will be halted until conditions can be managed to an acceptable level.

3.3.3 Heavy Metals

Samples collected from previous investigation have not contained elevated levels of metals. However, former MGP sites may contain elevated levels of metals including arsenic, chromium, lead, mercury, and selenium.

Exposure to arsenic can cause dermatitis, gastrointestinal disturbances, peripheral neuropathy, respiratory irritation, and hyperpigmentation of skin. Chronic exposure to arsenic has resulted in lung cancer in humans.

Exposure to lead may cause acute symptoms such as eye irritation, weakness, weight loss, abdominal pain, and anemia. Chronic exposure to lead may result in kidney disease, effects to the reproductive system, blood forming organs, and the CNS.

Both lead and arsenic are regulated by specific OSHA standards. They are 29 CFR 1910.1025/1926.52 and 29 CFR 1910.1018/1926.1118, respectively. These standards include specific requirements for air monitoring, signs and labels, training and medical surveillance.

Exposure to chromium can cause acute symptoms such as irritation of the eyes, nose and throat as well as wheezing and coughing. Chronic effects include nosebleeds, nasal congestion, dermatitis, and loss of sight.

Exposure to mercury can cause dizziness, salivation, nausea, vomiting, diarrhea, constipation, emotional disturbance, and kidney injury. Chronic exposure to mercury can cause CNS damage.

Exposure to selenium can cause mucous membrane irritation, coughing, sneezing, shortness of breath, chills, headaches, hypotension, and CNS depression. Chronic exposure to selenium could cause bronchial irritation, gastrointestinal distress, excessive fatigue, and skin discoloration.

As with SVOCs, the primary route of exposure is through inhalation of dust particles when soil is disturbed and becomes airborne.

3.3.4 Asbestos-Containing Materials (ACMs)

The Site is not known to have asbestos-containing materials (ACMs) in the form of historic demolition debris that may exist in fill. However, ACM is potentially present. Chronic exposure to asbestos may cause asbestosis and mesothelioma. The primary route of exposure for asbestos is inhalation during the disturbance and/or removal of asbestos from the pipe insulation and cement pipes.

Asbestos is strictly regulated under OSHA 29 CFR 1910.1001/1926.1101. Employees that may be potentially exposed to ACMs must participate in a medical surveillance program, have specific training in the hazards and controls of exposure to asbestos and wear respirators with high efficiency particulate (HEPA) filters. All work must be conducted in demarcated regulated areas to minimize the amount of people within the exposure area. Employers must conduct air sampling and provide signs and labels regarding the presence of asbestos.

3.3.5 Polychlorinated Biphenyls

Polychlorinated Biphenyls (PCBs) have previously been encountered during MGP site investigations at other sites. Analysis of soils from the Site did not indicate elevated PCB concentrations. However, standard PPE (gloves and face shields) are typically protective.

3.3.6 Cyanide

Cyanide compounds are common by-products of manufactured gas production. Hydrogen cyanide is toxic because it is a chemical asphyxiant. It replaces the oxygen in the blood and, thereby, suffocates the cells. Ferrocyanides are not considered toxic because the hydrogen cyanide ion is bound tightly to the iron and cannot, therefore, replace the oxygen. It takes a great amount of heat and/or acid to release cyanide gas from the ferrocyanide molecule, therefore, hydrogen cyanide is not a concern at this site. However, it is National Grid policy to monitor for hydrogen cyanide during earth-disturbing activities at sites where MGP-related contaminants have been found. As such, a gas meter will be used during intrusive work to monitor for hydrogen cyanide.

3.3.7 Hydrogen Sulfide

Hydrogen sulfide is another common by-product of manufactured gas production. Exposure to lower concentrations can result in eye irritation, a sore throat and cough, shortness of breath, and fluid in the lungs. These symptoms usually go away in a few weeks. Long-term, low-level exposure may result in fatigue, loss of appetite, headaches, irritability, poor memory, and dizziness. Breathing very high levels (>800 parts per million [ppm]) of hydrogen sulfide can cause death within just a few breaths. The primary route of exposure is through inhalation and, therefore, respiratory protection is the primary control against exposure to hydrogen sulfide. As such, a gas meter will be used during intrusive work to monitor for hydrogen sulfide.

3.3.8 Evaluation of Organic Vapor Exposure

Air monitoring reduces the risk of overexposure by indicating when action levels have been exceeded and when PPE must be upgraded or changed. Action levels for VOCs and associated contingency plans for the work zone are discussed within Section 8 of this HASP.

Exposure to organic vapors shall be evaluated and/or controlled by:

- Monitoring air concentrations for organic vapors at the upwind and downwind perimeters, in the breathing zone within the work area, with a photoionization detector (PID) or a flame ionizing detector (FID).
- When possible, engineering control measures will be utilized to suppress the volatile organic vapors. Engineering methods can include utilizing a fan to promote air circulation, utilizing volatile suppressant foam, providing artificial ground cover or covering up the impacted material with a tarp to mitigate volatile odors.
- When volatile suppression engineering controls are not effective and organic vapor meters indicate concentrations above the action levels, then appropriate respiratory protection (i.e., air purifying respirator with organic vapor cartridge) will be employed, until the odor source is mitigated. If continued use of an air-purifying respirator is necessary, work will be halted and the work plan will be re-evaluated.

3.3.9 Evaluation of Skin Contact and Absorption

Skin contact by contaminants may be controlled by use of proper hygiene practices, PPE, and good housekeeping procedures. The proper PPE (e.g., Tyvek® gloves, safety glasses) is described in Section 4 and will be worn for all activities where contact with potential contaminated media or materials are expected. Material Safety Data Sheets (MSDS) (as available) and/or Occupational Health Guidelines for decontamination chemicals that may be used on site are included in Appendix C. Specific chemical hazards information from the MSDS and Occupational Health Guidelines are summarized in Table 1 below.

Table 1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
Asbestos	1332-21-4	0.1 f/cc	0.1 f/cc over 8 hr period or 1.0f/cc over 30 min.	Inhalation Ingestion Skin Contact	Asbestosis (chronic exposure); mesothelioma, breathing difficulty, interstitial fibrosis' restricted pulmonary function, finger clubbing; irritate eyes, known human carcinogen	Respiratory system, eyes	White, greenish, blue, or gray-green fibrous solids FP: NA LEL: NA UEL NA VP: 0 mm
Arsenic	7440-38-2	0.01 mg/m^3	0.01 mg/m^3 A.L. .005mg/m^3	Inhalation Skin Absorption Ingestion Skin Contact	Ulceration of nasal septum, dermatitis, GI disturbances, peripheral neuropathy, respiratory irritation, hyperpigmentation of skin, potential carcinogen	Liver, kidneys, skin, lungs, lymphatic system	Metal: Silver-gray or tin-white, brittle, odorless solid FP: NA LEL: NA UEL: NA VP: 0 mm
Benzene	71-43-2	0.5 ppm (Skin)	1 ppm TWA 5 ppm STEL	Inhalation Skin Absorption Ingestion Skin Contact	Irritation of eyes, skin, nose, respiratory system, giddiness, headache, nausea; staggering gait, fatigue, anorexia, weakness, dermatitis, bone marrow depression, known human carcinogen	Eyes, skin, CNS, bone marrow, blood	FP: 12^o F LEL: 1.2% UEL:7.8% VP: 75 mm
Chromium (Chromic Acid and Chromates)	1333-82-0	0.05 mg/m^3	0.1 mg/m^3	Inhalation Ingestion Skin Contact	Irritates respiratory system, nasal, septum perforation, liver and kidney damage, leucocytosis (increased blood leucocytes), leukopenia (reduced blood leucocytes), moncytosis (increased monocytes), Eosinophilia, eye injury, conjunctivitis, skin ulcer, sensitivity dermatitis, potential carcinogen	Blood, respiratory system, liver, kidney, eyes, skin, lung cancer	FP:NA VP: Very Low LEL: NA UEL: NA

Table 1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
Ethylbenzene	100-41-4	100 ppm	100 ppm	Inhalation Ingestion Skin Contact	Eye, skin, mucous membrane irritation; headache; dermatitis, narcosis; coma	Eyes, skin, respiratory system, Central Nervous System	FP: 55^o F LEL: 0.8% UEL:6.7% VP: 7 mm
Hydrogen cyanide	74-90-8	4.7 ppm (5 mg/m^3) STEL [skin]	10 ppm (11 mg/m^3) [skin]	Inhalation Ingestion Absorption Skin/Eye Contact	Asphyxia; weakness, headache, confusion; nausea, vomiting; increased rate and depth of respiration or respiration slow and gasping; thyroid, blood changes	Central Nervous System, Cardiovascular system, thyroid, blood	Colorless or pale-blue liquid or gas (above 78°F) with a bitter, almond-like odor. VP: 630 mmHg
Hydrogen sulfide	7783-06-4	10 ppm TWA, 15 ppm STEL	20 ppm C, 50 ppm [10-min. Maximum peak]	Inhalation Skin/Eye Contact	Irritation eyes, respiratory system; apnea, coma, convulsions; conjunctivitis, eye pain, lacrimation (discharge of tears), photophobia (abnormal visual intolerance to light), corneal vesiculation; dizziness, headache, fatigue, irritability, insomnia; gastrointestinal disturbance; liquid: frostbite	Eyes, respiratory system, Central Nervous System	Colorless gas with a strong odor of rotten eggs. VP: 17.6 atm
Lead	7439-92-1	0.050 mg/m^3	0.05 mg/m^3 A.L. 0.03 mg/m3	Inhalation Ingestion Skin Contact	Weakness, insomnia; facial pallor; pal eye, anorexia, weight loss, malnutrition; constipation, abdominal pain, colic; anemia; gingival lead line; tremor; paralysis of wrist and ankles; irritates eyes, hypo tension	Eyes, GI tract, Central Nervous System, kidneys, blood, gingival tissue	A heavy, ductile, soft, gray solid. FP: NA LEL: NA UEL: NA VP: 0 mm
Mercury	7439-97-6	0.025 mg/m^3	0.10 mg/m^3	Inhalation Ingestion	Irritates eyes and skin, chest pain, cough, difficulty breathing,	Eyes, skin, respiratory tract,	Silver-white, heavy odorless liquid

Table 1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
				Skin Contact Skin Absorption	bronchitis, pneumonitis, tremor, insomnia, irritability, indecision, headache, fatigue, weakness, stomatitis, salivation, Gastrointestinal disturbance, weight loss, proteinuria	central nervous system	FP: NA LEL: NA UEL:NA VP: 0.0012 mm
Naphthalene	91-20-3		10 ppm (50 mg/m^3) TWA	Inhalation, skin absorption, ingestion, skin and/or eye contact	Irritation eyes; headache, confusion, excitement, malaise (vague feeling of discomfort); nausea, vomiting, abdominal pain; irritation bladder; profuse sweating; jaundice; hematuria (blood in the urine), renal shutdown; dermatitis, optical neuritis, corneal damage	Eyes, skin, blood, liver, kidneys, central nervous system	FP: 174 F IP: 8.12 eV, LEL: 0.8% UEL:6.7%, VP: 0.08 mm
PAH's as Coal tar pitch Volatiles (CTPV)	65996-93-2	0.2 mg/m^3	0.2 mg/m^3	Inhalation Skin contact Ingestion	Irritant to eyes, swelling, acne contact dermatitis, chronic bronchitis	Respiratory system, Central Nervous System, liver, kidneys, skin, bladder	Black or dark brown amorphous residue.
PCBs	11097-69-1	0.5 mg/m^3 (Skin)	0.5 mg/m^3 (Skin)	Inhalation Skin Absorption Ingestion Skin Contact	Irritate eyes; chloracne; liver damage	Skin, eyes, liver, reproductive system	Colorless liquid or solid with a mild, hydro-carbon odor VP = 0.00006 mm
Phenol	108-95-2	10 ppm (skin)	5 ppm (19 mg/m^3) [skin]	Inhalation Skin Absorption Ingestion Skin Contact	Irritates eyes, nose, throat, anorexia, weight loss, weakness, muscle ache, pain, dark urine, cyanosis, liver and kidney damage, skin burns, dermatitis, tremors, convulsions, twitching	Eyes, skin, respiratory system, liver, kidneys	Colorless to light pink crystalline solid with sweet, acrid odor. FP:175 °F IP:8.5 LEL:1.8% UEL: 8.6% VP: 0.4 mm

Table 1
Chemical Data

Compound	CAS #	ACGIH TLV	OSHA PEL	Route of Exposure	Symptoms of Exposure	Target Organs	Physical Data
Selenium	7782-49-2	0.2 mg/m^3	0.2 mg/m^3	Inhalation Ingestion Skin Contact	Irritant to eyes, skin, nose and throat, visual disturbance, headache, chills, fever, breathing difficulty, bronchitis, metallic taste, garlic breath, GI disturbance, dermatitis, eye and skin burns	Eyes, skin, respiratory system, liver, kidneys, blood spleen	Amphorous or crystalline, red to gray solid FP: NA LEL: NA UEL: NA VP: 0 mm
Toluene	108-88-3	50 ppm	200 ppm	Inhalation Skin Absorption Ingestion Skin Contact	Eye, nose irritation; fatigue, weakness, confusion, euphoria, dizziness, headache; dilated pupils, tearing of eyes; nervousness, muscle fatigue, insomnia, tingling in limbs; dermatitis	Eyes, skin, respiratory system, Central Nervous System, liver, kidneys	FP: 40^o F LEL: 1.1% UEL:7.1% VP: 21 mm
Xylene	1330-20-7	100 ppm	100 ppm	Inhalation Skin Absorption Ingestion Skin Contact	Eye, skin, nose, throat irritation; dizziness, excitement, drowsiness; incoordination, staggering gait; corneal damage; appetite loss, nausea, vomiting, abdominal pain; dermatitis	Eyes, skin, respiratory system, Central Nervous System, GI tract, blood, liver, kidneys	FP: 90^o F LEL: 0.9% UEL: 6.7% VP: 9 mm

Abbreviations	mm = millimeter
A.L. = Action Level	ppm = parts per million
C = ceiling limit, not to be exceeded	STEL = Short-term exposure limit (15 minutes)
FP = Flash point	TWA = Time-weighted average (8 hours)
GI = Gastro-intestinal	UEL = Upper explosive limit
LEL = Lower explosive limit	VP = vapor pressure approximately 68° F in mm Hg (mercury)
mg/m^3 = milligrams per cubic meter	

3.4 Biological Hazards

The Site is a paved, unoccupied parcel of land. There is little or no vegetation or viable habitat at the Site. As such, some of the biological hazards discussed below are not likely to be present at the Site. However, the potential still exists for them to be encountered. Therefore, employees working at the Site should be aware of the potential biological hazards discussed in detail below.

3.4.1 Poisonous Plants

Persons working on the Site should be aware of the possible presence of poisonous plants and insects. Poison ivy is a climbing plant with leaves that consist of three glossy, greenish leaflets. Poison ivy has conspicuous red foliage in the fall. Small yellowish-white flowers appear in May through July at the lower leaf axils of the plant. White berries appear from August through November. Poison ivy is typically found east of the Rockies. Poison oak is similar to poison ivy but its leaves are oak-like in form. Poison oak occurs mainly in the south and southwest. Poison sumac typically occurs as a small tree or shrub and may be 6-20 feet in height. The bark is smooth, dark and speckled with darker spots. Poison sumac is typically found in swampy areas and east of the Mississippi. The leaves have 7-13 smooth-edged leaflets and drooping clusters of ivory-white berries appear in August and last through spring.

The leaves, roots, stems and fruit of these poisonous plants contain urushiol. Contact with the irritating oil causes an intensely itching skin rash and characteristic, blister-like lesions. The oil can be transmitted on soot particles when burned and may be carried on the fur of animals, equipment and apparel.

Proper identification of these plants is the key to preventing contact and subsequent dermatitis. Wear long sleeves and pants when working in wooded areas. In areas of known infestation, wear Tyvek® coveralls and gloves. Oils are easily transferred from one surface to another. If you come in contact with these poisonous plants, wash all exposed areas immediately with cool water to remove the oils. Some commercial products such as Tecnu's Poison Oak-n-Ivy Cleanser claim to further help with the removal of oils.

3.4.2 Ticks

Lyme Disease

Ticks are bloodsuckers, attaching themselves to warm-blooded vertebrates to feed. Deer ticks, are associated with the transmission the bacteria that causes Lyme Disease. Female deer ticks are about one-quarter inch in length and are black and brick red in color. Males are smaller and all black. If a tick is not removed, or if the tick is allowed to remain for days feeding on human blood, a condition known as tick paralysis can develop. This is due to a neurotoxin, which the tick apparently injects while engorging. This neurotoxin acts upon the spinal cord causing incoordination, weakness and paralysis.

The early stages of Lyme disease, which can develop within a week to a few weeks of the tick bite, are usually marked by one or more of these signs and symptoms:

- Tiredness
- Chills and fever
- Headache
- Muscle and/or join pain
- Swollen lymph glands
- Characteristic skin rash (i.e., bulls eye rash)

Rocky Mountain Spotted Fever

Rocky Mountain spotted fever is spread by the American dog tick, the lone-star tick, and the wood tick, all of which like to live in wooded areas and tall, grassy fields. The disease is most common in the spring and summer when these ticks are active, but it can occur anytime during the year when the weather is warm.

Initial signs and symptoms of the disease include sudden onset of fever, headache, and muscle pain, followed by development of rash. Initial symptoms may include fever, nausea, vomiting, severe headache, muscle pain, lack of appetite.

The rash first appears 2-5 days after the onset of fever and is often not present or may be very subtle. Most often it begins as small, flat, pink, non-itchy spots on the wrists, forearms, and ankles. These spots turn pale when pressure is applied and eventually become raised on the skin. Later signs and symptoms include rash, abdominal pain, joint pain, and diarrhea.

The characteristic red, spotted rash of Rocky Mountain spotted fever is usually not seen until the sixth day or later after onset of symptoms, and this type of rash occurs in only 35% to 60% of patients with Rocky Mountain spotted fever. The rash involves the palms or soles in as many as 50% to 80% of patients; however, this distribution may not occur until later in the course of the disease.

Prevention

Tick season lasts from April through October; peak season is May through July. You can reduce your risk by taking these precautions:

- During outside activities, wear long sleeves and long pants tucked into socks. Wear a hat, and tie hair back.

- Use insecticides to repel or kill ticks. Repellents containing the compound DEET can be used on exposed skin except for the face, but they do not kill ticks and are not 100% effective in discouraging ticks from biting. Products containing permethrin kill ticks, but they cannot be used on the skin - only on clothing. When using any of these chemicals, follow label directions carefully.
- After outdoor activities, perform a tick check. Check body areas where ticks are commonly found: behind the knees, between the fingers and toes, under the arms, in and behind the ears, and on the neck, hairline, and top of the head. Check places where clothing presses on the skin.
- Remove attached ticks promptly. Removing a tick before it has been attached for more than 24 hours greatly reduces the risk of infection. Use tweezers, and grab as closely to the skin as possible. Do not try to remove ticks by squeezing them, coating them with petroleum jelly, or burning them with a match. Keep ticks in a zip-lock baggie in case testing needs to be performed.
- Report any of the above symptoms and all tick bites to the CHSO for evaluation.

3.4.3 Mosquito-Borne Disease - West Nile Virus

West Nile encephalitis is an infection of the brain caused by the West Nile virus, which is transmitted by infected mosquitoes. Following transmission from an infected mosquito, West Nile virus multiplies in the person’s blood system and crosses the blood-brain barrier to reach the brain. The virus interferes with normal central nervous system functioning and causes inflammation of the brain tissue. However, most infections are mild and symptoms include fever, headache and body aches. More severe infections may be marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, paralysis and rarely, death. Persons over the age of 50 have the highest risk of severe disease.

Prevention centers on public health action to control mosquitoes and on individual action to avoid mosquito bites. To avoid being bitten by the mosquitoes that cause the disease, use the following control measures:

If possible, stay inside between dusk and dark. This is when mosquitoes are most active. When outside between dusk and dark, long pants and long-sleeved shirts should be worn. Spray exposed skin with an insect repellent, preferably containing DEET.

3.4.4 Wasps and Bees

Wasps (hornets and yellow-jackets) and bees (honeybees and bumblebees) are common insects that may pose a potential hazard to the field team if work is performed during spring, summer or fall. Bees normally build their nests in the soil. However, they use other natural holes such as abandoned rodent nests or tree hollows. Wasps make a football-shaped, paper-like nest either below or above the ground. Yellow-jackets tend to build their nests in the ground but hornets tend to build their nests in trees and shrubbery. Bees are generally more mild-mannered than wasps and are less likely to sting. Bees can only sting once while wasps sting multiple times because their stinger is barbless. Wasps sting when they feel threatened. By remaining calm and not annoying wasps by swatting, you lessen the chance of being stung.

Wasps and bees inject a venomous fluid under the skin when they sting. The venom causes a painful swelling that may last for several days. If the stinger is still present, carefully remove it with tweezers. Some people may develop an allergic reaction (i.e., anaphylactic shock) to a wasp or bee sting. If such a reaction develops, seek medical attention at once.

3.4.5 Sun Exposure

Employees are encouraged to liberally apply sunscreen, with a minimum sun protection factor (SPF) of 15, when working outdoors to avoid sunburn and potential skin cancer, which is associated with excessive sun exposure to unprotected skin. Additionally, employees should wear safety glasses that offer protection from UVA/UVB rays.

4. Personal Protective Equipment

The PPE specified in Table 2 below represents PPE selection required by 29 CFR 1910.132, and is based on the Activity Hazard Analysis in Section 3.

The PPE program addresses elements, such as PPE selection based on site hazards, use and limitations, donning and doffing procedures, maintenance and storage, decontamination and disposal, training and proper fitting, inspection procedures prior to/during/and after use, evaluation of the effectiveness of the PPE program, and limitations during temperature extremes, heat stress, and other appropriate medical considerations.

A summary of PPE for each level of protection is as follows:

Table 2

Safety Equipment	Level A	Level B	Level C	Level D
Tyvek™ suit or work overalls				•
Hard hats with splash shields or safety glasses			•	•
Steel-toe/shank boots with overboots			•	•
Chemical-resistant gloves as appropriate for work being performed and materials handled			•	•
Half- or full-face respirators with appropriate cartridges as approved by the CHSO			•	
Tyvek™ splash-resistant suit			•	
Chemical-resistant clothing		•		
Pressure-demand, full-face SCBA or pressure-demand supplied air respirator with escape SCBA	•	•		
Inner and outer chemical-resistant gloves	•	•		
Chemical-resistant safety boots or shoes	•	•		
Two-way radio	•	•		
Hard hat	•	•		
Fully encapsulating chemical-resistant suit	•			
Reflective vest	•	•	•	•

PPE requirements for field activities are as follows.

Activity	Level of Protection	Backup Protection
Excavation and backfill (includes saw-cutting)	D	C
Dewatering	D	C
Site Restoration	D	C
Soil Boring/Well Installation	D	C
Groundwater Sampling	D	C
Asphalt Resurfacing	D	C

Use of Level A or Level B PPE is not anticipated. If conditions indicating the need for Level A or Level B PPE are encountered, personnel will leave the work area and this HASP will be revised with oversight of the CHSO. GEI personnel will not re-enter the work area until conditions allow.

OSHA Requirements for Personal Protective Equipment

All personal protective equipment used during the course of this field investigation must meet the following OSHA standards:

Type of Protection	Regulation	Source
Eye and Face	29 CFR 1910.133	ANSI Z87.1 1968
Respiratory	29 CFR 1910.134	ANSI Z88.1 1980
Head	29 CFR 1910.135	ANSI Z89.1 1969
Foot	29 CFR 1910.136	ANSI Z41.1 1967
ANSI = American National Standards Institute		

5. Key Project Personnel/Responsibilities and Lines of Authority

5.1 GEI Personnel

Jerry Zak	GEI Project Manager
Aaron Gorges	GEI Site Safety Officer
Aaron Gorges	GEI Field Representative
Robin DeHate	GEI Corporate Health and Safety Officer
Steven Hawkins	Regional Health and Safety Officer

The implementation of health and safety at this project location will be the shared responsibility of the GEI Project Manager (PM), the GEI CHSO, the GEI SSO, other GEI personnel implementing the proposed scope of work.

5.1.1 GEI Project Manager

The GEI PM, Jerry Zak, is responsible for ensuring that the requirements of this HASP are implemented. Some of the PM’s specific responsibilities include:

- Verifying that the GEI staff selected to work on this program are sufficiently trained for the sampling activities
- Assuring that all personnel to whom this HASP applies, including subcontractor personnel, have received a copy
- Providing the CHSO with updated information regarding conditions at the Site and the scope of site work
- Providing adequate authority and resources to the on-site SSO to allow for the successful implementation of all necessary safety procedures
- Supporting the decisions made by the SSO and CHSO
- Maintaining regular communications with the SSO and, if necessary, the CHSO
- Immediately notifying the National Grid Project Manager and GEI CHSO in the event of an accident or incident
- Verifying that the subcontractors selected by GEI to work on this program have completed GEI environmental, health and safety requirements and are acceptable for the proposed scope of work
- Coordinating the activities of all GEI subcontractors and ensuring that they are aware of the pertinent health and safety requirements for this project

5.1.2 GEI Corporate Health and Safety Officer

The GEI CHSO, Dr. Robin DeHate, is responsible for the review, interpretation and modification of this HASP. Modifications to this HASP which may result in less stringent precautions cannot be undertaken by the PM or the SSO without the approval of the CHSO. Specific duties of the CHSO include:

- Writing, approving and amending the HASP for this project;
- Advising the PM and SSO on matters relating to health and safety on this Site
- Recommending appropriate PPE and safety equipment to protect personnel from potential site hazards
- Conducting accident investigations; and maintaining regular contact with the PM and SSO to evaluate site conditions and new information which might require modifications to the HASP

5.1.3 GEI Site Safety Officer

All GEI field staff are responsible for implementing the safety requirements specified in this HASP. However, one person will serve as the SSO. For this program, the Construction Manager, Aaron Gorges, will serve as the SSO. The SSO will be on-site during all activities covered by this HASP. The SSO is responsible for enforcing the requirements of this HASP once work begins. The SSO has the authority to immediately correct all situations where noncompliance with this HASP is noted and to immediately stop work in cases where an immediate danger is perceived. Some of the SSO’s specific responsibilities include:

- Assuring that all personnel to whom this HASP applies, including subcontractors, have submitted a completed copy of the HASP receipt and acceptance form
- Conducting the pre-entry briefing prior to beginning work, and subsequent safety meetings as necessary
- Conduct daily Safety Tailboard meeting
- Assuring that all personnel to whom this HASP applies have attended and actively participated in a pre-entry briefing and any subsequent safety meetings that are conducted during the implementation of the program
- Maintaining a high level of health and safety consciousness among employees implementing the proposed activities
- Procuring the air monitoring instrumentation required and performing air monitoring for investigative activities
- Procuring and distributing the PPE and safety equipment needed for this project for GEI employees

- Verifying that all PPE and health and safety equipment used by GEI is in good working order
- Verifying that the selected contractors are prepared with the correct PPE and safety equipment and supplies
- Notifying the PM of all noncompliance situations and stopping work in the event that an immediate danger situation is perceived
- Monitoring and controlling the safety performance of all personnel within the established restricted areas to ensure that required safety and health procedures are being followed
- Stopping work in the event that an immediate danger situation is perceived
- Conducting accident/incident investigations and preparing accident/incident investigation reports

5.1.4 GEI Field Personnel

All GEI field personnel covered by this HASP are responsible for following the health and safety procedures specified in this HASP and for performing their work in a safe and responsible manner. Some of the specific responsibilities of the field personnel are as follows:

- Reading the HASP in its entirety prior to the start of on-site work
- Submitting a completed HASP Acceptance Form to the GEI SSO prior to the start of work
- Attending and actively participating in the required pre-entry briefing prior to beginning on-site work and any subsequent safety meetings that are conducted during the implementation of the program
- Stopping work in the event that an immediate danger situation is perceived
- Bringing forth any questions or concerns regarding the content of the HASP to the PM or the SSO prior to the start of work
- Reporting all accidents, injuries and illnesses, regardless of their severity, to the GEI SSO
- Complying with the requirements of this HASP and the requests of the SSO

Lines of Authority will be as follows:

On site – GEI will have responsibility for safety of its employees during the work performed at the Troy (Liberty Street) Non-Owned Former MGP Site. GEI's SSO will have a cell phone available to contact the appropriate local authorities, in the event of an emergency. GEI's SSO will be available for communication with the National Grid and GEI Project Managers.

5.2 Contractors and Subcontractors

Contractor and subcontractor selection for the work has not yet occurred. GEI and National Grid require its subcontractors to work in a responsible and safe manner. Contractors and subcontractors for this project will be required to develop their own HASP for protection of their employees but at a minimum must adhere to applicable requirements set forth in this HASP.

5.3 Emergency Contact List

EMERGENCY INFORMATION		
Important Phone Numbers		Directions to Hospital (See Appendix B for route maps)
Local Police Troy Police	911 (518) 270-4411	Turn **right out of Site** main gate **onto Hill** St. Follow Hill Street approximately 0.1 mile and **merge into 4th Street**. Follow 4th St approximately 0.2 miles and take a **right on Ferry St**. Follow Ferry St approximately 0.4 miles **and merge into Congress St (Route 2)**. Follow Congress St approximately 0.4 miles and turn **left onto 15th St**. Follow 15th St approximately 0.7 miles and take **right onto Peoples Ave**. Follow Peoples Ave approximately 0.3 miles. **Samaritan Hospital will be on the left.** **Directions to Occupational Health Care Clinic** **(See Appendix B for route map)** Head **south on Hill St** toward Washington St. Take **first right** onto **Washington St.** Take **first right** onto **4th St.** Turn **right** at **King St** and **continue** onto **River St.** Turn **right** at **Hoosick St** and turn **left** at **6th Ave.** Take **ramp** onto **NY-7 W. Keep left** at fork and **follow signs for I-87 S/ Albany** and **merge onto I-87 S.** Take **exit 5** for **NY-155 E** toward Latham. Turn **right** at **NY-155 W/Watervliet Shaker Rd. Follow to 776a Watervliet Shaker Rd.**
Fire Department Troy Fire Dept.	911 (518) 271-4471	
Ambulance Mohawk Empire	911 (518) 274-4888 (518) 271-0143	
State Police or County Sheriff	911	
Local Hospital		
Samaritan Hospital 2215 Burdett Avenue Troy, NY 12304 (518) 271-3300	(518) 271-3300	
Occupational Health Care Clinic Latham Access Health 776a Watervliet Shaker Road Latham, NY 12110	(518)-782-2200	
Project Manager Jerry Zak	(860) 368-5404 office (860) 558-3866 cell	
Corporate Health and Safety Officer Robin DeHate	(813) 774-6564 office (813) 323-6220 cell	
Client Contact Jim Morgan	(315) 428-3103 office (315) 882-2559 cell	
Utility Clearance Dig Safely New York Permit #	811 (800) 962-7962 TBD	
Nearest Telephone Location: On-site cellular		

6. Training Program

6.1 General Health and Safety Training

In accordance with 29 CFR 1910.120, hazardous waste site workers shall, at the time of job assignment, have received a minimum of 40 hours of initial health and safety training for hazardous waste site operations. At a minimum, the training shall have consisted of instruction in the topics outlined in the standard. Personnel who have not met the requirements for initial training shall not be allowed to work in any site activities in which they may be exposed to hazards (chemical or physical). Proof of training shall be submitted to the GEI CHSO or her representative prior to the start of field activities.

6.2 Annual Eight-Hour Refresher Training

Annual eight-hour refresher training is required of all hazardous waste site field personnel in order to maintain their qualifications for fieldwork. The training will cover a review of 29 CFR 1910.120 requirements and related company programs and procedures. Proof of current 8-hour refresher training shall be submitted to the GEI CHSO or her representative prior to the start of field activities.

6.3 Supervisor Training

Personnel acting in a supervisory capacity shall have received 8 hours of instruction in addition to the initial 40 hours training. In addition supervisors shall have one year of field experience and training specific to work activities (i.e., sampling, construction observation, etc.).

6.4 Site-Specific Training

Prior to commencement of field activities, the GEI CHSO or her representative will ensure all field personnel assigned to the project will have completed training that will specifically address the activities, procedures, monitoring, and equipment used in the site operations. It will include site and facility layout, hazards and emergency services at the Site and will highlight all provisions contained within this HASP. This training will also allow field workers to clarify anything they do not understand and to reinforce their responsibilities regarding safety and operations for their particular activity. Personnel that have not received site-specific training will not be allowed on-site.

6.5 On-Site Safety Briefings

Other GEI personnel will be given health and safety briefings daily by GEI’s field representative to assist GEI personnel in safely conducting work activities. The briefings will include information on new operations to be conducted, changes in work practices or changes in the site’s environmental conditions, as well as periodic reinforcement of previously discussed topics. The briefings will also provide a forum to facilitate conformance with safety requirements and to identify performance deficiencies related to safety during daily activities or as a result of safety inspections. Documentation of these briefings will be recorded in the GEI field book. The meetings will also be an opportunity to periodically update the workers on monitoring results. In addition, all GEI personnel shall sign the HASP to document that they understand the hazards and control measures presented and agree to comply with the procedures established in the plan.

6.6 First Aid and CPR

The PM will identify individuals certified in first aid and CPR, or identify individuals for such training in order to ensure that emergency medical treatment is available during field activities. The training will be consistent with the requirements of the American Red Cross Association.

7. Medical Surveillance Program

GEI maintains a continuous, corporate, medical surveillance program that includes a plan designed specifically for field personnel engaged in work at sites where hazardous or toxic materials may be present. Dr. Robin DeHate is GEI’s CHSO and is responsible for the administration and coordination of medical evaluations conducted for GEI’s employees at all branch office locations. Comprehensive examinations are given to all GEI field personnel participating in hazardous waste operations on an annual or biennial basis (as determined to be appropriate by the CHSO). The medical results of the examinations aid in determining the overall fitness of employees participating in field activities.

Under the CHSO’s supervision, all field personnel undergo a complete initial physical examination, including a detailed medical and occupational history, before they participate in hazardous waste site investigations. Extensive annual/biennial reexaminations are also performed. Upon completion of these tests, personnel are certified by an occupational health physician as to whether they are fit for field work in general, and fit to use all levels of respiratory protection, in particular.

If a GEI employee or other project worker shows symptoms of exposure to a hazardous substance and wishes to be rechecked, he/she will be directed to the nearest area hospital or medical facility.

All GEI subcontractor personnel that will enter any active waste handling or other active non-“clean” area must certify that they are participating in a medical surveillance program that complies with OSHA regulations for hazardous waste operations (i.e., 29 CFR 1910.120 and 29 CFR 1926.65). Proof of medical clearance shall be submitted to the GEI CHSO or her representative prior to the start of field activities.

8. Monitoring

Monitoring shall be performed to identify and quantify airborne levels of hazardous substances and safety and health hazards in order to determine the appropriate level of worker protection needed on site.

GEI will conduct perimeter air monitoring, and work zone monitoring for on-site workers. GEI will monitor and document daily Site conditions and operations and inform field representative of results. If action levels are exceeded, GEI's field representative will immediately implement dust suppression activities and notify GEI's PM.

GEI will provide the following equipment for health and safety monitoring of on-site personnel:

- Particulate Meter (PM-10 capable)
- PID
- Sound Level Meter if deemed necessary by the CHSO or PM (type to be appropriate to the activities performed)

The perimeter and work zone air monitoring will be conducted during intrusive activities. Table 3 below provides a summary of real time air monitoring action levels and contingency plans for work zone activities.

Table 3
Work Zone Air Monitoring Action Levels

Air Monitoring Instrument	Monitoring Location	Action Level	Site Action
PID	Breathing Zone	0.5 ppm	Use Dräger Chip Measurement System (CMS) tube for benzene or Z-nose® to verify if concentration is benzene.
PID	Breathing Zone	0 - 10 ppm	No respiratory protection is required.
		10 - 250 ppm	Stop work, withdrawal from work area, institute engineering controls, if levels persist Upgrade to Level C.
		> 250 ppm	Stop work, withdraw from work area; notify PM & CHSO.
Oxygen meter (O_2)	Breathing Zone	< 20.75%	Stop work; withdraw from work area; ventilate area, notify PM & CHSO.
		> 21.1%	Stop work; withdraw from work area; notify PM & CHSO.
Hydrogen Sulfide (H_2S) meter	Breathing Zone	<5 ppm	No respiratory protection is required.
		>5 ppm	Stop work, cover excavation, withdraw from work area, institute engineering controls, and notify PM & CHSO.

Table 3
Work Zone Air Monitoring Action Levels

Air Monitoring Instrument	Monitoring Location	Action Level	Site Action
Hydrogen Cyanide (HCN) meter	Breathing Zone	<1.0 ppm	Run CMS Dräger tube, continue monitoring with real time meter, and continue work if CMS Dräger Tube Reading is less than 2ppm.
		1.0< HCN <2.0 ppm	Run CMS Dräger tube and confirm concentration is less than 2.0 ppm, notify SSO and CHSO. Run CMS Dräger tube for sulfur dioxide, hydrogen sulfide, and phosphine chip potential interferences. Continue to monitor with real time meter.
		>2.0 ppm	Stop work, and move (with continuous HCN monitoring meter) at least 25 feet upwind of the excavation until continuous meter reads less than 1 ppm, Notify PM & CHSO. Run CMS Dräger hydrogen cyanide chip and re-evaluate activity, continue monitoring with a real time meter, resume work if concentrations read less than 1.0 ppm.
Combustible Gas Indicator (CGI)	Excavation/Work Zone	< 10 % Lower Explosive Limit (LEL)	Investigate possible causes, allow excavation to ventilate; use caution during procedures.
		> 10% LEL	Stop work; allow excavation, borehole to ventilate to < 10% LEL; if ventilation does not result in a decrease to < 10% LEL, withdraw from work area; notify PM & CHSO.
Particulate Meter	Excavation/ Work Zone	0.150 ug/m^3	Implement work practices to reduce/minimize airborne dust generation, e.g., spray/misting of soil with water.

9. Site Control Measures

9.1 Site Zones

Site zones are intended to control the potential spread of contamination and to assure that only authorized individuals are permitted into potentially hazardous areas. A three-zone approach will be utilized. It shall include an Exclusion Zone (EZ), Contamination Reduction Zone (CRZ) and a Support Zone (SZ). Specific zones shall be established at the Site when operations begin for each task requiring such delineation.

This project is being conducted under the requirements of 29 CFR 1910.120, and any personnel working in an area where the potential for exposure to site contaminants exists, will only be allowed access after proper training and medical documentation.

The following shall be used for guidance in revising these preliminary zone designations, if necessary.

Support Zone - The SZ is an uncontaminated area that will be the field support area for most operations. The SZ will be set up within its own temporary fencing. The SZ provides for field team communications and staging for medical emergency. Appropriate sanitary facilities and safety equipment will be located in this zone. Potentially contaminated personnel/materials are not allowed in this zone. The only exception may be appropriately packaged/decontaminated and labeled samples.

Contamination Reduction Zone - The CRZ is established between the EZ and the SZ. The CRZ contains the contamination reduction corridor and provides an area for decontamination of personnel and portable hand-held equipment, tools and heavy equipment. A personnel decontamination area will be prepared at each exclusion zone. The CRZ will be used for Exclusion Zone entry and egress in addition to access for heavy equipment and emergency support services.

Exclusion Zone - All activities which may involve exposure to site contaminants, hazardous materials and/or conditions should be considered an exclusion zone. This zone will be clearly delineated by cones, tapes or other means. The SSO may establish more than one EZ where different levels of protection may be employed or different hazards exist. The size of the EZ shall be determined by the SSO allowing adequate space for the activity to be completed, field members and emergency equipment.

The SSO is responsible for distinguishing, maintaining, and enforcing the zones.

9.2 Buddy System

GEI personnel should be in line-of-site or communication contact with another on-site person. The other on-site personnel should be aware of their role as a "buddy" and be able to provide assistance in the event of an emergency. A copy of this plan shall be given to any person acting as a GEI "buddy" for informational purposes.

9.3 Sanitation for Temporary Work Sites

Temporary sanitary facilities consisting of a toilet and a hand-washing station will be available on site within the temporary fence.

9.4 Illumination

Illumination requirements identified by OSHA are directed to work efforts inside buildings and/or during non-daylight hours. All activities planned for the Site are anticipated to occur outside during daylight hours. However, if yard areas are used after dark they will be equipped with illumination that meets or exceeds requirements specified in 29 CFR 1926.56, Illumination.

9.5 Utilities

The Site may have shallow, buried utilities and also overhead utilities in certain areas. It will be necessary for all parties disturbing the existing ground surface and conducting operations with heavy equipment having high clearances to exercise a high degree of caution in performing project-related work with respect to the presence of utilities.

Prior to field work, public utility companies with active buried lines in the Site area will mark all of their facilities as necessary. A private utility survey will also be conducted for the Site. Each location where intrusive work is required will be cleared using a hand auger or air knife before intrusive work begins. Site workers will use these data to choose apparently safe work locations.

9.5.1 Underground Utilities

No excavating, drilling, boring or other intrusive activities will be performed until a thorough underground utility survey, conducted by knowledgeable persons or agencies, has been made and it is found safe to begin. This survey will identify any underground and in-workplace utilities such as the following.

- Electrical lines and appliances
- Telephone lines
- Cable television lines
- Gas lines

- Pipelines
- Steam lines
- Water lines
- Sewer lines
- Pressurized air lines

The location of any utility that could pose a risk to workers must be communicated to all workers during site safety indoctrination. Utilities should be marked or access otherwise restricted to avoid chance of accidental contact. Based on the location of underground utilities, it may be necessary to relocate proposed intrusive work. Pre-excavation at the perimeter of the excavation to identity utilities that cross into the excavation may be necessary. If performed, once the locations for soil borings have been cleared, the top 5 feet of soils will be removed with a hand auger or a vacuum truck equipped with an air knife prior to drilling.

Even when a utility search has been completed, drilling, boring, and excavation should commence with caution until advanced beyond the depth at which such utilities are usually located. All utilities shall be considered “live” or active until reliable sources demonstrate otherwise.

9.5.2 Overhead Utilities

Overhead transmission and distribution lines will be carried on towers and poles which provide adequate safety clearance over roadways and structures. Clearances will be adequate for the safe movement of vehicles and for the operation of excavators, backhoes, drill rigs, and other heavy equipment.

Overhead or aboveground electric lines should be considered active until a reliable source has documented them to be otherwise. Elevated work platforms, ladders, scaffolding, man-lifts, and drill or vehicle superstructures shall be erected a minimum of 16 feet (the actual distance is dependent upon the voltage of the line) away from overhead electrical lines until the line is de-energized, grounded or shielded and a competent electrician has certified that arcing cannot occur between the work location or superstructure.

9.6 Waste Storage and Site Security

All waste will be stored (until removal) within the on-site temporary fencing, in Department of Transportation (DOT) steel 55-gallon drums (for solids) or poly tanks (for wastewater) contained within a bermed area sealed with heavy plastic to contain any leaks, should they occur.

Excess asphalt from excavations will be recycled. As such, it will be stored in a covered roll-off container within the fenced area. Night watchmen will be employed only if test-pit excavations will remain open overnight, which is not expected to take place.

10. Accident Reporting

GEI will report incidents involving GEI personnel or subcontractor personnel, such as: lost time injuries, injuries requiring medical attention, near miss incidents, fires, fatalities, accidents involving the public, and property damage. The report shall be made to the GEI Project Manager verbally within 2 hours of the incident and to the National Grid Project Manager within the same day. The Project Manager will immediately inform the CHSO and the Director of Human Resources of the incident. An Accident Report Form will be completed and submitted to the CHSO and the Director of Human Resources within 24 hours of the incident.

11. Decontamination Procedures

A decontamination area will be established within temporary fencing at the Site for personnel decontamination and equipment decontamination.

11.1 Personnel Decontamination Station

A personnel decontamination station will be set up and it will include a hand-washing station and portable toilet. Personnel will remove and dispose of PPE (as appropriate) in trash cans or bags, for ultimate disposal by Clean Harbors. Hand sanitizer will be available for personnel to sanitize their hands.

The following specific decontamination procedure may be used as necessary by GEI personnel or subcontractor personnel wearing PPE from Level D through Level C.

Step 1 Equipment drop (respirator, tools, monitoring equipment, etc.) Decontaminate as appropriate (per GEI's field representative's instructions).

Step 2 If necessary, based on conditions in the work zone, boot wash/rinse (wash with non-foaming detergent, rinse with fresh water spray. If inner and outer gloves are worn, wash outer gloves, remove and save for later use, or remove and discard outer gloves and place in trash can/bag provided.

Step 3 Hard hat removal, wash if visibly contaminated (use same wash as in Step 2).

Step 4 If Tyvek™ (or equivalent) suit was worn and is visibly contaminated, remove and place in trash bag/can provided or decontaminate (wash) and store for reuse. Contaminate washable coveralls should be removed and bagged for washing.

Step 5 Respirator and/or eye protection removal (as applicable). Wash (per Step 2) to remove visible contamination.

Step 6 Remove outer gloves.

Step 7 Wash potentially exposed skin (use water and soap at indoor sink).

Step 8 Disinfect respirator per manufacturer's recommendations.

Contaminated PPE (gloves, suits, etc.) will be decontaminated and stored for reuse or placed in plastic bags (or other appropriate container) and disposed of in an approved facility by Clean Harbors.

Decontamination wastewater and used cleaning fluids will be collected and disposed of by Clean Harbors in accordance with all applicable state and federal regulations.

11.2 Heavy Equipment Decontamination Pad

Heavy equipment decontamination will be performed within the limits of the on-site decontamination pad. A steam generator and brushes will be used to clean excavation equipment and other tools. No heavy equipment will be permitted to leave the Site unless it has been thoroughly decontaminated.

Wastewater from the heavy equipment and personnel decontamination areas will be collected and stored in a poly tank within temporary fencing until it can be disposed of in accordance with all applicable state and federal regulations. Clean Harbors will be used to dispose of investigation-derived wastes.

11.3 Decontamination Equipment Requirements

The following equipment, if required, should be in sufficient supply:

- Buckets
- Alconox™ detergent concentrate
- Hand pump sprayers
- Long handle soft bristle brushes
- Large sponges
- Cleaning wipes for respirators
- Bench or stool(s)
- Methanol
- Liquid disinfectant soap and paper towels
- Plastic trash bags

GEI is responsible for ensuring that the above materials are in sufficient supply.

12. Supplemental Contingency Plan Procedures

12.1 Hazard Communication Plan

GEI personnel have received hazard communication training as part of their 40-hour HAZWOPER training. All hazardous materials used on the Site will be properly labeled, stored, and handled. MSDS will be available to all potentially exposed employees.

12.2 Fire

In the event of a fire, all personnel will evacuate the area. GEI’s field representative will contact the local fire department with jurisdiction and report the fire. Notification of evacuation will be made to the GEI Project Manager and the CHSO. The field representative will account for GEI personnel and subcontractor personnel and report their status to the GEI PM.

12.3 Medical Support

In case of minor injuries, on site care shall be administered with the site first aid kit. For serious injuries, call 911 and request emergency medical assistance. Seriously injured persons should not be moved, unless they are in immediate danger.

Section 5 of this HASP contains detailed emergency information, including directions to the nearest hospital, and a list of emergency services and their telephone numbers. GEI field personnel will carry a cellular telephone.

12.4 Severe Weather

The contingency plan for severe weather includes reviewing the expected weather to determine if severe weather is in the forecast. Severe weather includes high winds over 30 mph, heavy rains or snow squalls, thunderstorms, hurricanes, and lightning storms. If severe weather is approaching, the decision to evacuate GEI personnel and subcontractor personnel from the Site will be the responsibility of GEI’s field representative. Notification of evacuation will be made to the GEI PM and the CHSO. The field representative will account for GEI personnel and subcontractor personnel and report their status to the GEI PM.

12.5 Spills or Material Release

If a hazardous waste spill or material release occurs, the SSO or his representative will immediately assess the magnitude and potential seriousness of the spill or release based on the following.

- MSDS for the material spilled or released
- Source of the release or spillage of hazardous material
- An estimate of the quantity released and the rate at which it is being released
- The direction in which the spill or air release is moving
- Personnel who may be or may have been in contact with the material, or air release, and possible injury or sickness as a result
- Potential for fire and/or explosion resulting from the situation
- Estimates of area under influence of release

If the spill or release is determined to be within the on-site emergency response capabilities, the SSO will ensure implementation of the necessary remedial action. If the release is beyond the capabilities of the site personnel, all personnel will be evacuated from the immediate area and the local fire department will be contacted. The SSO will notify the PM and the CHSO.

12.6 Alcohol and Drug Abuse Prevention

Alcohol and drugs will not be allowed on the work site. Project personnel under the influence of alcohol or drugs will not be allowed to enter the Site.

13. Health and Safety Plan Sign-off

All GEI personnel conducting site activities must read the Health and Safety Plan, be familiar with its requirements, and agree to its implementation.

Once the Health and Safety Plan has been read, complete this sign-off sheet, and return it to the Project Manager.

Site Name:
Troy (Liberty Street) Non-Owned Former MGP Site

Investigation:
Remedial Investigation

GEI Project No: 093300

I have received and read the Health and Safety Plan, been briefed on it, and agree to its implementation.

Name:	Signature:	Date:
Name:	Signature:	Date:
Name:	Signature:	Date:
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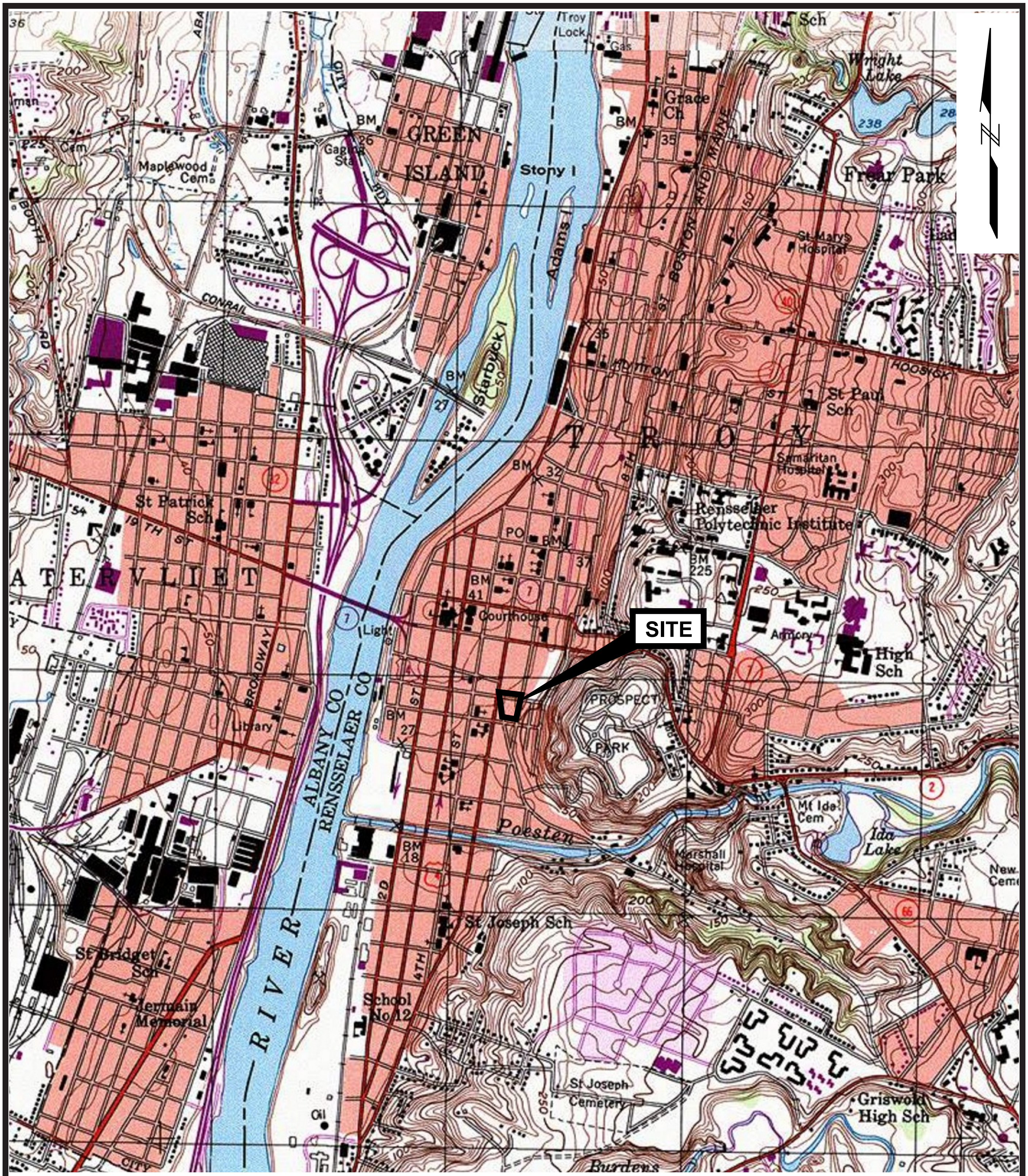
Figures



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0 2000 4000

SCALE, FEET

HEALTH AND SAFETY PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
TROY, NEW YORK

nationalgrid

GEI Consultants

Project 093300-2-1203

SITE LOCATION MAP

June 2013

Figure 1

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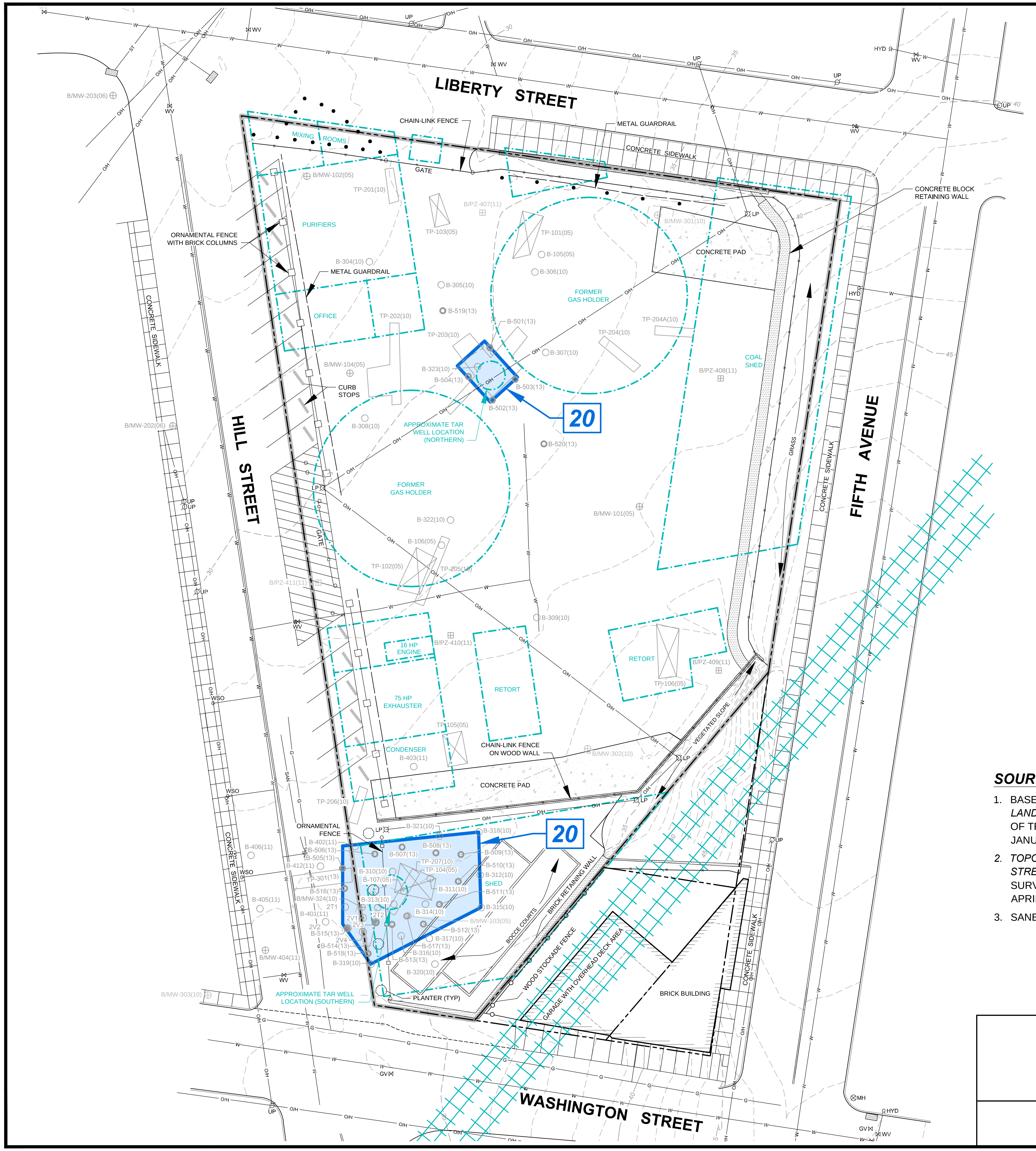

LEGEND:

▭	PROPOSED EXCAVATION
20	PROPOSED EXCAVATION DEPTH
— - - —	PROPERTY LINE
▬	SITE BOUNDARY
— — 45 — —	GROUND SURFACE CONTOURS
▨	CONCRETE BLOCK RETAINING WALL
—x—x—	CHAIN-LINK FENCE
□—□	METAL FENCE WITH BRICK PILLARS
— — —	GUIDE RAIL
═	EDGE OF PAVEMENT
╪	HISTORICAL RAILROAD TRACKS (APPROXIMATE)
⬚	HISTORICAL STRUCTURE BASED ON 1885 SANBORN FIRE INSURANCE MAP
◌	HISTORICAL GAS HOLDER/TAR WELL (SURVEYED UNLESS NOTED)
▭	CONCRETE PAD
●	BOLLARD
HYD	HYDRANT
UP	WOOD UTILITY POLE
LP	STEEL LIGHT POLE
CB	CATCH BASIN
⊗MH	MANHOLE
GV	GAS VALVE
○WSO	WATER SHUT OFF
WV	WATER VALVE
O/H	OVERHEAD UTILITY LINES
W	CITY OF TROY WATER MAIN
G	GAS LINE
SAN	SANITARY SEWER LINE
ST	STORM SEWER LINE
TP-101(05)	TEST PIT (EA ENGINEERING PC, 2005)
○ B-105(05)	SOIL BORING (EA ENGINEERING PC, 2005)
⊕B/MW-101(05)	SOIL BORING/MONITORING WELL (EA ENGINEERING PC, 2005)
⊕B/MW-201(06)	SOIL BORING/MONITORING WELL (EA ENGINEERING PC, 2006)
TP-201(10)	TEST PIT (GEI, 2010)
○B-304(10)	SOIL BORING (GEI, 2010)
⊕B/MW-301(10)	SOIL BORING/MONITORING WELL (GEI, 2010)
○2T1	NYSEARCH COAL TAR VAPORIZATION STUDY BORING (GEI, 2010)
⊙2V1	NYSEARCH COAL TAR VAPORIZATION STUDY SOIL VAPOR SAMPLE (GEI, 2010)
○B-401(11)	SOIL BORING (GEI, 2011)
⊞ B/PZ-407(11)	SOIL BORING/PIEZOMETER (GEI, 2011)
⊕B/MW-404(11)	SOIL BORING/MONITORING WELL (GEI, 2011)
TP-301(13)	TEST PIT (GEI, 2013)
○B-501(13)	SOIL BORING (GEI, 2013)
⊞ B/PZ-407(11)	PIEZOMETER DECOMMISSIONED MARCH 2013
⊕ B/MW-302(10)	MONITORING WELL DECOMMISSIONED MARCH 2013

NOTES:

1. ELEVATIONS REFERENCED TO NATIONAL GEODETIC VERTICAL DATUM OF 1929 (NGVD 29). HORIZONTAL LOCATIONS REFERENCED TO NORTH AMERICAN DATUM OF 1983 (NAD 83).
2. BOUNDARIES BASED ON SURVEY BY DELTA ENGINEERS, DATED JANUARY 2013.
3. EXCAVATION EXTENTS ARE BASED ON SOILS THAT CONTAIN GREATER THAN 500 ppm TOTAL PAHs AND/OR VISIBLE TAR CONTAMINATION TO 20 FEET BGS.

SOURCES:

1. BASE MAP TAKEN FROM *TOPOGRAPHIC AND BOUNDARY SURVEY, PORTION OF THE LANDS OF THE CITY OF TROY, NEW YORK (FORMER MGP SITE), 34 HILL STREET,* CITY OF TROY, RENSSELAER COUNTY, STATE OF NEW YORK, SCALE: 1" = 20', DATE: JANUARY 22, 2013 AND APRIL 19, 2013 BY DELTA ENGINEERS, VERNON, NY.
2. *TOPOGRAPHIC SURVEY AND MAP OF NIAGARA MOHAWK MGP SITE SITUATED AT HILL STREET,* CITY OF TROY, COUNTY OF RENSSELAER, N.Y., SCALE: 1" = 50', SITE SURVEYED IN DECEMBER 2005, DECEMBER 2006, OCTOBER 2010, DECEMBER 2010 AND APRIL 2011 BY M.J. ENGINEERING AND LAND SURVEYING, P.C., CLIFTON PARK, NY.
3. SANBORN FIRE INSURANCE MAP, 1885.

0 40 80

SCALE, FEET

HEALTH AND SAFETY PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
TROY, NEW YORK

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EXISTING CONDITIONS AND PROPOSED SCOPE OF WORK

Project 093300-2-1203 | June 2013 | Figure 2

I:\Project\National Grid\TROY\LIBERTY_ST\Remedial Action Work Plan\HASP\Drawings\Troy-RAWP-HASP Figures.dwg

APPENDIX A
CRIME STATISTICS

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Crime Statistics

Absolutely the BEST Places to BE!

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Search:

Search

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Troy Crime Report

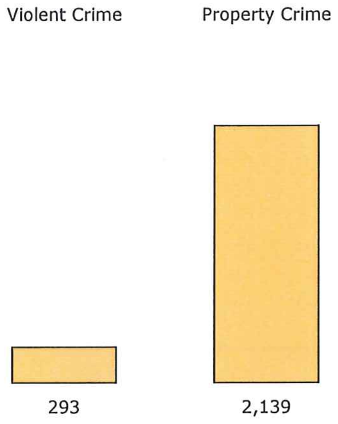
General Information:

State:	New York (NY)
City Population:	48,901
Murder:	2
Forcible Rape:	30
Robbery:	84
Aggravated Assault:	177
Burglary:	520
Larceny or Theft:	1,438
Car Theft:	181
Arson:	0

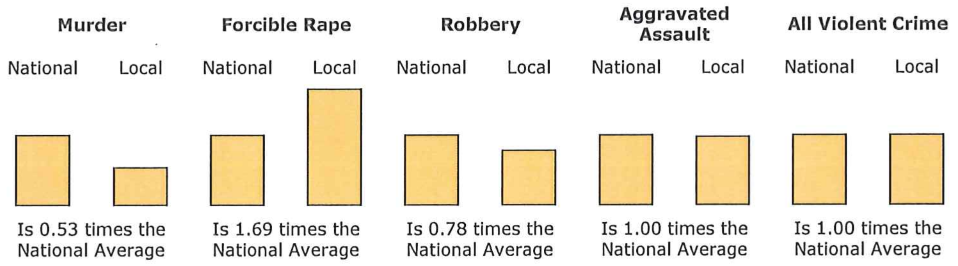
Data Source:
2003 FBI Report of Offenses Known to Law Enforcement

Zero values may indicate the data was not available.

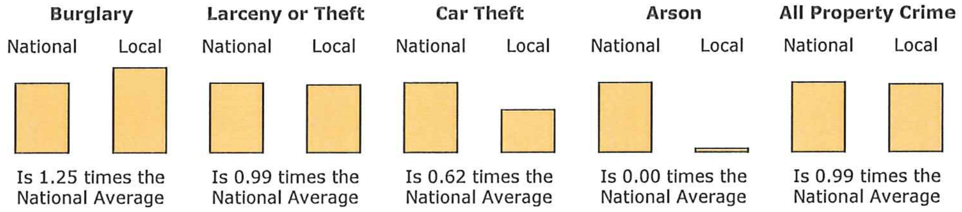
Violent vs. Property Crime Rate:



Troy Violent Crime Rate per Capita:



Troy Property Crime Rate per Capita:



Troy Information Links:

View Weather History View Weather Forecast More Cities

Questions? Comments?
E-mail: info@cityrating.com

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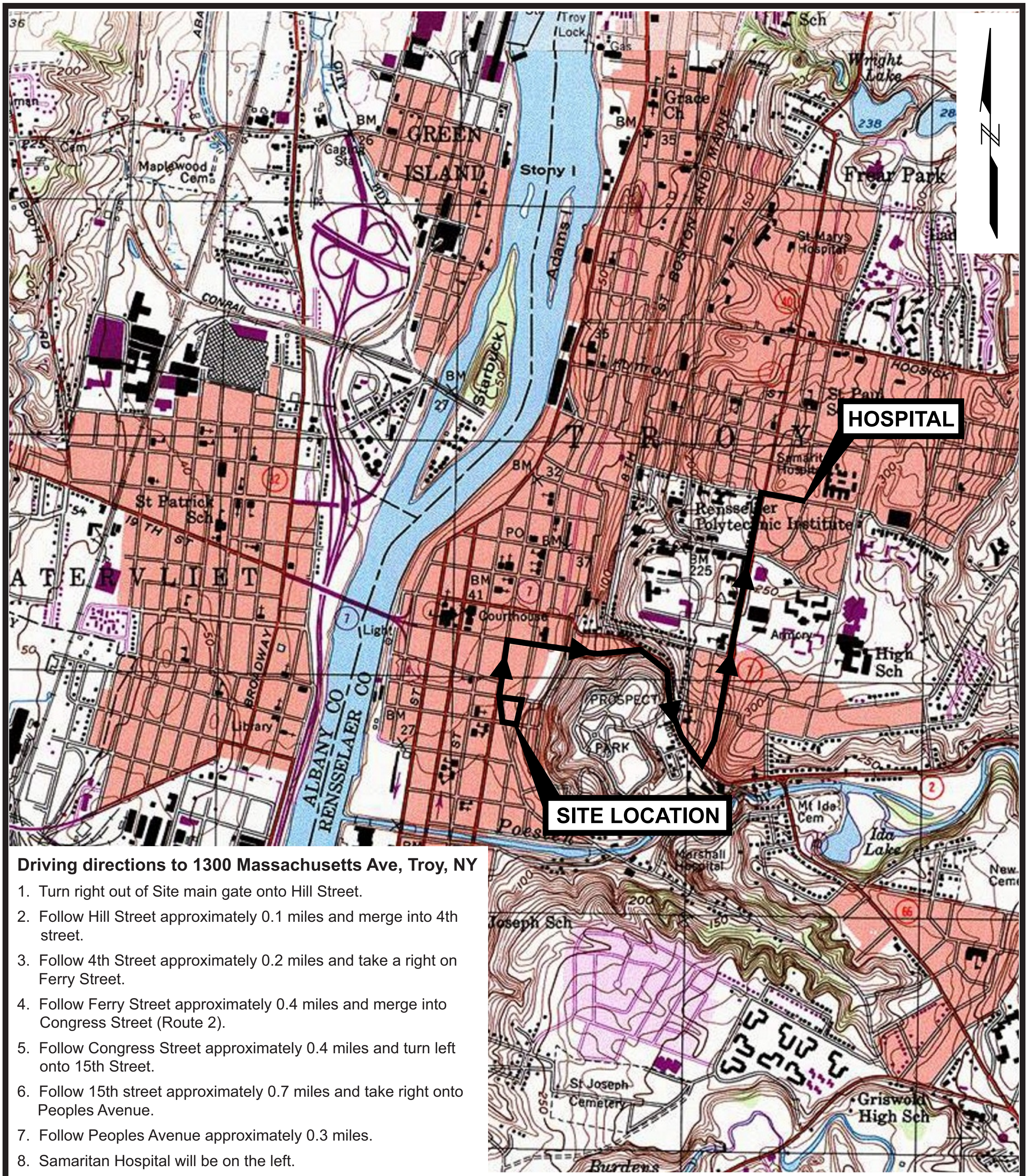
APPENDIX B
MAP TO HOSPITAL
and
OCCUPATIONAL HEALTH CARE CLINIC



Driving directions to 1300 Massachusetts Ave, Troy, NY

1. Turn right out of Site main gate onto Hill Street.
2. Follow Hill Street approximately 0.1 miles and merge into 4th street.
3. Follow 4th Street approximately 0.2 miles and take a right on Ferry Street.
4. Follow Ferry Street approximately 0.4 miles and merge into Congress Street (Route 2).
5. Follow Congress Street approximately 0.4 miles and turn left onto 15th Street.
6. Follow 15th street approximately 0.7 miles and take right onto Peoples Avenue.
7. Follow Peoples Avenue approximately 0.3 miles.
8. Samaritan Hospital will be on the left.

DIRECTIONS SOURCE: Google Maps (maps.google.com)

MAP SOURCE: Drawing created with TOPO! ® ©2001 National Geographic (www.nationalgeographic.com/topo)

0 2000 4000

SCALE, FEET

HEALTH AND SAFETY PLAN
TROY (LIBERTY STREET)
NON-OWNED FORMER MGP SITE
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ROUTE TO SAMARITAN HOSPITAL

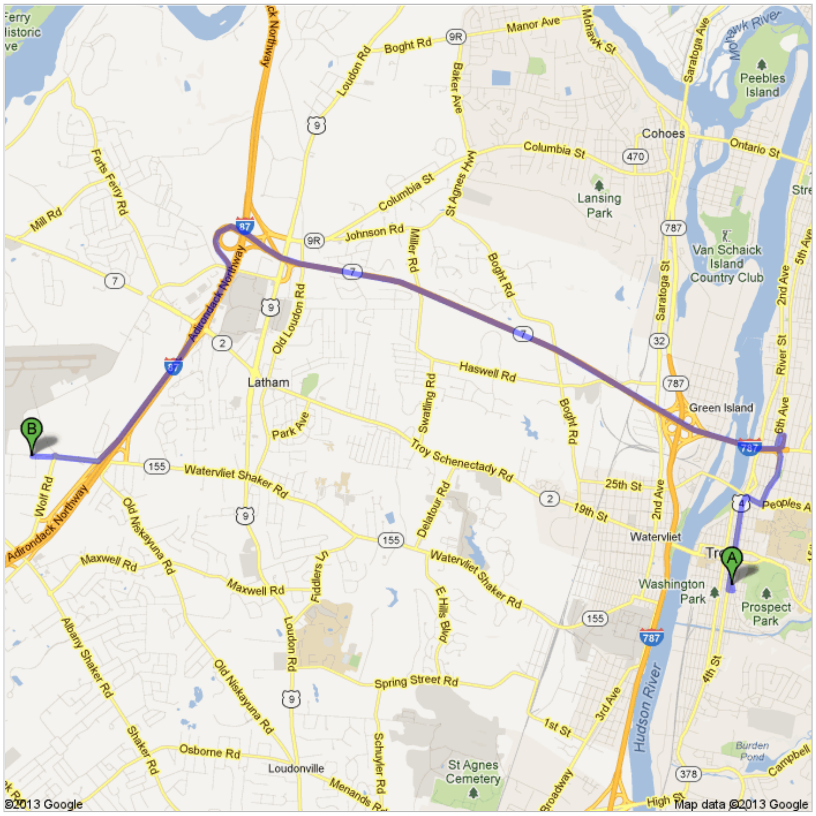
Project 093300-2-1203

June 2013

Appendix B

I:\Project\National Grid\TROY\LIBERTY_ST\Remedial Action Work Plan\HASP\Drawings\LIBERTY ST-SITE LOCATION.CDR

Directions to 776 Watervliet Shaker Rd, Latham, NY 12110
8.9 mi – about **15 mins**
Directions to Occupational Health Care Clinic



A 24 Hill St, Troy, NY 12180

	1. Head **south** on **Hill St** toward **Washington St**	go 184 ft total 184 ft
↱	2. Take the 1st right onto **Washington St**	go 180 ft total 364 ft
↱	3. Take the 1st right onto **4th St** About 3 mins	go 0.7 mi total 0.7 mi
↗	4. Slight right onto **River St**	go 328 ft total 0.8 mi
↱	5. Take the 1st right onto **Federal St**	go 0.1 mi total 0.9 mi
↰	6. Take the 3rd left onto **6th Ave** About 2 mins	go 0.6 mi total 1.5 mi
↗	7. Take the **New York 7 W/Interstate 787** ramp	go 0.2 mi total 1.7 mi
787	8. Merge onto **I-787**	go 0.5 mi total 2.2 mi
7	9. Continue onto **NY-7 W** About 4 mins	go 3.7 mi total 5.9 mi
87	10. Keep left at the fork, follow signs for **I-87 S/Albany** and merge onto **I-87 S** About 3 mins	go 2.3 mi total 8.1 mi
↗	11. Take exit **5** for **NY-155 E** toward **Latham**	go 0.2 mi total 8.4 mi
155	12. Turn right onto **NY-155 W/Watervliet Shaker Rd**	go 0.3 mi total 8.7 mi
↱	13. At the traffic circle, continue straight onto **Watervliet Shaker Rd** Destination will be on the left About 1 min	go 0.2 mi total 8.9 mi

B 776 Watervliet Shaker Rd, Latham, NY 12110

APPENDIX C
MATERIAL SAFETY DATA SHEETS

Genium Publishing Corporation
1145 Catalyn Street
Schenectady, NY 12303-1836 USA
(518) 377-8854

Material Safety Data Sheets Collection:

Sheet No. 316
Benzene

Issued: 11/78 Revision: E, 8/90

Section 1. Material Identification

32

Benzene (C_6H_6) Description: Derived by fractional distillation of coal tar, hydrodealkylation of toluene or pyrolysis of gasoline, catalytic reforming of petroleum, and transalkylation of toluene by disproportionation reaction. Used as a fuel; a chemical reagent; a solvent for a large number of materials such as paints, plastics, rubber, inks, oils, and fats; in manufacturing phenol, ethylbenzene (for styrene monomer), nitrobenzene (for aniline), dodecylbenzene (for detergents), cyclohexane (for nylon), chlorobenzene, diphenyl, benzene hexachloride, maleic anhydride, benzene-sulfonic acid, artificial leather, linoleum, oil cloth, varnishes, and lacquers; for printing and lithography; in dry cleaning; in adhesives and coatings; for extraction and rectification; as a degreasing agent; in the tire industry; and in shoe factories. Benzene has been banned as an ingredient in products intended for household use and is no longer used in pesticides.
Other Designations: CAS No. 0071-43-2, benzol, carbon oil, coal naphtha, cyclohexatriene, mineral naphtha, nitration benzene, phene, phenyl hydride, pyrobenzol.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R	1
I	4
S	2*
K	4

*Skin absorption

NFPA

3
2 0
-

HMIS

H	3
F	3
R	0
PPG†	

† Sec. 8

Cautions: Benzene is a confirmed *human carcinogen* by the IARC. *Chronic low-level exposure may cause cancer (leukemia) and bone marrow damage, with injury to blood-forming tissue.* It is also a dangerous fire hazard when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Benzene, ca 100%*

1989 OSHA PELs
(29 CFR 1910.1000, Table Z-1-A)
8-hr TWA: 1 ppm, 3 mg/m³
15-min STEL: 5 ppm, 15 mg/m³

(29 CFR 1910.1000, Table Z-2)
8-hr TWA: 10 ppm
Acceptable Ceiling Concentration: 25 ppm
Acceptable Maximum Peak: 50 ppm (10 min)†

1989-90 ACGIH
TLV-TWA: 10 ppm, 32 mg/m³

1988 NIOSH RELs
TWA: 0.1 ppm, 0.3 mg/m³
Ceiling: 1 ppm, 3 mg/m³

1985-86 Toxicity Data‡
Man, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted
Man, inhalation, TC_{Lo}: 150 ppm inhaled intermittently over 1 yr in a number of discrete, separate doses affects the blood (other changes) and nutritional and gross metabolism (body temperature increase)
Rabbit, eye: 2 mg administered over 24 hr produces severe irritation

---

* OSHA 29 CFR 1910.1000, Subpart Z, states that the final benzene standard in 29 CFR 1910.1028 applies to all occupational exposures to benzene except in some subsegments of industry where exposures are consistently under the action level (i.e., distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures); for the excepted subsegments, the benzene limits in Table Z-2 apply.
† Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift.
‡ See NIOSH, *RTECS* (CY1400000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 176 °F (80 °C)
Melting Point: 42 °F (5.5 °C)
Vapor Pressure: 100 mm Hg at 79 °F (26.1 °C)
Vapor Density (Air = 1): 2.7
Evaporation Rate (Ether = 1): 2.8

Molecular Weight: 78.11
Specific Gravity (15 °C/4 °C): 0.8787
Water Solubility: Slightly (0.180 g/100 g of H_2O at 25 °C)
%Volatile by Volume: 100
Viscosity: 0.6468 mPa at 20 °C

Appearance and Odor: A colorless liquid with a characteristic sweet, aromatic odor. The odor recognition threshold (100% of panel) is approximately 5 ppm (unfatigued) in air. Odor *is not* an adequate warning of hazard.

Section 4. Fire and Explosion Data

Flash Point: 12 °F (-11.1 °C), CC	Autoignition Temperature: 928 °F (498 °C)	LEL: 1.3% v/v	UEL: 7.1% v/v

Extinguishing Media: Use dry chemical, foam, or carbon dioxide to extinguish benzene fires. Water may be ineffective as an extinguishing agent since it can scatter and spread the fire. Use water spray to cool fire-exposed containers, flush spills away from exposures, disperse benzene vapor, and protect personnel attempting to stop an unignited benzene leak.
Unusual Fire or Explosion Hazards: Benzene is a Class 1B flammable liquid. A concentration exceeding 3250 ppm is considered a potential fire explosion hazard. Benzene vapor is heavier than air and can collect in low lying areas or travel to an ignition source and flash back. Explosive and flammable benzene vapor-air mixtures can easily form at room temperature. Eliminate all ignition sources where benzene is used, handled, or stored.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Structural firefighter's protective clothing provides limited protection. Stay out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Runoff to sewer can create pollution, fire, and explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Benzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Benzene explodes on contact with diborane, permanganic acid, bromine pentafluoride, peroxodisulfuric acid, and peroxomonosulfuric acid. It ignites on contact with dioxygen difluoride, dioxygenyl tetrafluoroborate, iodine heptafluoride, and sodium peroxide + water. Benzene forms sensitive, explosive mixture with iodine pentafluoride, ozone, liquid oxygen, silver perchlorate, nitryl perchlorate, nitric acid, and arsenic pentafluoride + potassium methoxide (explodes above 30 °C). A vigorous or incandescent reaction occurs with bromine trifluoride, uranium hexafluoride, and hydrogen + Raney nickel [above 410 °F (210 °C)]. Benzene is incompatible with oxidizing materials.
Conditions to Avoid: Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition of benzene can produce toxic gases and vapors such as carbon monoxide.

Section 6. Health Hazard Data

Carcinogenicity: The ACGIH, OSHA, and IARC list benzene as, respectively, a supected human carcinogen, a cancer hazard, and, based on sufficient human and animal evidence, a human carcinogen (Group 1).
Summary of Risks: Prolonged skin contact or excessive inhalation of benzene vapor may cause headache, weakness, appetite loss, and fatigue. The most important health hazards are cancer (leukemia) and bone marrow damage with injury to blood-forming tissue from chronic low-level exposure. Higher level exposures may irritate the respiratory tract and cause central nervous system (CNS) depression.
Medical Conditions Aggravated by Long-Term Exposure: Exposure may worsen ailments of the heart, lungs, liver, kidneys, blood, and CNS.
Target Organs: Blood, central nervous system, bone marrow, eyes, upper respiratory tract, and skin.
Primary Entry Routes: Inhalation, skin contact.
Acute Effects: Symptoms of acute overexposure include irritation of the eyes, nose, and respiratory tract, breathlessness, euphoria, nausea, drowsiness, headache, dizziness, and intoxication. Severe exposure may lead to convulsions and unconsciousness. Skin contact may cause a drying rash (dermatitis).
Chronic Effects: Long-term chronic exposure may result in many blood disorders ranging from aplastic anemia (an inability to form blood cells) to leukemia.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Immediately rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air. Emergency personnel should protect against inhalation exposure. Provide CPR to support breathing or circulation as necessary. Keep awake and transport to a medical facility.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* since aspiration may be fatal. Call a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Evaluate chronic exposure with a CBC, peripheral smear, and reticulocyte count for signs of myelotoxicity. Follow up any early indicators of leukemia with a bone marrow biopsy. Urinary phenol conjugates may be used for biological monitoring of recent exposure. Acute management is primarily supportive for CNS depression.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a benzene spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation, eye contact, and skin absorption. Absorb as much benzene as possible with an inert, noncombustible material. For large spills, dike far ahead of spill and contain liquid. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of confined spaces such as sewers, watersheds, and waterways because of explosion danger. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U019
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307 (a), 311 (b)(4), 112; and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations at least below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and incompatible materials. *Caution! Benzene vapor may form explosive mixtures in air.* To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. When opening or closing benzene containers, use nonsparking tools. Keep fire extinguishers readily available.
Engineering Controls: Because OSHA specifically regulates benzene (29 CFR 1910.1028), educate workers about its potential hazards and dangers. Minimize all possible exposures to carcinogens. If possible, substitute less toxic solvents for benzene; use this material with extreme caution and only if absolutely essential. Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Designate regulated areas of benzene use (see legend in the box below) and label benzene containers with "DANGER, CONTAINS BENZENE, CANCER HAZARD."
Other Precautions: Provide preplacement and periodic medical examinations with emphasis on a history of blood disease or previous exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Benzene (*benzol*)
DOT Hazard Class: Flammable liquid
ID No.: UN1114
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Benzene
IMO Hazard Class: 3.2
ID No.: UN1114
IMO Label: Flammable liquid
IMDG Packaging Group: II

DANGER
BENZENE
CANCER HAZARD
FLAMMABLE–NO SMOKING
AUTHORIZED PERSONNEL ONLY
RESPIRATOR REQUIRED

***MSDS Collection* References:** 1, 2, 12, 26, 73, 84-94, 100, 101, 103, 109, 124, 126, 127, 132, 134, 136, 138, 139, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

Genium Publishing Corp.
One Genium Plaza
Schenectady, NY 12304-4690
(518) 377-8854

Material Safety Data Sheet Collection

Bromoform **MSDS No. 648**

Issue Date: 5/99

Section 1 - Chemical Product and Company Identification 52

Product/Chemical Name: Bromoform
Chemical Formula: $CHBr_3$
CAS Number: 75-25-2
Synonyms: formyl tribromide; methane, tribromo-; methyl tribromide; tribrommethan (German); tribromomethane
Derivation: Prepared from acetone and sodium hypobromite; or by heating acetone or ethanol with bromine and alkali hydroxide and recovery by distillation (similar to acetone process of chloroform); by treating chloroform with aluminum bromide; and by electrolysis of potassium bromide in ethyl alcohol.
General Use: As an antitussive, hypnotic; in medicines (as a sedative); as an intermediate in organic synthesis; in geological assaying; solvent for waxes, greases and oils; ingredient in fire resistant chemicals and gauge fluid; used in shipbuilding and aircraft industries; pharmaceutical synthesis; floatation agent in mineral separation.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Bromoform. Purity grades 96% and 99%
Trace Impurities: Commercial preparation is generally stabilized by the addition of 3% to 4% alcohol.

OSHA PEL	**NIOSH REL**	**DFG (Germany) MAK**
8-hr TWA: 0.5 ppm (5 mg/m^3), *Skin*	10-hr TWA: 0.5 ppm (5 mg/m^3), *Skin*	None established
ACGIH TLV	**IDLH Level**	
TWA: 0.5 ppm (5.2 mg/m^3), *Skin*	850 ppm	

Section 3 - Hazards Identification

ANSI Signal Word: Warning!

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Bromoform is a colorless heavy liquid with a chloroform-like odor. It is extremely irritating to the eyes, skin, and respiratory system and may cause burns. The central nervous system, respiratory system, liver and kidneys seem to be the most affected. Chronic exposure may alter genetic material. Animal studies have shown bromoform to be mutagenic and a confirmed animal carcinogen and it is listed as a suspected human carcinogen. Note that the odor threshold is at the same level as the exposure limits.

Wilson Risk Scale	
R	1
I	4
S	2*
K	0
*Skin absorption	
HMIS	
H	2
F	0
R	0
PPE†	
†Sec. 8	

Potential Health Effects

Primary Entry Routes: Inhalation, skin absorption, ingestion, skin and/or eye contact
Target Organs: Respiratory and central nervous systems, skin, eyes, liver, and kidneys
Acute Effects
Inhalation: Bromoform vapors will cause irritation of the respiratory tract, pharynx, and larynx, including lacrimation and salivation. It has a narcotic action and acts as a depressant on the central nervous system, leading to dizziness, a lightheaded feeling and unconsciousness. Symptoms of exposure include coughing, wheezing, laryngitis, shortness of breath, headache, nausea and vomiting, pulmonary edema, convulsions, and shock. When used medicinally, abuse can lead to addiction and serious consequences.
Eye: Contact causes irritation and burning sensation.
Skin: Considered moderately toxic by subcutaneous route; absorption can affect the central nervous system and damage the liver. Contact will cause skin irritation, rash or burning feeling upon contact.
Ingestion: Considered a human poison by ingestion. Accidental ingestion of this liquid can produce central nervous system depression, coma, and loss of reflexes. Small ingested amounts have led to listlessness, headache, and vertigo.
Carcinogenicity: ACGIH (A3 - Confirmed Animal Carcinogen with Unknown Relevance to Humans); EPA (B2 - Sufficient evidence from animal studies; inadequate evidence or no data from epidemiological studies); IARC (3 - Not Classifiable as to Carcinogencity to Humans); MAK (B - Justifiably suspected of having carcinogenic potential). OSHA and NTP do not list bromoform as a carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Serious damage to the liver.
Chronic Effects: None reported; however, long-term exposure may alter genetic material.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed. *Do not* use mouth-to-mouth method if victim has ingested or inhaled the substance. Induce artificial respiration with the aid of a pocket mask equipped with a one-way valve or other proper respiratory-medical device.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician or ophthalmologist immediately.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Section 5 - Fire-Fighting Measures

Flash Point: Not applicable; material may burn, but does not ignite readily.

Autoignition Temperature: Not listed.

LEL: Not applicable.

UEL: Not applicable.

Flammability Classification: Noncombustible Liquid

Extinguishing Media: For small fires use dry chemical, CO_2, water spray or regular foam; on large fires use water spray, fog or regular foam.

Unusual Fire or Explosion Hazards: Containers may explode in heat of fire.

Hazardous Combustion Products: Toxic fumes of bromine oxides are produced in fire situations.

Fire-Fighting Instructions: For large scale fires consider initial evacuation of 1/2 mile (800 meters) in all directions. *Do not* release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing *is* recommended for fire situations.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Consider downwind evacuation for at least 330 feet (100 meters). Cleanup personnel should wear fully-encapsulated, vapor-protective clothing. See Section 8 - Protective Clothing for suggested suitable material. Structural firefighters' protective clothing is not recommended in spill situations. Keep spilled material out of low or enclosed spaces.

Small Spills: Take up with sand or other noncombustible absorbent material and place into containers for later disposal.

Large Spills

Containment: For large spills, dike far ahead of liquid spill for later disposal. *Do not* release into sewers or waterways. Do not use water spray since bromoform is heavier than water, and spray may only spread spill. Heavy vapors may accumulate in low spaces.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Where possible, automatically pump liquid bromoform from drums or other storage containers to process containers.

Storage Requirements: Store in tightly closed containers protected from exposure to both light and air (oxygen). Maintain storage area above freezing point (47 °F).

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Unless a less toxic chemical can be substituted for a hazardous substance, engineering controls are the most effective way of reducing exposure. The best protection, however, is to enclose all processes where possible to prevent dispersion of vapors into work area. Train workers in the proper handling and use of this possible carcinogen.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, liver, kidney, or chronic respiratory diseases.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For concentrations of >0.5 to 5 ppm use an air-purifying, negative-pressure with half mask, plus eye protection; for concentrations at >5 to 50 ppm use an air-purifying, negative-pressure, full face. Note that a negative-pressure respirator is not appropriate in oxygen-deficient atmospheres. At concentrations of >50 to <850 ppm use a supplied-air, constant flow/pressure-demand, full-ace respirator; for concentrations of 850 to unlimited ppm use a self-contained breathing apparatus (SCBA), operated in the pressure-demand mode with full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl-alcohol and Vitron™ (breakthrough time >8 hr) are suggested as suitable material for PPE. The following are deemed unsuitable due to breakthrough times of an hour or less: butyl rubber, natural rubber, neoprene, nitrile rubber, and polyvinyl chloride. Wear splashproof chemical goggles and face shield, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not protective eye devices. Appropriate eye protection must be worn instead of, or in conjunction with, contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid

Appearance and Odor: Colorless to yellow, heavy liquid with chloroform odor.

Odor Threshold: 1-6 mg/m^3

Vapor Pressure: 5 mm Hg at 68 °F (20 °C)

Formula Weight: 252.8

Density (H_2O=1, at 4 °C): 2.9035

Specific Gravity: 2.8912 at 68 °F (20 °C)

Water Solubility: Slightly soluble (0.1%)

Other Solubilities: Miscible with alcohol, benzene, chloroform, ether, petroleum ether, acetone, and oils

Vapor Density: 8.7

Boiling Point: 301 °F (149.4 °C)

Freezing Point: 47 °F (8.3 °C)

Ionization Potential: 10.48 ev

Critical Temperature: 797 °F (425 °C)

Liquid Surface Tension: 41.53 dynes/cm at 68 °F (20°C)

BCF: estimated at 37.4

Henry's Law Constant (H): estimated at 6.6 x 10^{-4}

Octanol/Water Partition Coefficient: log K_{ow} = calculated at 2.38

Soil Sorption Coefficient (K_{oc}): calculated at 1.99

Refractive Index: 1.5980 at 84.2 °F (29 °C)

Section 10 - Stability and Reactivity

Stability: Bromoform is stable at room temperature in tightly closed containers, protected from light and air (oxygen), under normal storage and handling conditions.

Polymerization: Hazardous polymerization cannot occur.

Chemical Incompatibilities: Acetone; aluminum; calcium; caustic alkalies; lithium; magnesium; potassium; sodium; strong caustics; zinc. Crown ethers and potassium hydroxide promote dihalocarbene formation. Liquid bromoform will attack some forms of plastics, rubber, and coatings.

Conditions to Avoid: Bromoform mixed with lithium can explode on contact. Mixtures of bromoform and sodium-potassium alloy can explode on standing at room temperatures.They are especially sensitive to impact. Exposure to light and air will accelerate decomposition. Gradual decomposition has begun if liquid takes on a yellowish appearance. The interaction of bromoform with acetone in the presence of powdered potassium hydroxide or other bases is violently exothermic, even in the presence of diluting solvents.

Hazardous Decomposition Products: Thermal oxidative decomposition of bromoform can produce highly toxic gases of carbon monoxide, hydrogen bromide, and bromine oxides.

Section 11 - Toxicological Information

Toxicity Data:*

Acute Oral Effects:

Human, oral, LD_{Lo}: 143 mg/kg

Rat, oral, LD_{50}: 933 mg/kg caused dyspnea.

Acute Inhalation Effects:

Mammal, inhalation, LC_{50}: 12100 mg/m^3

Rat, inhalation, LC_{Lo}: 45 g/m^3/4 hr

Acute Dermal Effects:

Rabbit, subcutaneous, LD_{Lo}: 410 mg/kg

Reproductive Effects:

Mice (male/female), oral: 200 mg/kg/day had no significant effect on reproduction and fertility of the dosed animals.

Tumorigenicity:

Rat, oral: 10400 mg/kg administered continuously over 2 years produced toxic effects: carcinogenic by *RTECS* criteria; gastrointestinal tumors.

Mouse, intraperitoneal: 1100 mg/kg for 8 weeks, intermittent, produced toxic effects: neoplastic by *RTECS* criteria; tumors of lung, throat or respiratory system.

Mutagenicity:

Human, lymphocyte: 80 µmol/L produced sister chromatid exchange

Bacteria, *Styphimurium*, 100 µg/plate (-S9) induced mutation.

Teratogenicity:

Pregnant rats administered 100 or 200 mg/kg/day during gestation had an increased incidence of minor skeletal anomalies, but no other significant feto- or teratogenic effects.

Other Multiple Dose Toxicity:

Rat, oral: 5840 mg/kg administered continuously over 1 year produced toxic effects: Kidney, ureter, and bladder - Other changes in urine composition.

Rat, oral: 13 g/kg administered intermittently over 13 weeks produced toxic effects: Liver - Other changes.

Rat, oral: 5600 mg/kg administered intermittently over 14 days produced toxic effects: Death.

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* See NIOSH, *RTECS* (PB5600000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: *Cyprinodon variegatus* (sheepshead minnow), LC_{50}: 17,900 mg/L/96 hr static bioassay; *Crassostrea virginica* (eastern oyster) larvae, LD_{50}: 1 mg/L/48 hr static bioassay; after 48 hours, only approximately 30 percent of original concentration was still present. *Lepomis macrochirus* (bluegill sunfish), LC_{50}: 29,300 mg/L/96 hr static bioassay; *Mysidopsis bahia* (mysid shrimp), LC_{50}: 24,400 mg/L/96 hr static bioassay.

Environmental Transport: Hydrolysis is expected to be slow. Release to the atmosphere will result in the reaction with photochemically-generated hydroxyl radicals with an estimated half-life of 1.45 years. Direct photolysis in the troposphere is not expected to be significant, but may occur in the stratosphere.

Environmental Degradation: Anaerobic biodegradation may occur, but aerobic biodegradation is not expected to be significant.

Soil Absorption/Mobility: Release to soil will likely result in leaching to groundwater due to the weak absorption to soil; volatilization from moist soil surfaces should also occur.

Section 13 - Disposal Considerations

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable federal, state, and local regulations. Bromoform is a potential candidate for rotary kiln incineration, liquid injection incineration and fluidized bed incineration (specific incineration temperatures vary). Consult with an environmental regulatory agency for guidance on acceptable disposal practices in your area.

Disposal Regulatory Requirements: None reported.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Methane, tribromo-
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN2515
Packing Group: III
Label: Keep Away From Food
Special Provisions (172.102): T7

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft/Rail: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 12, 40

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33)
RCRA Hazardous Waste Number: U225
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per CWA, Sec. 307(a); RCRA, Sec. 3001
CERCLA Final Reportable Quantity (RQ), 100 lb (45.35 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 1, 73, 103, 124, 136, 149, 176, 190, 208, 209, 217, 222, 223, 224, 227, 228, 230

Prepared By .... N Golub/M Adams, Ph.D
Research Date 4/98
Review Date 4/99
Industrial Hygiene Review .... DJ Wilson, CIH
Medical Review .... G Kelafant, MD

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Material Safety Data Sheets Collection:

Sheet No. 514
***p*-Dichlorobenzene**

Issued: 10/83 Revision: A, 11/90

Section 1. Material Identification

33

***p*-Dichlorobenzene ($C_6H_4Cl_2$) Description:** Derived by chlorinating monochlorobenzene. Used as a general insecticide; a moth repellent; a germicide; a chemical intermediate in the production of polyphenylene sulfide; a plastic used in the electrical and electronics industries; a space deodorant in products such as room deodorizers, urinal and toilet bowl blocks, and diaper pail deodorizers; and in producing 1,2,4 trichlorobenzene.

Other Designations: CAS No. 0106-46-7, 1,4-dichlorobenzene, dichlorocide, Evola,® NCI-c 54955, Paracide,® Paracrystals, Paradi,® paradichlorobenzol, Paramoth,® *p*-chlorophenyl chloride, PDB,® Santochlor.®

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

Cautions: *p*-Dichlorobenzene vapor is an eye and upper respiratory tract irritant. *It is toxic to the liver*. Prolonged exposure to high concentrations may cause weakness, dizziness, and weight loss. Flammable when exposed to heat, flame, or oxidizers.

R 1
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NFPA
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HMIS
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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

p-Dichlorobenzene, ca 100%

1989 OSHA PELs	**1990-91 ACGIH TLVs**	**1988 NIOSH REL**	**1985-86 Toxicity Data***
8-hr TWA: 75 ppm, 450 mg/m³ 15-min STEL: 110 ppm, 675 mg/m³	TWA: 75 ppm, 451 mg/m³ STEL: 110 ppm, 661 mg/m³	None established	Human, oral, TD_{Lo}: 300 mg/kg produced sense organs and special senses (other eye effects); lungs, thorax, or respiration (other changes); and gastrointestinal (hypermotility, diarrhea) effects Human, eye: 80 ppm

1987 IDLH Level
1000 ppm

* See NIOSH, *RTECS* (CZ4550000), for additional irritative, mutative, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 345 °F (174 °C) at 760 mm Hg
Melting Point: 127.6 °F (53.1 °C)
Vapor Pressure: 10 mm Hg at 130.6 °F (54.8 °C)
Vapor Density (Air = 1): 5.08
Molecular Weight: 147.01
Specific Gravity: 1.248 at 131 °F (55 °C)
Water Solubility: Insoluble

Appearance and Odor: Volatile, white crystals with a distinctive mothball-like odor that becomes very strong at concentrations between 30 and 60 ppm. At concentrations of 80 to 160 ppm, vapors are painful to the eyes and nose. Odors and irritating effects are good warnings against overexposure to *p*-dichlorobenzene; however, individuals may develop tolerance to high concentrations.

Section 4. Fire and Explosion Data

Flash Point: 150 °F (66 °C), CC	**Autoignition Temperature:** None reported	**LEL:** 1.7% v/v	**UEL:** None reported

Extinguishing Media: Use dry chemical, carbon dioxide, alcohol foam, or water spray. Use water spray to cool fire-exposed container, to disperse vapors, or to blanket a pool fire.

Unusual Fire or Explosion Hazards: Explosive and toxic mixtures may form in air when this material is heated, such as in a fire.

Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective clothing. Thoroughly decontaminate firefighting equipment after use. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: *p*-Dichlorobenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: *p*-Dichlorobenzene is incompatible with strong oxidizers and oxidizing agents.

Conditions to Avoid: Avoid incompatibilities and heat or ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of *p*-dichlorobenzene includes carbon monoxide, chlorides, and chlorine.

Section 6. Health Hazard Data

Carcinogenicity: *p*-Dichlorobenzene is an NTP anticipated human carcinogen and an IARC possible human carcinogen (Group 2B) with inadequate human evidence and sufficient animal evidence.
Summary of Risks: This material has a relatively low level of acute or chronic toxicity. It may be irritating to eyes, nose, upper airways, and intestinal tract upon inhalation or ingestion. Limited case reports link acute exposure to hemolytic anemia, jaundice, methemglobinemia, granulomas of the lung, liver atrophy, toxic hepatitis, kidney injury, and allergic pigmentation and purpura (tiny hemorrhages) of the skin. Occupational studies of PDB-exposed workers reveal none of the blood abnormalities noted with similar substances. Vapors may produce painful irritation of the eyes at 50 to 80 ppm and severe discomfort at 160 ppm.
Medical Conditions Aggravated by Long-Term Exposure: Individuals with liver disease should not be exposed to *p*-dichlorobenzene.
Target Organs: Liver, respiratory system, eyes, kidneys, and skin.
Primary Entry Routes: Inhalation and dermal contact.
Acute Effects: Acute exposures to PDB vapor may be irritating to mucous membranes of the eyes and upper respiratory tract. Ingestion of the solid resulted in toxicity to a 3-year old child, with hemolytic anemia, jaundice, and methemglobinemia. Nausea, vomiting, and diarrhea are seen in other cases. Prolonged skin exposure may cause skin irritation.
Chronic Effects: Limited case studies show chronic toxicity with exposure to PDB. Chronic ingestion is linked to anemia, leukemia, and kidney damage. In one case, chemical dependence was noted with signs of withdrawal when ingestion stopped. Chronic vapor exposure is suggested in cases of lung granulomatosis, liver abnormalities, kidney damage, anemia, other blood cell abnormalities, and cataract formation.
FIRST AID
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious* person drink 1 to 2 glasses of water, then induce vomiting. Consult a physician.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Urinary excretion of 2,5-dichlorophenol, a metabolite of *p*-dichlorobenzene, may be useful as an index of exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, and remove or extinguish all heat and ignition sources. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For liquid spills, take up spilled material with noncombustible absorbent material and place into clean metal containers for disposal. For large liquid spills, dike far ahead of spill to contain liquid. For dry spills, shovel spilled material into clean metal containers for disposal. Runoff to sewers or waterways may create health and explosion hazards. (96-hr LC_{50}, fathead minnow: 4.2 to 30 mg/l, moderately toxic.) Pesticide wastes are toxic. Follow applicable EPA and OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U072
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per Clean Water Act, Sec. 311(b)(4), Sec. 307(a), and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. A gas mask with organic vapor canister and dust filter is suitable to 1000 ppm. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Neoprene gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below OSHA PELs and ACGIH TLVs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and oxidizing agents. *p*-Dichlorobenzene melts at 127 °F (53 °C). Protect containers against physical damage.
Engineering Controls: Avoid dust or vapor inhalation and eye and skin contact (especially when heated). Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Practice good personal hygiene and housekeeping procedures.
Other Precautions: Provide preplacement and annual physical examinations that emphasize the liver (liver function tests), upper respiratory tract, and eyes.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Dichlorobenzene, para, solid
DOT Hazard Class: ORM-A
ID No.: UN1592
DOT Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.510

IMO Shipping Name: *p*-Dichlorobenzene
IMO Hazard Class: 6.1
ID No.: UN1592
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 1-7, 9, 10, 12, 14, 16, 23, 26, 31, 34, 38, 43, 48, 73, 84, 85, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 139, 140, 142, 143, 146, 148
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists 1,2-dichloroethylene as a carcinogen.

Summary of Risks: 1,2-Dichloroethylene's most important effect is its irritation of the central nervous system (CNS) and narcosis. This material toxic by inhalation, ingestion, and skin contact. It is also irritating to the eyes. The trans-isomer at 2200 ppm causes nausea, vertigo, and burning of the eyes. The trans-isomer is twice as potent as the cis-isomer. If renal effects occur, they are transient.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Central nervous system, eyes, respiratory system.

Primary Entry Routes: Inhalation, ingestion, skin and eye contact.

Acute Effects: Inhalation of 1,2-dichloroethylene causes narcosis, respiratory tract irritation, nausea, vomiting, tremor, weakness, central nervous depression, and epigastric (the abdomen's upper midregion) cramps. Contact with the liquid causes eye and skin (on prolonged contact) irritation. Ingestion causes slight depression to deep narcosis.

Chronic Effects: None reported.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed. Have trained personnel administer 100% oxygen, preferably with humidification.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Physician's Note: Intravenous injections of calcium gluconate may relieve cramps and vomiting. Treat central nervous system effects symptomatically.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a 1,2-dichloroethylene spill control and countermeasure plan (SCCP).* Notify safety personnel, remove all heat and ignition sources, evacuate hazard area, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Absorb small spills on paper towels. After evaporating the 1,2-dichloroethylene from these paper towels in a fume hood, burn the paper in a suitable location away from combustible material. Collect and atomize large quantities in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Follow applicable OSHA regulations (29 CFR 1910.120).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001, per Clean Water Act, Sec. 307(a)]†

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

† Listed as 1,2-*trans*-dichloroethylene.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. 1,2-dichloroethylene attacks some forms of plastics, rubber, and coatings.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and oxidizing materials. Outside or detached storage is preferred. If stored inside, place containers in a standard flammable liquids storage cabinet or room. Protect containers from physical damage.

Engineering Controls: Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. 1,2-dichloroethylene is a ngerous fire hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide replacement questionnaires which emphasize detecting a history of chronic respiratory disease.

Transportation Data (49 CFR 172.101, .102): Not listed

MSDS Collection **References:** 7, 26, 38, 73, 84, 85, 87, 88, 100, 101, 103, 109, 126, 127, 136, 137

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists 1,2-dichloroethylene as a carcinogen.

Summary of Risks: 1,2-Dichloroethylene's most important effect is its irritation of the central nervous system (CNS) and narcosis. This material toxic by inhalation, ingestion, and skin contact. It is also irritating to the eyes. The trans-isomer at 2200 ppm causes nausea, vertigo, and burning of the eyes. The trans-isomer is twice as potent as the cis-isomer. If renal effects occur, they are transient.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Central nervous system, eyes, respiratory system.

Primary Entry Routes: Inhalation, ingestion, skin and eye contact.

Acute Effects: Inhalation of 1,2-dichloroethylene causes narcosis, respiratory tract irritation, nausea, vomiting, tremor, weakness, central nervous depression, and epigastric (the abdomen's upper midregion) cramps. Contact with the liquid causes eye and skin (on prolonged contact) irritation. Ingestion causes slight depression to deep narcosis.

Chronic Effects: None reported.

FIRST AID

Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.

Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed. Have trained personnel administer 100% oxygen, preferably with humidification.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Physician's Note: Intravenous injections of calcium gluconate may relieve cramps and vomiting. Treat central nervous system effects symptomatically.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a 1,2-dichloroethylene spill control and countermeasure plan (SCCP).* Notify safety personnel, remove all heat and ignition sources, evacuate hazard area, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Absorb small spills on paper towels. After evaporating the 1,2-dichloroethylene from these paper towels in a fume hood, burn the paper in a suitable location away from combustible material. Collect and atomize large quantities in a suitable combustion chamber equipped with an appropriate effluent gas cleaning device. Follow applicable OSHA regulations (29 CFR 1910.120).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33)

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 100 lb (45.4 kg) [* per RCRA, Sec. 3001, per Clean ater Act, Sec. 307(a)]†

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1)

† Listed as 1,2-*trans*-dichloroethylene.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).

Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.

Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. 1,2-dichloroethylene attacks some forms of plastics, rubber, and coatings.

Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLV (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, well-ventilated area away from all incompatible materials (Sec. 5) and oxidizing materials. Outside or detached storage is preferred. If stored inside, place containers in a standard flammable liquids storage cabinet or room. Protect containers from physical damage.

Engineering Controls: Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. 1,2-dichloroethylene is a ngerous fire hazard. All engineering systems should be of maximum explosion-proof design and electrically grounded and bonded. Provide replacement questionnaires which emphasize detecting a history of chronic respiratory disease.

Transportation Data (49 CFR 172.101, .102): Not listed

***MSDS Collection* References:** 7, 26, 38, 73, 84, 85, 87, 88, 100, 101, 103, 109, 126, 127, 136, 137

Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Hardies, MD

Material Safety Data Sheet

from Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 385

ETHYL BENZENE
(Revision A)
Issued: August 1978
Revised: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: ETHYL BENZENE

Description (Origin/Uses): Used as a solvent and as an intermediate in the production of styrene monomer.

Other Designations: Phenylethane; Ethylbenzol; $C_2H_5C_6H_5$; CAS No. 0100-41-4

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

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R 0
PPG*
*See sect. 8

R 1
I 3
S 2
K 4

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
Ethyl Benzene, CAS No. 0100-41-4 *See NIOSH, *RTECS* (DA0700000), for additional data with references to reproductive, irritative, and mutagenic effects.	Ca 100	**OSHA PELs** 8-Hr TWA: 100 ppm, 435 mg/m³ 15- Min STEL: 125 ppm, 545 mg/m³ **ACGIH TLVs, 1988-89** TLV-TWA: 100 ppm, 435 mg/m³ TLV-STEL: 125 ppm, 545 mg/m³ **Toxicity Data*** Human, Inhalation, TC_{Lo}: 100 ppm (8 Hrs) Rat, Oral, LD_{50}: 3500 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point: 277°F (136°C)
Melting Point: -139°F (-95°C)
Vapor Pressure: 7.1 Torrs at 68°F (20°C)
Vapor Density (Air = 1): 3.7
% Volatile by Volume: Ca 100

Molecular Weight: 106 Grams/Mole
Solubility in Water (%): Slight
Specific Gravity (H_2O = 1): 0.86258 at 77°F (25°C)

Appearance and Odor: A clear, colorless, flammable liquid; characteristic aromatic hydrocarbon odor.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point and Method: 64°F (18°C) CC	Autoignition Temperature: 810°F (432.22°C)	LEL: 1% v/v	UEL: 6.7% v/v

Extinguishing Media: Use foam, dry chemical, or carbon dioxide to put out ethyl benzene fires. A water spray may be ineffective in extinguishing the fire, because it can scatter and spread the burning liquid. Use water spray to cool fire-exposed containers of ethyl benzene, to disperse ethyl benzene vapor, and to protect personnel attempting to stop an ethyl benzene leak. **Unusual Fire or Explosion Hazards:** This liquid can readily form explosive vapor-air mixtures, especially when heated. Ethyl benzene vapor is heavier than air and may travel a considerable distance to a low-lying source of ignition and flash back to its origin. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: Ethyl benzene is stable in closed containers during routine operations. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Hazardous chemical reactions can occur between ethyl benzene and strong oxidizing agents, acids, ammonia, and bases. **Conditions to Avoid:** Avoid any exposure to sources of ignition such as heat, sparks, open flame, and lighted tobacco products, etc., and to incompatible chemicals. Use caution when entering confined spaces, particularly low-lying areas where explosive concentrations of ethyl benzene vapor may be present. Provide good ventilation to such areas to prevent the concentration of this vapor. **Hazardous Products of Decomposition:** Thermal-oxidative degradation can include toxic gases such as carbon monoxide and/or aromatic hydrocarbon gases.

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: Ethyl benzene is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Ethyl benzene vapor is severely irritating to the eyes and to the mucous membranes of the respiratory system. Sustained inhalation of excessive levels can cause depression of the central nervous system (CNS) characterized by dizziness, headache, narcosis, and coma. Skin contact with liquid ethyl benzene causes irritation; dermatitis and defatting can also develop. The acute oral toxicity of ethyl benzene is low; however, ingestion of it presents a serious aspiration hazard. Aspirating even a small amount into the lungs can result in extensive edema (lungs filled with fluid) and hemorrhaging of the lung tissue. No systemic effects are expected at the levels that produce pronounced, unignorable, disagreeable skin and eye irritation. The TLVs cited in section 2 are set to prevent this intolerable irritation. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, and CNS. **Primary Entry:** Inhalation, skin contact **Acute Effects:** Irritation of the skin, eyes, and respiratory system. Also, cardiac-rhythm disturbance due to sensitization; acute bronchitis, bronchospasm, pulmonary and laryngeal edema; euphoria; headache; giddiness; dizziness; and incoordination, as well as possible depression; confusion; and coma. **Chronic Effects:** None reported. **First Aid:** Eyes. Immediately

SECTION 6. HEALTH HAZARD INFORMATION, cont.

flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with plenty of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. **Ingestion.** Unlikely. Should this type of exposure occur, the aspiration hazard must be considered. Do not induce vomiting unless directed to do so by a physician. To prevent aspiration by spontaneous vomiting, keep the victim's head low (between his or her knees). **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Professional judgment is required as to whether or not to induce vomiting because of the possibility of aspiration. A gastric lavage may be administered, followed by saline catharsis, if this procedure is appropriate to the specific incident. Monitor cardiac and pulmonary functions.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, eliminate all sources of ignition immediately, and provide adequate explosion-proof ventilation. Cleanup personnel need protection against skin or eye contact with this liquid as well as inhalation of its vapor (see sect. 8). Contain large spills and collect waste or absorb it with an inert material such as sand, earth, or vermiculite. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of sewers, watersheds, and waterways. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).

EPA Designations (40 CFR 302.4)

CERCLA Hazardous Substance, Reportable Quantity: 1000 lbs (454 kg), per the Clean Water Act (CWA), §§ 311 (b) (4) and 307 (a).

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Wear a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, etc., to prevent prolonged or repeated skin contact with this material. **Ventilation:** Install and operate general and local maximum, explosion-proof ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale ethyl benzene vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store ethyl benzene in closed containers in a cool, dry, well-ventilated area away from sources of ignition and strong oxidizers. Protect containers from physical damage. **Special Handling/Storage:** Outside, isolated, detached, or remote storage is recommended for large quantities of ethyl benzene. Isolate bulk storage areas from acute fire hazards. **Engineering Controls:** Make sure all engineering systems (production, transportation) are of maximum explosion-proof design. To prevent static sparks, electrically ground and bond all containers, pipelines, etc., used in shipping, transferring, reacting, production, and sampling operations. **Other:** Use safety cans for transferring small amounts of ethyl benzene.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Ethyl Benzene
DOT Hazard Class: Flammable Liquid
ID No. UN1175
DOT Label: Flammable Liquid
DOT Packaging Exceptions: 49 CFR 173.118
DOT Packaging Requirements: 49 CFR 173.119

IMO Shipping Name: Ethylbenzene
IMO Hazard Class: 3.2
IMO Label: Flammable Liquid
IMDG Packaging Group: II

eferences: 1, 26, 38, 84-94, 100, 116, 117, 120, 122.

Prepared by PJ Igoe; BS

Industrial Hygiene Review: DJ Wilson, CIH

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Material Safety Data Sheets Collection:

Sheet No. 467
Automotive Gasoline, Lead-free

Issued: 10/81 Revision: A, 9/91

Section 1. Material Identification

35

Automotive Gasoline, Lead-free, Description: A mixture of volatile hydrocarbons composed mainly of branched-chain paraffins, cycloparaffins, olefins, naphthenes, and aromatics. In general, gasoline is produced from petroleum, shale oil, Athabasca tar sands, and coal. Motor gasolines are made chiefly by cracking processes, which convert heavier petroleum fractions into more volatile fractions by thermal or catalytic decomposition. Widely used as fuel in internal combustion engines of the spark-ignited, reciprocating type. Automotive gasoline has an octane number of approximately 90. A high content of aromatic hydrocarbons and a consequent high toxicity are also associated with a high octane rating. Some gasolines sold in the US contain a minor proportion of tetraethyllead, which is added in concentrations not exceeding 3 ml per gallon to prevent engine "knock." However, methyl-tert-butyl ether (MTBE) has almost completely replaced tetraethyllead.

Other Designations: CAS No. 8006-61-9, benzin, gasoline, gasolene, motor spirits, natural gasoline, petrol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

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* Skin absorption

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† Sec. 8

Cautions: Inhalation of automotive gasoline vapors can cause intense burning in throat and lungs, central nervous system (CNS) depression, and possible fatal pulmonary edema. Gasoline is a dangerous fire and explosion hazard when exposed to heat and flames.

Section 2. Ingredients and Occupational Exposure Limits

Automotive gasoline, lead-free*

1990 OSHA PELs
8-hr TWA: 300 ppm, 900 mg/m^3
15-min STEL: 500 ppm, 1500 mg/m^3

1990-91 ACGIH TLVs
TWA: 300 ppm, 890 mg/m^3
STEL: 500 ppm, 1480 mg/m^3

1990 NIOSH REL
None established

1985-86 Toxicity Data*
Man, inhalation, TC$_{Lo}$: 900 ppm/1 hr; toxic effects include sense organs and special senses (conjunctiva irritation), behavioral (hallucinations, distorted perceptions), lungs, thorax, or respiration (cough)
Human, eye: 140 ppm/8 hr; toxic effects include mild irritation
Rat, inhalation, LC$_{50}$: 300 g/m^3/5 min

* A typical modern gasoline composition is 80% paraffins, 14% aromatics, and 6% olefins. The mean benzene content is approximately 1%. Other additives include sulfur, phosphorus, and MTBE.
† See NIOSH, *RTECS* (LX3300000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: Initially, 102 °F (39 °C); after 10% distilled, 140 °F (60 °C); after 50% distilled, 230 °F (110 °C); after 90% distilled, 338 °F (170 °C); final boiling point, 399 °F (204 °C)

Vapor Density (air = 1): 3.0 to 4.0

Density/Specific Gravity: 0.72 to 0.76 at 60 °F (15.6 °C)

Water Solubility: Insoluble

Appearance and Odor: A clear (gasoline may be colored with dye), mobile liquid with a characteristic odor recognizable at about 10 ppm in air.

Section 4. Fire and Explosion Data

Flash Point: -45 °F (-43 °C)	**Autoignition Temperature:** 536 to 853 °F (280 to 456 °C)	**LEL:** 1.3% v/v	**UEL:** 6.0% v/v

Extinguishing Media: Use dry chemical, carbon dioxide, or alcohol foam as extinguishing media. Use of water may be ineffective to extinguish fire, but use water spray to knock down vapors and to cool fire-exposed drums and tanks to prevent pressure rupture. Do not use a solid stream of water since it may spread the fuel.

Unusual Fire or Explosion Hazards: Automobile gasoline is an OSHA Class IB flammable liquid and a dangerous fire and explosion hazard when exposed to heat and flames. Vapors can flow to an ignition source and flash back. Automobile gasoline can also react violently with oxidizing agents.

Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode, and full protective clothing. When the fire is extinguished, use nonsparking tools for cleanup. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Automotive gasoline is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.

Chemical Incompatibilities: Automotive gasoline can react with oxidizing materials such as peroxides, nitric acid, and perchlorates.

Conditions to Avoid: Avoid heat and ignition sources.

Hazardous Products of Decomposition: Thermal oxidative decomposition of automotive gasoline can produce oxides of carbon and partially oxidized hydrocarbons.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC list gasoline as a possible human carcinogen (Group 2B). Although the IARC has assigned an overall evaluation to gasoline, it has not assigned an overall evaluation to specific substances within this group (inadequate human evidence).
Summary of Risks: Gasoline vapors are considered moderately poisonous. Vapor inhalation can cause central nervous system (CNS) depression and mucous membrane and respiratory tract irritation. Brief inhalations of high concentrations can cause a fatal pulmonary edema. Reported [illegible]nses to gasoline vapor concentrations are: 160 to 270 ppm causes eye and throat irritation in several hours; 500 to 900 ppm causes eye, nose, [illegible]roat irritation, and dizziness in 1 hr; and 2000 ppm produces mild anesthesia in 30 min. Higher concentrations are intoxicating in 4 to 10 minutes. If large areas of skin are exposed to gasoline, toxic amounts may be absorbed. Repeated or prolonged skin exposure causes dermatitis. Certain individuals may develop hypersensitivity. Ingestion can cause CNS depression. Pulmonary aspiration after ingestion can cause severe pneumonitis. In adults, ingestion of 20 to 50 g gasoline may produce severe symptoms of poisoning.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eye, respiratory and central nervous systems.
Primary Entry Routes: Inhalation, ingestion, skin contact.
Acute Effects: Acute inhalation produces intense nose, throat, and lung irritation; headaches; blurred vision; conjunctivitis; flushing of the face; mental confusion; staggering gait; slurred speech; and unconsciousness, sometimes with convulsions. Ingestion causes inebriation (drunkenness), vomiting, dizziness, fever, drowsiness, confusion, and cyanosis (a blue to dark purplish coloration of skin and mucous membrane caused by lack of oxygen). Aspiration causes choking, cough, shortness of breath, increased rate of respiration, excessively rapid heartbeat, fever, bronchitis, and pneumonitis. Other symptoms following acute exposure include acute hemorrhage of the pancreas, fatty degeneration of the liver and kidneys, and passive congestion of spleen.
Chronic Effects: Chronic inhalation results in appetite loss, nausea, weight loss, insomnia, and unusual sensitivity (hyperesthesia) of the distal extremities followed by motor weakness, muscular degeneration, and diminished tendon reflexes and coordination. Repeated skin exposure can cause blistering, drying, and lesions.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* due to aspiration hazard. Give conscious victim a mixture of 2 tablespoons of activated charcoal mixed in 8 oz of water to drink. Consult a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources, and provide maximum explosion-proof ventilation. Cleanup personnel should protect against vapor inhalation and liquid contact. Use nonsparking tools. Take up small spills with sand or other noncombustible adsorbent. Dike storage areas to control leaks and spills. Follow applicable OSHA regulations (29 CFR 1910.120).
Aquatic Toxicity: Bluegill, freshwater, LC_{50}, 8 ppm/96 hr.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.21): Characteristic of ignitability
CERCLA Hazardous Substance (40 CFR 302.4): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
[illegible] Toxic Chemical (40 CFR 372.65): Not listed

[illegible] Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. There are no specific NIOSH recommendations. However, for vapor concentrations not immediately dangerous to life or health, use chemical cartridge respirator equipped with organic vapor cartridge(s), or a supplied-air respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Materials such as neoprene or polyvinyl alcohol provide excellent/good resistance for protective clothing. Note: Resistance of specific materials can vary from product to product.
Ventilation: Provide general and local explosion-proof exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry, well-ventilated area away from heat and ignition sources and strong oxidizing agents. Protect containers from physical damage. Avoid direct sunlight. Storage must meet requirements of OSHA Class IB liquid. Outside or detached storage preferred.
Engineering Controls: Avoid vapor inhalation and skin or eye contact. Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Indoor use of this material requires explosion-proof exhaust ventilation to remove vapors. Only use gasoline as a fuel source due to its volatility and flammable/explosive nature. Practice good personal hygiene and housekeeping procedures. Wear clean work clothing daily.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Gasoline (*including casing-head and natural*)
DOT Hazard Class: Flammable liquid
ID No.: UN1203
D[illegible]abel: Flammable liquid
L[illegible] Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Gasoline
IMO Hazard Class: 3.1
ID No.: UN1203
IMO Label: Flammable liquid
IMDG Packaging Group: II

MSDS Collection References: 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 138, 140, 143, 146, 153, 159

Prepared by: M Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 311
Methyl Chloroform

Issued: 11/75 Revision: F, 3/92 Errata: 6/92

Section 1. Material Identification

38

Methyl Chloroform ($C_2H_3Cl_3$) Description: Derived by catalytic addition of hydrogen chloride to 1,1-dichloroethylene or by re-fluxing chlorine monoxide with carbon tetrachloride and chloroethane. Available in technical and solvent grades which differ only in the amount of stabilizer added to prevent metal parts corrosion. Used as a solvent for oils, waxes, tars, cleaning precision instruments, and pesticides; as a component of inks and drain cleaners; in degreasing metals, and textile processing. In recent years, methyl chloroform has found widespread use as a substitute for carbon tetrachloride.

Other Designations: CAS No. 71-55-6, α-trichloroethane; Inhibisol; 1,1,1-trichloroethane; Strobane.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Methyl chloroform is a skin, eye, and respiratory tract irritant and can become narcotic with an anesthetic effect at high concentrations.

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* Sec. 8

* Data on skin absorption via methyl chloroform is conflicting.(133) Some studies show definite absorption where others don't.

Section 2. Ingredients and Occupational Exposure Limits

Methyl chloroform, ca 92 to 97%*

1990 OSHA PELs
8-hr TWA: 350 ppm (1900 mg/m^3)
15-min STEL: 450 ppm (2450 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
15-min Ceiling: 350 ppm (1900 mg/m^3)

1991-92 ACGIH TLVs
TWA: 350 ppm (1910 mg/m^3)
STEL: 450 ppm (2460 mg/m^3)

1990 DFG (Germany) MAKs
TWA: 200 ppm (1080 mg/m^3)
Half-life: 2 hr to shift length
Peak Exposure Limit: 1000 ppm/30 min (average value)/2 per shift

1985-86 Toxicity Data†
Human, oral, TD_{Lo}: 670 mg/kg produced diarrhea, nausea, and vomiting
Human, inhalation, LC_{Lo}: 27 g/m^3/10 min; toxic effects not yet reviewed
Man, eye: 450 ppm/8 hr produced irritation
Rat, inhalation, TC_{Lo}: 2100 ppm/24 hr for 14 days prior to mating and from 1 to 20 days of pregnancy produced specific developmental abnormalities of the musculoskelatal system

* Methyl chloroform usually contains inhibitors (3 to 8%) to prevent corrosion of aluminum and some other metals. Typical inhibitors are nitromethane, butylene oxide, secondary butyl alcohols, ketones, and glycol diesters.

† See NIOSH, *RTECS* (KJ2975000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 165 °F (75 °C)
Freezing Point: -22 °F (-30 °C)
Vapor Pressure: 100 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 4.55
Corrosivity: Readily corrodes aluminum and its alloys
Refraction Index: 1.43765 at 69.8 °F (21 °C)
Viscosity: 0.858 cP at 68 °F (20 °C)
Molecular Weight: 133.42
Density: 1.3376 at 68/39.8 °F (20/4 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, carbon tetrachloride, and carbon disulfide
% in Saturated Air: 16.7% at 77 °F (25 °C)
Relative Evaporation Rate (butyl acetate = 1): 12.8

Appearance and Odor: Colorless liquid with a sweetish, chloroform-like odor. The odor threshold is 44 ppm.

Section 4. Fire and Explosion Data

Flash Point: None (in conventional CC tests)	Autoignition Temperature: 932 °F (500 °C)	LEL: 7% v/v	UEL: 16% v/v

Extinguishing Media: *Noncombustible liquid* whose *vapor* burns in the presence of excess oxygen or a strong ignition source. For small fires, use dry chemical or carbon dioxide (CO_2). For large fires use fog or regular foam. If these materials are unavailable, a water spray may be used but be aware that water reacts slowly with methyl chloroform to release hydrochloric acid.

Unusual Fire or Explosion Hazards: Vapors are heavier than air and may travel to a strong ignition source and flash back. Air/vapor mixtures may explode when heated. Container may explode in heat of fire. Exposure to open flames or arc welding can produce hydrogen chloride and phosgene.

Special Fire-fighting Procedures: Methyl chloroform's burning rate is 2.9 mm/min. Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. Wear clothing specifically recommended by the manufacturer for use in fires involving methyl chloroform. Apply cooling water to container sides until after fire is extinguished. Stay away from ends of tanks. Isolate area for 1/2 mile if fire involves tank, truck, or rail car. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Methyl chloroform is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can occur in contact with aluminum trichloride.

Chemical Incompatibilities: Methyl chloroform is incompatible with sodium hydroxide, nitrogen tetroxide, oxygen (liquid or gas), strong oxidizers, and chemically active metals like aluminum, zinc, and magnesium powders; reacts violently with caustics to form dichloroacetylene; reacts slowly with water to form hydrochloric acid; forms shock sensitive mixtures with potassium; and polymerizes in contact with aluminum trichloride.

Conditions to Avoid: Exposure to moisture, strong ignition sources, and arc-welding units, and contact with incompatibles.

Hazardous Products of Decomposition: Thermal oxidative decomposition (temperatures >500 °F, contact with hot metals, or under UV rays) of methyl chloroform can produce carbon dioxide (CO_2) and toxic dichloroacetylene, hydrogen chloride, and phosgene gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC (Class 3, inadequate evidence),(164) NTP,(142) and OSHA(164) do not list methyl chloroform as a carcinogen.

Summary of Risks: Methyl chloroform is considered one of the least toxic of the liquid chlorinated hydrocarbons. It is irritating to eyes, skin, and respiratory tract. Although low in systemic toxicity, methyl chloroform is an anesthetic capable of causing death at high concentrations (>15,000 ppm), generally in poorly ventilated, enclosed areas. Quick and complete recovery is observed after prompt removal of unconscious persons from area of exposure. Like many other solvents, methyl chloroform sensitizes the heart to epinephrine (blood pressure-raising hormone) and may induce cardiac arrhythmias and arrest.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Skin, eyes, central nervous (CNS) and cardiovascular (CVS) systems.

Continue on next page

Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation, skin contact. **Acute Effects:** Methyl chloroform defats the skin causing irritation, redness, dryness, and scaling. Contact with eyes produces irritation and mild conjunctivitis. Vapor inhalation can cause headache, dizziness, equilibrium disturbances, and in high ncentrations may lead to CNS depression, unconsciousness, and coma. During a 60-min exposure period these effects are observed: 100 ppm is the rved odor threshold, at 500 ppm there is obvious odor and decreased reaction time, 1000 ppm causes slight equilibrium loss, at 5000 ppm there is nite incoordination, and 20,000 ppm produces surgical strength anesthesia with possible death. Mild liver and kidney dysfunction may occur after CNS depression recovery. Although unlikely, if ingestion occurs, symptoms include nausea, vomiting, diarrhea, and possible esophageal burns. The acute lethal human dose is ~500 to 5000 mg/kg. **Chronic Effects:** None reported.

FIRST AID

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Inhalation: Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center, and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. When deciding whether to induce vomiting, carefully consider amount ingested, time since ingestion, and availability of medical help. If large amounts are recently ingested (absorption into the body is not yet likely to have occurred), and medical help or transportation to a medical facility is not readily available, induce vomiting. Otherwise, vomiting is not recommended since aspiration of vomitus can produce chemical pneumonitis.
Note to Physicians: Do not use adrenaline or sympathomimetic amines in treatment because of the increased cardiac sensitivity involved.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, shut off leak. Cleanup personnel should wear fully encapsulating vapor-protective clothing. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material. Using nonsparking tools, place in suitable containers for disposal or reclamation. For large spills, dike far ahead of liquid spill for later disposal or reclamation. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: In water, methyl chloroform's half-life is hours to weeks depending on wind and mixing conditions. It is very persistent in groundwater. On land it volatilizes due to its high vapor pressure and leaches extensively. When released to the atmosphere, methyl chloroform can be transported long distances and returned to earth via rain. It is slowly degraded by reaction with hydroxyl radicals and has a half-life of 6 months to 25 years. The Natural Resources Defenses Council reported recently that methyl chloroform depletes ozone.
Ecotoxicity Values: *Pimephales promelas* (fathead minnow), LC_{50}: 52.8 mg/L/96 hr; *Poecilia reticulata* (guppy), LC_{50}: 133 ppm/7 day.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U226
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per RCRA, Sec. 3001, CWA, Sec. 307(a), and CAA, Sec. 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

tion 8. Special Protection Data

Goggles: Wear splash-proof, protective chemical safety goggles or faceshields, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Viton and butyl rubber [with breakthrough times (BTs) of >8 hr and 4 to 7.9 hr, respectively] are recommended materials for protective gear. *Do not use* neoprene, polyvinyl chloride (PVC), natural rubber, or polyethylene because these materials have a BT of <1 hr.
Ventilation: Provide general and local exhaust (in some cases, explosion-proof) ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated (use pressure-vacuum ventilation) area away from ignition sources, arc-welding operations, and incompatibles (Sec. 5). Regularly monitor inhibitor levels. *Do not* store in aluminum containers or use pressure-spraying equipment when methyl chloroform is involved.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used in methyl chloroform manufacturing, use, storage, transfer, and shipping.
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize CNS, CVS, liver and skin.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: 1,1,1-Trichloroethane
DOT Hazard Class: ORM-A
.: UN2831
Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.605

IMO Shipping Name: 1,1,1-Trichloroethane
IMO Hazard Class: 6.1
ID No.: UN2831
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 148, 153, 159, 162, 163, 164
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet Collection

Naphthalene **MSDS No. 624**

Date of Preparation: 11/87 Revision: A, 9/97

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Naphthalene
Chemical Formula: $C_{10}H_8$
CAS Number: 91-20-3
Synonyms: Albocarbon; camphor tar; Dezodorator; Mighty 150; moth balls; moth flakes; naftalen (Polish); naphthalin; naphthaline; naphthalinum; naphthene; NTM; tar camphor; white tar
Derivation: From coal tar; from petroleum fractions after various catalytic processing operations.
General Use: Used as a moth repellent, an antiseptic, toilet bowl deodorant, heat transfer agent, fungicide, smokeless powder, cutting fluid, lubricant, wood preservative; an intermediate for naphthol, phthalic anhydride, chlorinated naphthalenes, Tertralin, Decalin, naphthyl and naphthol derivatives, and dyes; in synthetic resins, synthetic tanning, textile chemicals, scintillation counters, and emulsion breakers.
Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Naphthalene, ca 100% wt. Grade: By melting point, 165 °F (74 °C) min (crude) to greater than 174 °F (79 °C) (refined); scintillation 176-177 °F (80-81 °C)

OSHA PELs	**ACGIH TLVs**	**NIOSH RELs**	**IDLH Level**
8-hr TWA: 10 ppm (50 mg/m^3); *Vacated 1989 Final Rule Limit:* 15-min. STEL: 15 ppm (79 mg/m^3)	TWA: 10 ppm (52 mg/m^3) STEL: 15 ppm (79 mg/m^3)	10-hr TWA: 10 ppm (50 mg/m^3); 15-min. STEL: 15 ppm (75 mg/m^3)	500 ppm **DFG (Germany) MAK** 10 ppm (50 mg/m^3)

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Naphthalene is a white crystalline solid with a 'moth ball' or coal-tar odor. It is toxic by ingestion. Irritating to skin, eyes, and respiratory system. Naphthalene is a combustible solid. Dust may form explosive mixtures in air if subjected to an ignition source.

Wilson Risk Scale	
R	1
I	3
S	2*
K	2

*Skin absorption

HMIS	
H	2†
F	2
R	0
PPE‡	

†Chronic Effects
‡Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin absorption, skin and/or eye contact
Target Organs: Blood (red blood cell effects), eyes, skin, central nervous system (CNS), liver and kidneys
Acute Effects
Inhalation: Vapor inhalation causes headache, confusion, nausea, sometimes vomiting, loss of appetite, extensive sweating, dysuria (painful urination), hematuria (blood in the urine), and hemolysis (destruction of red blood cells).
Eye: Irritation, conjunctivitis, and corneal injury upon prolonged contact.
Skin: Irritation and hypersensitivity dermatitis.
Ingestion: Unlikely. However, ingestion causes irritation of the mouth and stomach, hemolytic anemia with hepatic and renal lesions and vesical congestion, kidney failure, hematuria, jaundice, depression of CNS, nausea, vomiting, abdominal pain, blue face, lips, or hands, rapid and difficult breathing, headache, confusion, excitement, malaise, fever, perspiration, urinary tract pain, dizziness, convulsions, coma, and death. Symptoms may appear 2 to 4 hours after exposure.
Carcinogenicity: IARC, NTP, and OSHA do not list naphthalene as a carcinogen. EPA-D, Not Classifiable as to Human Carcinogenicity; MAK-B, Justifiably suspected of having carcinogenic potential; TLV-A4, Not Classifiable as a Human Carcinogen.
Medical Conditions Aggravated by Long-Term Exposure: Diseases of the blood, liver and kidneys; individuals with a hereditary deficiency of the enzyme glucose-6-phosphate dehydrogenase in red blood cells are particularly susceptible to the hemolytic properties of naphthalene metabolites.
Chronic Effects: May cause optical neuritis, corneal injuries, cataracts, kidney damage.
Other: There are two reports of naphthalene crossing the placenta in humans.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed. Contact a physician immediately if symptoms of systemic poisoning are present.

Eye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 min. Consult a physician or ophthalmologist if pain, irritation, swelling, or photophobia persist.

Skin Contact: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area thoroughly with soap and water. For reddened or blistered skin, consult a physician. Contact a physician immediately if symptoms of systemic poisoning are present.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Contact a physician immediately.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Obtain baseline CBC, electrolytes, liver and renal function rests, glucose-6-phosphatase dehydrogenase level, urinalysis, and benzidine dipstick to check for hemoglobinuria. Urinary metabolite, 1-naphthol or mercapturic acid, may help confirm the diagnosis.

Section 5 - Fire-Fighting Measures

Flash Point: 174 °F (79 °C); 190 °F (88 °C)
Flash Point Method: OC; CC
Burning Rate: Data not found.
Autoignition Temperature: 979 °F (526 °C)
LEL: 0.9% v/v
UEL: 5.9% v/v
Flammability Classification: Combustible solid

Extinguishing Media: Use dry chemical, foam, carbon dioxide (CO_2), or water spray. Water or foam may cause frothing. Use water spray to keep fire-exposed containers cool.

nusual Fire or Explosion Hazards: Volatile solid that gives off flammable vapors when heated. Dust may explode in air if an ignition source is provided.

Hazardous Combustion Products: Toxic vapors including carbon monoxide.

Fire-Fighting Instructions: Move containers from the fire area if it can be done without risk. Otherwise cool fire-exposed containers until well after the fire is extinguished. *Do not* release runoff from fire control methods to sewers or waterways.

Fire-Fighting Equipment: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Wear full protective clothing (see Sec. 8). Structural clothing is permeable, remain clear of smoke, water fall out, and water run off.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources. Isolate and ventilate area, deny entry, stay upwind. Stop leak if you can do it without risk. Use spark-proof tools and explosion proof equipment. Cleanup personnel should wear personal protective equipment to protect against exposure (see Sec. 8).

Small Spills: *Do not* sweep! Carefully scoop up or vacuum (with a HEPA filter). Absorb liquid spill with an inert, noncombustible absorbent such as sand or vermiculite.

Large Spills

Containment: For large spills, dike far ahead of liquid spill for later disposal. *Do not* release into sewers or waterways.

Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: To avoid vapor inhalation use only with ventilation sufficient to reduce airborne concentrations to nonhazardous levels. Avoid skin and eye contact. Wear personal protective clothing and equipment to prevent any contact with skin and eyes (see Sec. 8). Practice good personal hygiene procedures to prevent inadvertently ingesting this material.

Storage Requirements: Store in tightly closed, explosion-proof containers in a cool, well-ventilated area away from heat, ignition sources, and incompatibles (see Sec. 10). May be stored under nitrogen gas. Protect containers against physical damage. Use monitoring equipment to measure the extent of vapor present in any storage facility containing naphthalene because of potential fire and explosion hazards.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Where feasible, enclose operations to avoid vapor and dust dispersion into the work area. Ventilate at the site of chemical release. During the fractional distillation of naphthalene and in any operation entailing the heating or volatilization of naphthalene, enclosed apparatus should be employed.

Ventilation: Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.

Administrative Controls: Educate workers about the health and safety hazards associated with naphthalene. Train in work practices which minimize exposure. Consider preplacement and periodic medical exams with emphasis on the eyes, skin, liver, kidneys, CBC (RBC count, WBC count, differential count of a stained smear, hemoglobin, and hematocrit), and urinalysis including at a minimum specific gravity, albumin, glucose, and a microscopic examination on centrifuged sediment.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Teflon® is recommended. *Do not* use butyl rubber, natural rubber, neoprene or polyvinyl chloride. Wear chemical dust-proof safety goggles and face shield, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove naphthalene from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Crystalline solid

Appearance and Odor: White, volatile flakes, cakes, cubes, spheres, or powder; strong coal-tar or moth ball odor

Odor Threshold: 0.084 ppm to 0.3 ppm

Vapor Pressure: 0.05 mm Hg at 68 °F (20 °C); 1.0 mm Hg at 127 °F (53 °C)

Formula Weight: 128.2

Density: 1.145 g/cm^3 at 68 °F (20 °C)

Saturated Vapor Concentration: 100 ppm at 77 °F (25 °C) (approx.)

Water Solubility: Insoluble [31.7 mg/L at 68 °F (20 °C)]

Other Solubilities: Benzene, absolute alcohol; very soluble in ether, chloroform, carbon disulfide, hydronaphthalenes, fixed and volatile oils

Boiling Point: 424 °F (218 °C)

Melting Point: 176 °F (80.2 °C)

Volatility: Volatilizes appreciably at room temperature; volatile with steam

Octanol/Water Partition Coefficient: $\log K_{ow} = 3.30$

Section 10 - Stability and Reactivity

Stability: Naphthalene is stable at room temperature in closed containers under normal storage and handling conditions. It volatilizes at room temperature.

Polymerization: Hazardous polymerization cannot occur.

Chemical Incompatibilities: Include aluminum chloride, benzoyl chloride, chromic acid, chromium trioxide, oxidizers. Explosive reaction with dinitrogen pentaoxide. Melted naphthalene will attack some forms of plastics.

Conditions to Avoid: Exposure to heat and ignition sources, incompatibles.

Hazardous Decomposition Products: Thermal oxidative decomposition of naphthalene can produce toxic fumes including carbon monoxide.

Section 11- Toxicological Information

Toxicity Data:*

Acute Effects:

Human (child), oral, LD_{Lo}: 100 mg/kg

Man, unreported, LD_{Lo}: 74 mg/kg

Rat, oral, LD_{50}: 490 mg/kg

Reproductive Effects:

Rat, oral: 4500 mg/kg administered on gestational days 6-15 produced fetotoxicity and other developmental abnormalities.

Section 11- Toxicological Information, *continued*

Toxicity Data:*

Acute Effects: *continued*
Mouse, oral, LD_{50}: 533 mg/kg
Rat, inhalation, LC_{50}: >340 mg/m^3 produced lacrimation and somnolence.

Genetic Effects:
Hamster, ovary: 15 mg/L induced sister chromatid exchange.

Tumorigenicity:
Mouse, inhalation: 30 ppm/6 hr/2 yr administered intermittently produced toxic effects: tumorigenic - neoplastic by RTECS criteria; lungs, thorax, or respiration - tumors.

Skin Effects:
Rabbit, skin, open Draize test: 495 mg produced mild irritation.

Eye Effects:
Rabbit, eye, standard Draize test: 100 mg produced mild irritation.

*See *NIOSH RTECS* (QJ0525000) for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: *Oncorhynchus gorbuscha* (pink salmon): 1.37 ppm/96 hr at 39 °F (4 °C). *Pimephales promelas* (fathead minnow): 7.76 mg/L/24 hr.

Environmental Fate: If released to the atmosphere, naphthalene rapidly photodegrades with a half-life of 3-8 hr. Volatilization, photolysis, adsorption, and biodegradation are important loss mechanisms for naphthalene discharged into water. Depending on local conditions, the half-lives range from a couple of days to a few months. If released on land, it is adsorbed moderately to soil, undergoes biodegradation; but in some cases biodegradation may still occur if conditions are aerobic. Bioconcentration occurs to a moderate extent, but is a temporary problem since depuration and metabolism readily proceed in aquatic organisms.

Section 13 - Disposal Considerations

Disposal: Consider rotary kiln or fluidized bed incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Container Cleaning and Disposal: Handle empty containers carefully as hazardous residues may still remain.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Naphthalene, crude or Naphthalene, refined
Shipping Symbols: Not listed
Hazard Class: 4.1
ID No.: UN1334
Packing Group: III
Label: FLAMMABLE SOLID
Special Provisions (172.102): A1

Packaging Authorizations
a) Exceptions: 173.151
b) Non-bulk Packaging: 173.213
c) Bulk Packaging: 173.240

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 25 kg
b) Cargo Aircraft Only: 100 kg

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: Not listed

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33). Hazardous Waste Number: U165
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307(a); CAA, Sec. 112
CERCLA Final Reportable Quantity (RQ), 100 lb (45.4 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

OSHA Regulations:
Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A): Not listed

Section 16 - Other Information

References: 73, 99, 103, 124, 139, 140, 167, 168, 179, 190, 196, 197, 200, 220 PC-W6

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Material Safety Data Sheet Collection

Pentachlorophenol **MSDS No. 517**

Issue Date: 5/99

Section 1 - Chemical Product and Company Identification 52

Product/Chemical Name: Pentachlorophenol **Chemical Formula:** C_6HCl_5O; C_6Cl_5OH **CAS Number:** 87-86-5

Synonyms: Acutox; Chem-Penta; Chem-Tol; Chlon; Chlorophen; Cryptogil Oil; Dow Pentachlorophenol DP-2 Antimicrobial; Dowicide 6; Dowicide 7 Antimicrobial; Dowicide EC-7; Dura Treet II; Durotox; EP 30; Forpen-50 Wood Preservative; Fungifen; Grundier Arbezol; 1-hydroxypentachlorobenzene; Lauxtol A; Liroprem; Ontrack WE Herbicide; Ortho Triox Liquid Vegetation Killer; Osmose Wood Preserving Compound; PCP; Penchlorol; Penta; Penta Concentrate; Penta Ready; Penta WR; pentachlorophenate; 2,3,4,5,6-pentachlorophenol; pentachlorophenol, DP-2; Pentacon; Penta-Kil; Pentasol; Penwar; Peratox; Permacide; Permagard; Permasan; Permatox DP-2; Permite; Prevenol; Priltox; Santobrite; Santophen 20; Term-i-trol; Thompson's Wood Fix; Watershed Wood Preservative; Weed and Brush Killer; Weedone; Witophen P; Woodtreat A

Derivation: Produced by chlorinating phenol.

General Use: Used as an insecticide for termite control; as a pre-harvest defoliant; general herbicide; molluscide; fungicide; bactericide; antimildew agent; wood preservative; in the synthesis of pentachlorophene esters; in cooling towers of electric plants; as additives to adhesives based on starch and vegetable and animal protein; in shingles, roof tiles, brick walls, concrete blocks, insulation, pipe sealant compounds, photographic solutions, and textiles; and in drilling mud in the petroleum industry.

Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Trace Impurities: chlorodibenzodioxins, chlorodibenzofurans (commercial); polychlorophenols, chlorodibenzodioxins, chlorodibenzofurans, polychlorobenzenes, hydroxychlorodiphenyl ethers, 2-bromo-3,4,5,6-tetrachlorophenol (technical grade)

OSHA PEL
8-hr TWA: 0.5 mg/m^3, *Skin*

NIOSH REL
10-hr TWA: 0.5 mg/m^3, *Skin*

DFG (Germany) MAK
Danger of cutaneous absorption

ACGIH TLV
*TWA: 0.5 mg/m^3, *Skin*

IDLH Level
2.5 mg/m^3

*Substances for which there are also ACGIH Biological Exposure Indices (BEIs™).

Section 3 - Hazards Identification

ANSI Signal Word: Danger!

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Pentachlorophenol is a white or dark gray (technical grade) crystalline solid with a phenolic odor. It is highly toxic by ingestion or skin absorption and toxic by inhalation. Severely irritating to skin, eyes, and respiratory system. Also causes: upset stomach, high fever, increased metabolic rate, heart failure. Animal data suggest that pentachlorophenol may be a human carcinogen. Mutation data reported.

Wilson Risk Scale
R 1
I 3
S 3*
K 0
*Skin absorption

HMIS
H 3*
F 0
R 0
PPE†
*Chronic effects
†Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin and/or eye contact, skin absorption **Target Organs:** Eyes, skin, liver, kidneys, and respiratory, central nervous (CNS), and cardiovascular systems **Acute Effects**: **Inhalation:** Causes irritation, cough, sneezing, rapid breathing; and systemic effects. **Eye:** Causes severe irritation or burns, pupil dilation, corneal opacity and numbness, and possibly permanent visual change or loss. **Skin:** Causes severe irritation or burns, dermatitis and systemic effects including upset stomach, weakness, twitching, rapid breathing, polyuria (frequent urination), followed by oliguria (little urination), metabolic acidosis, anemia, hemolysis, high fever, profuse sweating, thirst, increased basal metabolic rate, rapid heart beat, seizures, collapse, heart failure, coma, cerebral edema (brain swelling), and death. Significant exposures may cause permanent damage including impaired autonomic nervous function and circulation. **Ingestion:** Causes gastrointestinal tract irritation, loss of hunger, and systemic effects. **Carcinogenicity:** NTP and OSHA do not list pentachlorophenol as a carcinogen. IARC lists it as 2B (Possibly Carcinogenic to Humans); EPA as B2 (Probable Human Carcinogen, Sufficient Evidence From Animal Studies); DFG (Germany) MAK as A2 (Unmistakably carcinogenic in animal experimentation only); and TLV as A3 (Confirmed Animal Carcinogen with Unknown Relevance to Humans). **Medical Conditions Aggravated by Long-Term Exposure:** Individuals with kidney, liver, or metabolic disorders may be at a higher risk from exposure to pentachlorophenol. *Note: Pentachlorophenol may cross the placenta and affect an unborn child.* **Chronic Effects:** Chronic exposure to pentachlorophenol may cause dermatitis, chloracne, conjunctivitis, bronchitis, damage to the cardiovascular and immune systems, anorexia (appetite loss).

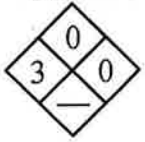
anemia, weight loss, bruising, weakness, fever, sweating, dizziness, headache, anxiety, difficult breathing, kidney and liver damage, and possibly cancer.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed. **Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 min. Consult a physician or ophthalmologist if pain or irritation persist. **Skin Contact:** *Quickly* remove contaminated clothing and wash exposed area with soap and water, repeatedly. Get medical attention immediately. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. *Do not* induce vomiting due to risk of CNS depression and seizures. ***After first aid, get appropriate in-plant, paramedic, or community medical support.*** **Note to Physicians:** Severe systemic poisoning results primarily from uncoupling of mitochondrial oxidative phosphorylation, with ensuing hyperpyrexia. Reduce temperature and replace fluid and electrolytes lost through sweating. Treat symptomatically and supportively. *Do not* administer salicylates. Treat severe acidosis with IV sodium bicarbonate. Monitor for electrolyte imbalance, metabolic acidosis, hemolytic anemia, methemoglobinemia, pancreatitis, and liver and kidney dysfunction. Administer oxygen by mask continuously to minimize tissue anoxia.

Section 5 - Fire-Fighting Measures

NFPA



Flash Point: Not applicable; noncombustible solid **Autoignition Temperature:** None reported.
LEL: None reported. **UEL:** None reported. **Flammability Classification:** Noncombustible solid
Extinguishing Media: Use agent suitable for surrounding fire.
Unusual Fire or Explosion Hazards: May be dissolved in hydrocarbon solution.
Hazardous Combustion Products: Include hydrogen chloride (HCl) and chlorinated phenols.
Fire-Fighting Instructions: *Do not* release runoff from fire control methods to sewers or waterways. Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel, evacuate all unnecessary personnel, remove heat and ignition sources. Isolate the area for at least 80 to 160 feet. Ventilate area, deny entry, stay upwind. Stop leak if you can do so without risk. Cleanup personnel should protect against exposure. **Small Spills:** If in solid form, *do not* sweep! Carefully scoop up or vacuum (with a HEPA filter). Absorb liquid spill with an inert, noncombustible absorbent such as sand or vermiculite. **Large Spills: Containment:** For large spills, dike far ahead of liquid spill for later disposal. Cover with plastic sheet to prevent dispersion. *Do not* release into sewers or waterways. **Cleanup:** If in water, apply activated carbon (10 times the spilled amount of pentachlorophenol). Remove trapped material with suction hoses. **Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Use only with adequate ventilation to maintain concentrations at nonhazardous levels (Sec. 2). Wear personal protective clothing and equipment to prevent any contact with skin and eyes (Sec. 8), and avoid dust inhalation. Practice good personal hygiene procedures to prevent inadvertently ingesting this material. *Do not* attempt to handle broken containers without proper protective equipment. Immediately wash skin if contact with pentachlorophenol occurs. Shower and change into clean clothing after working with pentachlorophenol. **Storage Requirements:** Store in tightly closed containers in a cool, well-ventilated area away from heat, light, ignition sources, and incompatibles. Protect containers from physical damage. Outside or detached storage is preferred. **Regulatory Requirements:** Store according to USEPA hazardous waste storage regulations.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Where feasible, enclose operations to avoid dust dispersion into the work area. Whenever possible, automatically transfer pentachlorophenol from storage containers to process containers. **Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred. **Administrative Controls:** Educate workers about the hazards associated with this material. Train in work practices which minimize exposure. Consider preplacement and periodic medical exams with emphasis on the lungs, liver, kidneys, skin, cardiovascular and nervous systems. **Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For concentrations ≥ 2.5 mg/m^3: any chemical cartridge respirator with organic vapor cartridge(s) in combination with a dust, mist, and fume filter, or any powered, air-purifying respirator with organic vapor cartridge(s) in combination with a dust, mist and fume filter, or any supplied-air respirator, or any SCBA with a full facepiece; emergency/unknown concentrations/IDLH conditions: any SCBA that has a full facepiece and is operated in pressure-demand or other positive-pressure mode, or any supplied-air respirator that has a full facepiece and is operated in pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode; escape: any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister having a high-efficiency particulate filter or any appropriate escape-type SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent any skin contact. Nitrile rubber and Viton™ are recommended >8, neoprene and 4H™ >4. *Do not* use natural rubber or polyvinyl alcohol. Wear dust-proof eyeglasses (solid form) or chemical safety goggles (solution), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not protective eye devices. Appropriate eye protection must be worn instead of, or in conjunction with, contact lenses. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Segregate contaminated clothing such that cleaning personnel *do not* come in contact with pentachlorophenol. Remove this material from your shoes and clean personal protective equipment. Immediately remove contaminated clothing. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Solid

Appearance and Odor: White or dark gray (technical grade) crystalline solid; may be in solution.

Odor Threshold: 857 μg/L at 86 °F (30 °C) (solution)

Vapor Pressure: 0.00011 mm Hg at 77 °F (25 °C)

Vapor Density (Air=1): 9.2

Saturated Vapor Density: 1.20 kg/m^3

Formula Weight: 266.35

Specific Gravity (H_2O=1, at 4 °C): 1.978 at 22 °C/4 °C

Water Solubility: 514 mg/L at 68 °F (20 °C) (slight)

Other Solubilities: Soluble in methanol, ethanol, alcohol, pine oil, dilute alkali, and ether.

Boiling Point: 588 °F (309 °C) (decomposes)

Melting Point: 374 °F (190 °C)

Evaporation Rate: Low, calculated

Henry's Law Constant (H): 2.45 x 10^{-8} atm-m^3/mole at 77 °F

Octanol/Water Partition Coefficient: log K_{ow} = 5.12

Soil Sorption Coefficient (K_{oc}): 1000, calculated; 3000-4000 (measured, sediment)

Section 10 - Stability and Reactivity

Stability: Pentachlorophenol is stable at room temperature in closed containers under normal storage and handling conditions. **Polymerization:** Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include strong oxidizers (contact may produce fire or explosion), strong acids or bases, acid chlorides, acid anhydrides, and ultraviolet light (solution). **Conditions to Avoid:** Avoid contact with chemical incompatibles. **Hazardous Decomposition Products:** Thermal oxidative decomposition of pentachlorophenol can produce hydrogen chloride (HCl), chlorinated phenols, and carbon monoxide.

Section 11- Toxicological Information

Toxicity Data:*

Skin Effects:

Rabbit, open draize test: 10 mg/24 hr: mild irritation.

Acute Dermal Effects:

Rabbit, skin, LD_{Lo}: 40 mg/kg; toxic effects: muscle weakness; BP elevation not characterized in autonomic section; urine volume increased.

Rat, skin, LD_{50}: 96 mg/kg; toxic effects: excitement, muscle contraction or spasticity; dyspnea.

Acute Oral Effects:

Rat, oral, LD_{50}: 27 mg/kg; toxic effects: BP elevation not characterized in autonomic section; hyperglycemia; body temperature increase.

Man, oral, LD_{Lo}: 401 mg/kg; toxic effects: change in motor activity (specific assay); sweating; body temperature increase.

Multiple Dose Toxicity Data:

Rat, oral: 840 mg/kg for 12 weeks, continuous; toxic effects: changes in liver weight; changes in erythrocite (RBC) cell count; weight loss or decreased weight gain.

Rat, oral: 84 mg/kg for 28 days, intermittent; toxic effects: endocrine - other changes; changes in serum composition.

Teratogenicity:

Rat, female, oral: 60 mg/kg, administered on gestational day 9 produced effects on embryo or fetus - fetotoxicity.

Rat, female, oral: 50 mg/kg, administered on gestational days 6-15 produced specific developmental abnormalities - musculoskeletal system.

Reproductive Effects:

Rat, female, oral: 4 g/kg, administered 77 days prior to mating produced effects on newborn - weaning or lactation index; growth statistics.

Section 11- Toxicological Information, *continued*

Acute Inhalation Effects:
Rat, inhalation, LC_{50}: 355 mg/m^3; toxic effects: excitement, muscle contraction or spasticity; dyspnea.

Tumorigenic Effects:
Mouse, oral: 8736 mg/kg for 2 years, continuous; toxic effects: tumorigenic - carcinogenic by RTECS criteria; endocrine - tumors.
Mouse, subcutaneous: 46 mg/kg; toxic effects: tumorigenic - equivocal tumorigenic agent by RTECS criteria; lungs, thorax, or respiration - tumors; liver - tumors.

Mutagenicity:
S. typhimurium, 40 nmol/plate induced mutation.
S. Cerevisiae, 400 mg/L induced mutation.

* See NIOSH, *RTECS* (SM6300000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Pentachlorophenol is highly toxic to algae, crustaceans, and fish. Trout, fresh water, 5 ppm for 3 hr: lethal. Mallard duck, LC_{50}: 4500 ppm. *Daphnia magna*, 7 day LC_{50}: 0.53 mg/L. Fathead minnow, small, 24 hr LC_{50}: 0.24 mg/L. *Poecilia reticulata*, >7 day LC_{50}: 0.38 mg/L. **Environmental Fate:** If released to soil, it will be subject to slow biodegradation and leaching into groundwater. If released in water, it will adsorb to sediment, photodegrade (especially at high pH) and slowly biodegrade. Bioconcentration in fish will be moderate. **Environmental Degradation:** In air, it will be lost due to photolysis and reaction with photochemically produced hydroxyl radicals. Half-life in soil: weeks to 3 months. **Soil Adsorption/Mobility:** Very low mobility in soil. It tends to adsorb to soil and sediment. However, leaching to groundwater is possible.

Section 13 - Disposal Considerations

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable federal, state, and local regulations. One method is to burn in a chemical incinerator equipped with a scrubber and ash disposal facility.
Disposal Regulatory Requirements: This material and its container must be disposed of as hazardous waste.
Container Cleaning and Disposal: Handle empty containers carefully as hazardous residues may still remain. *Do not* reuse empty containers. Combustible containers should be burned in a pesticide incinerator or disposed of in a specified landfill.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Pentachlorophenol
Shipping Symbols: –
Hazard Class: 6.1
ID No.: UN3155
Packing Group: II
Label: POISON
Special Provisions (172.102): –

Packaging Authorizations
a) Exceptions: –
b) Non-bulk Packaging: 173.212
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft/Railcar: 25 kg
b) Cargo Aircraft Only: 100 kg

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: –

Section 15 - Regulatory Information

EPA Regulations:
Listed as a RCRA Hazardous Waste (40 CFR 261.33); RCRA Hazardous Waste Number: D037
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per (1) CWA, Sec. 311 (b)(4); (2) CWA, Sec. 307(a); (3) CAA, Sec. 112; (4) RCRA, Sec. 3001; CERCLA Final Reportable Quantity (RQ), 10 lb (4.54 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 1, 73, 99, 103, 124, 136, 176, 190, 208, 209, 216, 217, 218, 222, 223, 224, 227, 228, 230

Prepared By.....................................S Fleming, BS/ DJ Wilson, CIH
Research Date:.................................4/98 **Review Date:** 3/99
Industrial Hygiene Review...............DJ Wilson, CIH **Medical Review**..................G Kelafant, MD

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Material Safety Data Sheets Collection:
Sheet No. 313
Perchloroethylene

Issued: 11/78 Revision: E, 9/92

Section 1. Material Identification

Perchloroethylene (C_2Cl_4) Description: By chlorination of hydrocarbons and pyrolysis of the carbon tetrachloride that is formed, or by catalytic oxidation of 1,1,2,2-tetrachloroethane. Used in dry cleaning and textile processing, metal degreasing, insulating fluid and cooling gas in electrical transformers, production of adhesives, aerosols, paints, and coatings; as a chemical intermediate, a solvent for various applications, extractant for pharmaceuticals, a pesticide intermediate, and an antihelminthic (parasitic worm removal) agent in veterinary medicine.

Other Designations: CAS No. 127-18-4, Ankilostin, carbon dichloride, Didakene, ethylene tetrachloride, Perchlor, Perclene, Perk, Tetracap, tetrachloroethylene.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2*
K 0
* Skin absorption

NFPA


HMIS
H 2†
F 0
R 0
PPE‡
† Chronic effects
‡ Sec. 8

Cautions: Perchloroethylene is a central nervous system depressant, causes liver and kidney damage (from acute or chronic exposures), and is considered an IARC Class 2B carcinogen (animal sufficient evidence, human inadequate data).

Section 2. Ingredients and Occupational Exposure Limits

Perchloroethylene, < 99%. Impurities include a small amount of amine or phenolic stabilizers.

1991 OSHA PEL
8-hr TWA: 25 ppm (170 mg/m^3)

1990 IDLH Level
500 ppm

1990 NIOSH REL
NIOSH-X Carcinogen
Limit of Quantitation: 0.4 ppm

1992-93 ACGIH TLVs
TWA: 50 ppm (339 mg/m^3)
STEL: 200 ppm (1357 mg/m^3)

1990 DFG (Germany) MAK
TWA: 50 ppm (345 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Man, inhalation, TC_{Lo}: 280 ppm/2 hr caused conjunctival irritation and anesthesia.
Human, lung: 100 mg/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 3005 mg/kg; caused somnolence, tremor, and ataxia.
Rat, inhalation, TC_{Lo}: 200 ppm/6 hr given intermittently over 2 years produced leukemia and testicular tumors.
Rabbit, eye: 162 mg caused mild irritation.
Rabbit, skin: 810 mg/24 hr caused severe irritation.

* See NIOSH, *RTECS* (KX3850000), for additional irritation, mutation, reproductive, tumorigenic, & toxicity data.

Section 3. Physical Data

Boiling Point: 250 °F (121.2 °C)
Freezing Point: -8 °F (-23.35 °C)
Vapor Pressure: 13 mm Hg at 68 °F (20 °C)
Surface Tension: 31.74 dyne/cm at 68 °F (20 °C)
Viscosity: 0.84 cP at 77 °F (25 °C)
Refraction Index: 1.50534 at 68 °F (20 °C)
Molecular Weight: 165.82

Density: 1.6311 at 59 °F (15/4 °C)
Water Solubility: 0.02% at 77 °F (25 °C)
Other Solubilities: Miscible with alcohol, ether, benzene, chloroform, and oils.
Odor Threshold: 47 to 71 ppm (poor warning properties since olfactory fatigue is probable)
Evaporation Rate: 0.15 gal/ft^2/day at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.081 lb/ft^3 or 1.296 kg/m^3

Appearance and Odor: Colorless liquid with an ether-like odor.

Section 4. Fire and Explosion Data

Flash Point: Nonflammable	**Autoignition Temperature:** Nonflammable	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2). For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and collect in low-lying areas.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Perchloroethylene is stable up to 932 °F (500 °C) in the absence of catalysts, moisture, and oxygen but deteriorates rapidly in warm, moist climates. It is slowly decomposed by light. Amine or phenolic stabilizers are usually added. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Slowly (faster in presence of water) corrodes aluminum, iron, and zinc. It is incompatible with chemically active metals (i.e., barium, beryllium, and lithium (explodes with lithium shavings), strong oxidizers, sodium hydroxide, caustic soda, potash, and nitric acid. Perchloroethylene forms an explosive mixture with dinitrogen tetraoxide and reacts with activated charcoal at 392 °F (200 °C) to yield hexachloroethane and hexachlorobenzene. **Conditions to Avoid:** Contact with moisture and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of perchloroethylene can produce carbon dioxide and toxic chlorine, hydrogen chloride, and phosgene gas (also produced by contact with UV light).

Section 6. Health Hazard Data

Carcinogenicity: Perchloroethylene is listed as a carcinogen by The IARC (Group 2B, animal sufficient evidence, human inadequate data),[164] NTP (Class 2, reasonably anticipated as a carcinogen, with limited human evidence and sufficient animal evidence),[169] NIOSH (Class-X, carcinogen defined with no further explanation),[164] and DFG (MAK-B, justifiably suspected of having carcinogenic potential)[164]. There is some controversy regarding human carcinogenicity because even though there is an increased number of cancers of the skin, colon, lung, urogenital tract, and lympho-sarcomas; the dry cleaning workers studied were also exposed to other chemicals. **Summary of Risks:** Perchloroethylene is stored in the fatty tissue and slowly metabolized with the loss of chlorine. The half-life of its urinary metabolite (trichloroacetic acid) is 144 hours. Perchloroethylene exerts the majority of its toxicity on the central nervous system causing symptoms ranging from light-headedness and slight 'inebriation' to unconsciousness. Liver damage is possible after severe acute or minor long-term exposure. It has a synergistic effect with toluene.

Continue on next page

Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: Nervous, liver, kidney, or skin disorders. **Target Organs:** Liver, kidney, eyes, upper respiratory tract, skin, and central nervous system. **Primary Entry Routes:** Inhalation and skin and eye contact. **Acute Effects:** Exposure to high levels can cause liver damage which may take several weeks to develop. Vapor exposure can cause slight smarting of the eyes and throat (in high concentrations). In human studies, exposure to 2000 ppm/5 min caused mild CNS depression; 600 ppm/10 min caused numbness around the mouth, dizziness, and incoordination; 100 ppm/7 hr caused mild eye, nose, and throat irritation, flushing of the face and neck, headache, somnolence, and slurred speech. Skin contact may produce dermatitis because of perchloroethylene's defatting action (more common after repeated exposure). Direct eye contact causes tearing and burning but no permanent damage. Ingestion is rare but can cause irritation of the lips, mouth and gastrointestinal tract, irregular heartbeat, nausea & vomiting, diarrhea (possibly blood stained), drowsiness, unconsciousness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Prolonged exposure can cause impaired memory, extremity (hands, feet) weakness, peripheral neuropathies, impaired vision, muscle cramps, liver damage (fatty degeneration, necrosis, yellow jaundice, and dark urine) and kidney damage (oliguric uremia, conjestion and granular swelling).

FIRST AID ***Rescuers must not enter areas with potentially high perchloroethylene levels without a self-contained breathing apparatus.***
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. *Never administer adrenalin!* **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Be sure victim's head is positioned to avoid aspiration of vomitus into the lungs. **Note to Physicians:** Monitor level of consciousness, EEG (abnormalaties may indicate chronic toxicity), blood enzyme levels (for 2 to 3 wk after exposure), EKG, adequacy of respirations & oxygenation, and liver and kidney function. *BEIs:* C_2Cl_4 in expired air (10 ppm), sample prior to last shift of work week; C_2Cl_4 in blood (1 mg/L), sample prior to last shift of work week; trichloroacetic acid in urine (7 mg/L), sample at end of workweek.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources (although noncombustible, it forms toxic vapors from thermal decomposition). For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of spill and await reclamation or disposal. Report any release in excess of 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, perchloroethylene evaporates and some leaches to groundwater. It may absorb slightly to soils with heavy organic matter. Biodegradation may be important in anaerobic soils. In water, it is subject to rapid volatilization with an estimated half-life from <1 day to several weeks. In air, it exists mainly in the vapor-phase and is subject to photooxidation with a half-life of 30 minutes to 2 months. **Ecotoxicity Values:** Guppy (*Poecilia reticulata*), LC_{50} = 18 ppm/7 days; fathead minnow (*Pimephales promelas*), LC_{50} = 18.4 mg/L/96 hr, flow through bioassay. **Disposal:** Consider recovery by distillation. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) or fluidized bed incineration at 842 to 1796 °F (450 to 980 °C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U210
isted as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per CWA Sec. 307 (a)]
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear a faceshield (8 inch minimum) per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a supplied-air respirator or SCBA with a full facepiece operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, Neoprene, or Viton to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from sunlight, and incompatibles. Do not store sludge from vapor degreasers in tightly-sealed containers and keep outside until disposal is arranged. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Check stabilizer levels frequently and ventilation equipment (air velocity, static pressure, air valve) at least every 3 months. Install an air dryer in ventlines to storage tanks to prevent moisture from rusting and weakening the tank and contaminating or discoloring its contents. Purge all tanks before entering for repairs or cleanup. Build a dike around storage tanks capable of containing all the liquid. Ground tanks to prevent static electricity. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize liver, kidney, and nervous system function, and the skin. Alcoholism may be a predisposing factor.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetrachloroethylene
DOT Hazard Class: 6.1
No.: UN1897
DOT Packing Group: III
DOT Label: Keep away from food
Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 683
Polychlorinated Biphenyls (PCBs)

Issued: 11/88 Revision: A, 9/92

Section 1. Material Identification

39

Polychlorinated Biphenyls [$C_{12}H_{10-n}Cl_n$ (n=3, 4, 5)] Description: A class of nonpolar chlorinated hydrocarbons with a biphenyl nucleus (two benzene nuclei connected by a single C-C bond) in which any or all of the hydrogen atoms have been replaced by chlorine. Commercial PCBs are mixtures of chlorinated biphenyl isomers with varying degrees of chlorination. Prepared industrially by the chlorination of biphenyl with anhydrous chlorine in the presence of a catalyst such as ferric chloride or iron filings. Except for limited research and development applications, PCBs have not been produced in the US since 1977. When large quantities of PCBs were manufactured in the US, they were marketed under the tradename Aroclor (Monsanto) and were characterized by four digit numbers. The first two digits indicating biphenyls (12), triphenyls (54), or both (25, 44); the last two digits indicating the weight percent of chlorine. PCBs' thermal stability, nonflammability, and high dielectric capability made them very useful in electrical equipment. Formerly used as additives in hydraulic fluids, heat transfer systems, lubricants, cutting oils, printer's ink, fire retardants, asphalt, brake linings, automobile body sealants, plasticizers, adhesives, synthetic rubber, floor tile, wax extenders, dedusting agents, pesticide extenders, and carbonless reproducing paper. PCBs are still used in certain existing electrical capacitors and transformers that require enhanced electrical protection to avoid heating from sustained electric faults.

R 1
I 4
S 3*
K 1
* Skin absorption

NFPA

HMIS
H 2‡
F 1
R 0
PPE†
† Sec. 8
‡ Chronic Effects

Other Designations: CAS No. 1336-36-3, Aroclor, Clophen, Chlorextol, chlorinated biphenyls, chlorinated diphenyl, chlorinated diphenylene, chloro biphenyl, chloro-1,1-biphenyl, Dykanol, Fenclor, Inerteen, Kaneclor, Montar, Noflamol, Phenoclor, Pyralene, Pyranol, Santotherm, Sovol, Therminol FR-1

Cautions: PCBs are potent liver toxins that may be absorbed through skin. Potentially, chronic or delayed toxicity is significant because PCBs accumulate in fatty tissue and may reasonably be anticipated to be carcinogens. PCBs are a bioaccumulative environmental hazard. When burned, decomposition products may be more hazardous than the PCBs.

Section 2. Ingredients and Occupational Exposure Limits

PCBs, contain various levels of polychlorinated dibenzofurans and chlorinated naphthalenes as contaminants

1991 OSHA PELs, Skin
8-hr TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m^3
8-hr TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m^3

1990 DFG (Germany) MAK, Danger of Cutaneous Absorption
TWA (Chlorodiphenyl, 42% chlorine): 0.1 ppm (1 mg/m^3)
Category III: Substances with systemic effects, onset of effect > 2 hr., half-life > shift length (strongly cumulative)
Short-term Level: 1 ppm, 30 min., average value, 1 per shift

TWA (Chlorodiphenyl, 54% chlorine): 0.05 ppm (0.5 mg/m^3)
Category III: (see above)
Short-term Level: 0.5 ppm, 30 min., average value, 1 per shift

1985-86 Toxicity Data*
Rat, oral, TD: 1250 mg/kg administered intermittently for 25 weeks produced liver tumors.
Mammal, oral, TD_{Lo}: 325 mg/kg administered to female for 30 days prior to mating and from the 1st to the 36th day of gestation produced effects on newborn (stillbirth; live birth index; viability index).

1990 NIOSH REL
TWA (Chlorodiphenyl, 42% chlorine): 0.001 mg/m^3
TWA (Chlorodiphenyl, 54% chlorine): 0.001 mg/m^3

1992-93 ACGIH TLVs, Skin *
TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m^3
TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m^3

* These guidelines offer reasonably good protection against systemic intoxication, but may not guarantee that chloroacne won't occur.
† See NIOSH, *RTECS* (TQ1350000), for additional reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data*

Boiling Point: 644-707 °F (340-375 °C)
Melting Point: 42%: -2.2 °F (-19°C); 54%: 14 °F (-10 °C)
Vapor Pressure: 1 mm Hg at 100 °F (38 °C); 10^{-6} to 10^{-3} mm at 20 °C
Molecular Weight: 188.7 to 398.5
Specific Gravity: 1.3 to 1.8 at 20 °C
Water Solubility: Low solubility (0.007 to 5.9 mg/L)
Other Solubilities: Most common organic solvents, oils, and fats; slightly soluble in glycerol and glycols.

Appearance and Odor: PCBs vary from mobile oily liquids to white crystalline solids and hard non-crystalline resins, depending upon chlorine content.

* Physical and chemical properties vary widely according to degree and to the position of chlorination.

Section 4. Fire and Explosion Data

Flash Point: 286-385 °F (141-196 °C) OC*	**Autoignition Temperature:** 464 °F (240 °C)	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Use extinguishing media suitable to the surrounding fire. Use dry chemical, foam, carbon dioxide (CO_2), or water spray. Water spray may be ineffective. Use water spray to cool fire-exposed containers or transformers. Do not scatter PCBs with high-pressure water streams. **Unusual Fire or Explosion Hazards:** Combustion products (hydrogen chloride, phosgene, polychlorinated dibenzofurans, and furans) are more hazardous than the PCBs themselves. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Approach fire from upwind to avoid highly toxic decomposition products. Structural firefighter's protective clothing will provide *limited* protection. Do not release runoff from fire control methods to sewers or waterways. Dike for later disposal.

* Flash points shown are a range for various PCBs. Some forms do not have flash points.

Section 5. Reactivity Data

Stability/Polymerization: PCBs are very stable materials but are subject to photodechlorination when exposed to sunlight or UV (spectral region above 290 nanometers). Hazardous polymerization cannot occur. **Chemical Incompatibilities:** PCBs are chemically inert and resistant to oxidation, acids, and bases. **Conditions to Avoid:** Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition [1112-1202 °F (600-650 °C)] of PCBs can produce highly toxic derivatives, including polychlorinated dibenzo-para-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hydrogen chloride, phosgene and other irritants.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) and NTP(169) list PCBs as an IARC probable carcinogen (overall evaluation is 2A; limited human data; sufficient animal data) and NTP anticipated carcinogen, respectively. **Summary of Risks:** PCBs are potent liver toxins that can be absorbed through unbroken skin in toxic amounts without immediate pain or irritation. PCBs have low acute toxicity, but can accumulate in fatty tissue and severe health effects may develop later. Generally, toxicity increases with a higher chlorine content; PCB-oxides are more toxic. The toxic action on the liver also increases with simultaneous exposure to other liver toxins, e.g. chlorinated solvents, alcohol, and certain drugs. Pathological pregnancies (abnormal pigmentations, abortions, stillbirths, and underweight births) have been associated with increased PCB serum levels in mothers; PCBs can be passed in breast milk. PCBs can affect the reproductive system of adults. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, liver, and respiratory disease. **Target Organs:** Skin, liver, eyes, mucous membranes, and respiratory tract. **Primary Entry Routes:** Inhalation, dermal contact, ingestion. **Acute Effects:** Exposure to PCB vapor or mist is severely irritating to the skin, eyes, nose, throat, and upper respiratory tract. Intense acute exposure to high concentrations may result in eye, lung, and liver injury. Systemic effects include nausea, vomiting, increased blood pressure, fatigue, weight loss, jaundice, edema and abdominal pain. Cognitive, neurobehavior and psychomotor impairment and memory loss have also been seen after acute exposure. **Chronic Effects:** Repeated exposure to PCBs can cause chloroacne; redness, swelling, dryness, thickening and darkening of the skin and nails; swelling and burning of the eyes, and excessive eye discharge; distinctive hair follicles; gastrointestinal disturbances; neurological symptoms including headache, dizziness, depression, nervousness, numbness of the extremities, and joint and muscle pain; liver enlargement; menstrual changes in women; and chronic bronchitis. Cancer, primarily liver, is also a possible result of exposure, but data is inconclusive.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Rinsing eyes with medical oil (olive, mineral) initially may remove PCB and halt irritation better than water rinsing alone. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. *Multiple soap and water washings are necessary.* Avoid the use of organic solvents to clean the skin. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** In most cases, accidental PCB ingestion will not be recognized until long after vomiting would be of any value. Never give anything by mouth to an unconscious or convulsing person. Vomiting of the pure substance may cause aspiration. Consult a physician. **Note to Physicians:** Monitor patients for increased hepatic enzymes, chloroacne, and eye, gastrointestinal, and neurologic symptoms listed above. Diagnostic tests include blood levels of PCBs and altered liver enzymes.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, provide adequate ventilation, and isolate hazard area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For small spills, take up with sand or other noncombustible material and place into containers for later disposal. For larger spills, dike far ahead of spill to contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** PCBs have been shown to bio-concentrate significantly in aquatic organisms. **Ecotoxicity:** Bluegill, TLm: 0.278 ppm/96 hr. Mallard Duck, LD_{50}: 2000 ppm. **Environmental Degradation:** In general, the persistence of PCBs increases with an increase degree of chlorination. **Soil Absorption/Mobility:** PCBs are tightly absorbed in soil and generally do not leach significantly in most aqueous soil systems. However, in the presence of organic solvents, PCBs may leach rapidly through the soil. Volatilization of PCBs from soil may be slow, but over time may be significant. **Disposal:** Approved PCB disposal methods include: incineration with scrubbing, high-efficiency boilers, landfills, and EPA-approved alternative disposal methods. Each disposal method has various criteria. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

RCRA Hazardous Waste (40 CFR 261.33): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1 lb (0.454 kg) [* per CWA, Sec. 311(b)(4) and 307(a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. Minimum respiratory protection should include a combination dust-fume-mist and organic vapor cartridge or canister or air-supplied, depending upon the situation. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Butyl rubber, neoprene, Teflon, and fluorocarbon rubber have break through times greater than 8 hrs. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Segregate contaminated clothing in such a manner that there is no direct contact by laundry personnel. Implement quality assurance to ascertain the completeness of the cleaning procedures. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a closed, labelled, container in a ventilated area with appropriate air pollution control equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Inform employees of the adverse health effects associated with PCBs. Limit access to PCB work areas to authorized personnel. Consider preplacement and periodic medical examinations with emphasis on the skin, liver, lung, and reproductive system. Monitor PCB blood levels. Consider possible effects on the fetus. Keep medical records for the entire length of employment and for the following 30 yrs.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Polychlorinated biphenyls
DOT Hazard Class: 9
ID No.: UN2315
DOT Packing Group: II
DOT Label: CLASS 9
Special Provisions (172.102): 9, N81

Packaging Authorizations
a) **Exceptions:** 173.155
b) **Non-bulk Packaging:** 173.202
c) **Bulk Packaging:** 173.241

Quantity Limitations
a) **Passenger Aircraft or Railcar:** 100 L
b) **Cargo Aircraft Only:** 220 L

Vessel Stowage Requirements
a) **Vessel Stowage:** A
b) **Other:** 34

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 163, 164, 168, 169, 174, 175, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy MPH, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 351
Styrene *monomer*

Issued: 8/79 Revision: D, 6/92

Section 1. Material Identification

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Styrene *monomer* ($C_6H_5CHCH_2$) Description: Produced by catalytic dehydrogenation of ethylbenzene at 932 to 1292 °F (500 to 700 °C) at 30 mm Hg; catalyst is a mixture of zinc oxide (86%), aluminum, calcium, and magnesium. Available in technical (99.2% pure) and polymer (99.6% pure) grades. Occurs naturally in the sap of styracaceous plants, in pyrolysis and cracking products of petroleum derivatives, in bituminous-coal and shale-oil tars, in rubber latexes, and as a product of organic substance pyrolysis. Used in the manufacture of a wide range of polymers including polystyrene and copolymer elastomers such as butadiene-styrene rubber or acrylonitrile-butadiene-styrene (ABS); in production of plastics and insulators, as a resin modifying additive, dental filling component, chemical reaction intermediate, and in agricultural products.
Other Designations: CAS No. 100-42-5, cinnamene, Diarex HF 77, ethenylbenzene, NCI-C02200, phenylethylene, styrol, styropor, vinylbenzene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Styrene is extremely flammable and polymerizes easily. The vapor is irritating to eyes, skin, and respiratory system and the liquid may cause burns. Inhalation of high concentrations can lead to central nervous system (CNS) depression.

R	2
I	3
S	2*
K	3

* Skin absorption

NFPA†

HMIS

H	2
F	3
R	2
PPG‡	

‡ Sec. 8

† Rating is for *inhibited* monomer

Section 2. Ingredients and Occupational Exposure Limits

Styrene *monomer*, ca 99.6%, containing inhibitors butylcatechol or hydroquinone

1991 OSHA PELs
8-hr TWA: 50 ppm (215 mg/m^3)
15-min STEL: 100 ppm (425 mg/m^3)

1990 IDLH Level
5000 ppm

1990 NIOSH RELs
TWA: 50 ppm (215 mg/m^3)
STEL: 100 ppm (425 mg/m^3)

1991-92 ACGIH TLVs (Skin)
TWA: 50 ppm (213 mg/m^3)
STEL: 100 ppm (426 mg/m^3)

1990 DFG (Germany) MAKs
Ceiling: 20 ppm (85 mg/m^3)
Half-life: < 2 hr
Peak Exposure Limit: 40 ppm, 30 min. average value, 4 per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 20 $\mu g/m^3$ caused eye effects.
Human, skin: 500 mg (non-standard test, *accident*) caused irritation.
Human, HeLa cell: 28 mmol/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 5000 mg/kg; toxic effects not yet reviewed
Rat, inhalation, LC_{50}: 24 g/m^3/ 4 hr produced an antipsychotic effect.

* See NIOSH, *RTECS* (WL3675000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 293 °F (145 °C)
Freezing Point: -23 °F (-31 °C)
Vapor Pressure: 5 mm Hg at 68 °F (20 °C)
Viscosity: 0.751 mPa
Refraction Index: 1.5463 at 68 °F (20 °C)
Odor Threshold Range: 0.15 to 25 ppm
Density: 0.9045 at 25/25 °C
Surface Tension: 32.14 dyne/cm at 66.2 °F (19 °C)
Molecular Weight: 104.2
Saturated Vapor Density (air = 1.2 kg/m^3): 1.22 kg/m^3 or 0.076 lbs/ft^3
Water Solubility: Practically insoluble, 0.3 lbs/100 lbs water; floats on water
Other Solubilities: Soluble in benzene, carbon disulfide, carbon tetrachloride, ethanol, ethyl ether and ketones. Dissolves organic substances and polymers.

Appearance and Odor: Colorless to slightly yellow oily liquid with a sweet, pleasant odor at low levels becoming pungent as levels increase.

Section 4. Fire and Explosion Data

Flash Point: 88 °F (31 °C), CC	**Autoignition Temperature:** 914 °F (490 °C)	**LEL:** 1.1% v/v	**UEL:** 7% v/v

Extinguishing Media: A Class 1C flammable liquid. For small fires, use dry chemical, carbon dioxide (CO_2), or regular foam. For large fires, use fog, or regular foam. Water may be ineffective since styrene tends to float on water; use only when other agents are unavailable.
Unusual Fire or Explosion Hazards: Styrene may accumulate static electricity. Hazardous polymerization can occur causing container to rupture due to heat of fire. Vapors may travel to ignition source and flash back. Styrene poses a vapor explosion hazard indoors, outdoors, and in sewers.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Use protective clothing specifically recommended by manufacturer. Apply cooling water to container sides until well after fire is out. If possible without risk, remove container from fire area. Stay away from ends of tanks. For massive fire in cargo area use monitor nozzles or unmanned hose holders; if this is impossible, withdraw from area and let fire burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Uninhibited styrene monomer is very unstable and even when inhibited (butylcatechol or hydroquinone) polymerization occurs slowly at room temperature and fast at elevated temperatures or in contact with certain initiators. **Chemical Incompatibilities:** Styrene vapor is explosive when exposed to heat or flame; reacts with oxygen above 104 °F (40 °C) to form a heat-sensitive explosive peroxide. Violent polymerization may be initiated by alkali metal-graphite composites, butyllithium, dibenzoyl peroxide, azoisobutyronitrile or di-*tert*-butyl peroxide. Styrene reacts violently with chlorosulfonic acid, oleum, sulfuric acid, chlorine + iron (II) chloride (above 50 °C) and can react vigorously with oxidizing materials. **Conditions to Avoid:** Exposure to heat and ignition sources, light, and contact with incompatibles.
Hazardous Decomposition Products: Thermal oxidative decomposition of styrene can produce carbon dioxide, acrid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC[164] lists styrene monomer as a carcinogen; Class 2B (possibly carcinogenic, limited human evidence in the absence of sufficient animal data). **Summary of Risks:** Styrene is irritating to the eyes, skin, and respiratory system. It is absorbed through the skin at 9 to 15 $mg/m^2/hr$ (hand and forearm). Inhalation of high concentrations can cause CNS depression but styrene's pungent, irritating odor is usually enough to prevent acute toxic exposures. If heavy exposure occurs, styrene can saturate the body in 30-40 minutes, is distributed throughout the organs and is rapidly eliminated (~85% in 24 hr) either in urine (71%) or expired air (10%). Unexcreted styrene accumulates in adipose tissue (subcutaneous connective tissue containing fat cells). Ovulation and menstrual disorders were observed in women exposed to styrene. In one case, CNS effects were observed in infants whose mother was exposed to chemicals such as styrene during pregnancy. In general, pregnant women may be at elevated risk because styrene crosses the placental barrier. **Target Organs:** CNS, eyes, respiratory system, and skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Medical Conditions Aggravated by Long-term Exposure:** Possibly, liver, kidney, blood, skin, and CNS disorders.
Acute Effects: Inhalation of concentrations as low as 50 ppm causes irritation of the eyes, and respiratory tract.

Continue on next page

Section 6. Health Hazard Data, *continued*

Symptoms include watering eyes and nose, chest heaviness or pain, difficulty breathing, coughing, bluish face and lips, wheezing, headache, nausea, vomiting, dizziness, fatigue, diarrhea and risk of pulmonary edema (fluid in lungs). Skin contact is irritating, with itching, inflammation and possible blisters. Splashes to the eyes cause irritation, watering, lid inflammation, chemical corneal burns, and possibly, serious lesions. Cases of ingestion have not been reported but by analogy to animal studies it could cause irritation of the lips, mouth, and throat; painful swallowing, abdominal pain, nausea, vomiting, state of shock, possible convulsions and risk of pulmonary edema. **Chronic Effects:** Repeated exposure has caused "styrene sickness" described by nausea, vomiting, appetite loss, and general weakness. Occupational asthma may occur rarely. Functional disorders of the nervous system, irritation of the upper airways, and blood changes particularly leukopenia (abnormally low number of circulating, nucleated white or colorless blood cells) and lymphocytosis (increased number of lymphocytes which are involved in the immune system) have also been observed. Medical exams revealed toxic hepatitis in workers exposed to ~50 mg/m^3 styrene for over 5 yr. Prolonged exposure to < 50 mg/m^3 caused certain liver function disorders (protein, pigment, glycogen). Peripheral neuropathies were observed in chronically exposed workers. Repeated or prolonged skin exposure may cause dermatitis with rough, dry, fissured skin due to defatting.

FIRST AID **Eyes:** Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Do *not* allow victim to rub or keep eyes tightly shut. Immediately consult a physician. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not induce vomiting!* Gastric lavage may be indicated if victim is at risk of convulsing but the decision should be carefully weighed since severe esophageal irritation may occur. **Note to Physicians:** For acute exposure, give baseline liver and kidney function tests and obtain urinalysis, CBC, amylase and lipase levels. Monitor arterial blood gases and perform chest X-ray if significant respiratory irritation occurs. Phenylglyoxylic and mandelic acid may be determined in urine.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should protect against inhalation and eye and skin contact. Shut off all ignition sources. Use water spray to cool and disperse vapors (this may not prevent ignition in closed spaces). For small spill, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. For large spills, dike far ahead of liquid spill for later disposal or reclamation. For spills in water, apply activated carbon at 10 X the spilled amount (at least 10,000 ppm) or use barriers or oil spill booms to limit motion. "Universal" gelling agent injected into spill may aid in solidification. Remove material with suction hoses or mechanical dredges. Follow applicable OSHA regulations (29 CFR 1910.120). Report spills in excess of 1000 lb. **Ecotoxicity Values:** TLm, *Pimephales promelas* (fathead minnow), 53.6 mg/L/48 hr; TLm, *Artemia salina* (brine shrimp), 68 mg/L/24 hr and 52 mg/L/48 hr. **Environmental Degradation:** In water, styrene monomer volatilizes rapidly and may be subjected to biodegradation. It is not expected to hydrolyze. In air, styrene will react rapidly with hydroxyl radicals and ozone with a combined calculated half-life of 2.5 to 9 hr. In soil, styrene will biodegrade and leach to groundwater with low to moderate mobility (depending on soil conditions). **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations Listed as a RCRA Hazardous Waste (40 CFR 261.21 & 261.23): D001 and D003, Characteristic of ignitability and reactivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311(b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A & Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH/MSHA-approved respirator. For < 500 ppm, use any supplied air respirator (SAR) or SCBA. For < 1250 ppm, use any SAR operated in a continuous flow mode. For < 5000 ppm, use any SAR with a full facepiece in positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol is recommended as suitable material for PPG. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Thoroughly decontaminate PPG. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Styrene is corrosive to copper or copper alloy containers. Store in cool (hazardous above 32 °C), dry, well-ventilated area away from incompatibles (Sec. 5). Store small refrigerated amounts in glass containers and large amounts in vented metal tanks in outside or detached storage under an inert blanket (i.e., nitrogen). Install electrical equipment Class 1, Group D. Inhibit styrene during storage to prevent polymerization. Uninhibited vapor may polymerize in vents and cause blockage. To prevent static sparks, electrically ground and bond all equipment used in styrene manufacture, use, storage, transfer, and shipping. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Continuously monitor workplace air levels of styrene. Make sure ducting, piping, and pipe joints are leak tight. Give preference to continuous rather than batch techniques and mechanize manual operations. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, blood, liver, kidney, and skin. Consider precluding pregnant women from styrene exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Styrene monomer, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN2055
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Styrene monomer, inhibited
IMO Hazard Class: 3.3
ID No.: UN2055
IMO Label: Flammable liquid
IMDG Packaging Group: II

MSDS Collection References: 73, 89, 100, 101, 103, 124, 126, 127, 131, 132, 133, 136, 139, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD

Material Safety Data Sheet

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GENIUM PUBLISHING CORP.

No. 677

1,1,2,2-TETRACHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

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Material Name: 1,1,2,2-TETRACHLOROETHANE

Description (Origin/Uses): Used as a solvent primarily for cleaning and extraction procedures and as a chemical intermediate in the manufacture of trichloroethylene and tetrachloroethylene; and as an analytic reagent by textile manufacturers in polymer characterization tests.

Genium

Other Designations: Acetylene Tetrachloride; *sym*-Tetrachloroethane; $CHCl_2CHCl_2$; CAS No. 0079-34-5

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

HMIS			
H	2	R	1
F	0	I	4
R	0	S	–
PPG*		K	–

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
1,1,2,2-Tetrachloroethane, CAS No. 0079-34-5 *This material can be absorbed through intact skin, which contributes to overall exposure. **See NIOSH, *RTECS* (KI8575000), for additional data with references to reproductive, tumorigenic, and irritative effects.	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 1 ppm, 7 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 1 ppm, 7 mg/m³ **Toxicity Data**** Human, Oral, TD_{Lo}: 30 mg/kg Human, Inhalation, TC_{Lo}: 1000 mg/m³ (30 Mins) Rat, Oral, LD_{50}: 800 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point: 295°F (146°C)
Melting Point: -47°F (-44°C)
% Volatile by Volume: Ca 100
Vapor Pressure: 6 Torrs at 77°F (25°C)*

Molecular Weight: 168 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.58658 at 77°F (25°C)

Appearance and Odor: A colorless, nonflammable, heavy, mobile liquid; sweetish, suffocating, characteristic chloroform odor. The odor recognition threshold is reported to be less than 3 ppm.

*At 77°F (25°C) the concentration of 1,1,2,2-tetrachloroethane in saturated air is approximately 7900 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2,2-Tetrachloroethane does not burn. Use extinguishing agents that will put out the surrounding fire. **Unusual Fire or Explosion Hazards:** None reported. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode to protect against the effects of the nearby fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2,2-Tetrachloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Hazardous reactions between 1,1,2,2-tetrachloroethane and 2,4-dinitrophenyl disulfide, nitrogen tetroxide, chemically active metals such as potassium; and strong caustics such as potassium hydroxide, sodium, sodium-potassium alloy, hot iron, aluminum, and zinc in the presence of steam are reported. **Conditions to Avoid:** Prevent exposure to the incompatible chemicals listed above. Contact with water causes appreciable hydrolysis that will degrade and decompose this liquid. **Hazardous Products of Decomposition:** Thermal-oxidative degradation of 1,1,2,2-tetrachloroethane can produce highly toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: NIOSH lists 1,1,2,2-tetrachloroethane as a carcinogen.
Summary of Risks: 1,1,2,2-Tetrachloroethane is absorbed through intact skin in significant amounts; one human fatality has been attributed to this route of exposure. This liquid is considered to be one of the most toxic of the common chlorinated hydrocarbons, particularly with respect to the liver. Severely acute exposure causes depression of the central nervous system (CNS), which can cause death within 12 hours. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, CNS, gastrointestinal system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** The initial symptoms of exposure are lacrimation, salivation, and irritation of the nose and throat; continued exposure can lead to nausea, vomiting, and narcosis. Also, low blood pressure and cardiac rhythm abnormalities; respiratory depression; nausea, vomiting, burns of the esophagus, and diarrhea; and anesthesia with dizziness leading to loss of consciousness and coma; plus possible transient liver and kidney changes.
Chronic Effects: The two sets of manifestations are (1) malaise, drowsiness, decreased appetite, then nausea and retching, a bad taste in the throat, constipation, headache, pale stools, jaundice, and dark urine, as well as mental confusion, stupor, and coma; and (2) hand

SECTION 6. HEALTH HAZARD INFORMATION, cont.

tremors, sensation of deafness, numbness in hands and feet, a decrease in reflexes, headache, and nausea. FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. Skin. Rinse the affected areas with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. Should this type of exposure occur, give the exposed person 3 glasses of water to drink and induce vomiting, then repeat this procedure. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Workers exposed to this liquid should be evaluated with a full battery of tests for the liver, kidneys, and CNS systems, as well as the blood.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel must be properly clothed and equipped to protect the skin and eyes against any contact with the liquid as well as inhalation of its vapor (see sect. 8). Vacuum the spilled 1,1,2,2-tetrachloroethane and pump it into suitable containers for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Waste, No. U209
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of this liquid is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent skin contact with this liquid. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale 1,1,2,2-tetrachloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2,2-tetrachloroethane in closed, airtight containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Provide storage areas with adequate ventilation to prevent concentrations of the vapor from building up beyond the occupational exposure limits cited in section 2.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Tetrachloroethane
DOT Hazard Class: ORM-A
ID No. UN1702
DOT Packaging Requirements: 49 CFR 173.620
DOT Packaging Exceptions: 49 CFR 173.505

IMO Shipping Name: 1,1,2,2-Tetrachloroethane
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

Prepared by: PJ Igoe, BS
Industrial Hygiene Review: DJ Wilson, CIH
Medical Review: W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 664
Tetraethyl Lead

Issued: 8/88 Revision: A, 9/92

Section 1. Material Identification 39

Tetraethyl Lead [$(C_2H_5)_4Pb$] Description: Derived by alkylation of lead-sodium alloy with excess ethyl chloride in a nitrogen atmosphere or electrolysis of an ethyl Grignard reagent with an anode of lead pellets. Used as anti-knock agent in gasoline aviation fuel. Formerly used in organomercury fungicides and in the manufacture of other metal alkyls such as ethyl mercury compounds. Since 1974 its use in gasoline was largely replaced by methyl tert butyl ether [(MTBE), see *Genium* MSDS No. 735] after the USEPA issued regulations requiring its gradual reduction in gasoline. Du Pont was the last known company to produce TEL in the US and stopped production in 1990. There are still US companies with branches in Canada that continue to manufacture tetraethyl lead since it is still widely used in gasoline there and in Europe.

Other Designations: CAS No. 78-00-2, TEL, NCI-C54988, tetraethyl plumbane.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Tetraethyl lead is highly toxic to the central nervous system (CNS). The liquid and vapor are easily absorbed through the skin because of TEL's lipid solubility. It is a combustible liquid and can decompose explosively if exposed to air.

R 3
I 4
S -*
K 1
* Skin absorption

NFPA

HMIS
H 3†
F 2
R 3
PPE-Sec. 8
† Chronic effects

Section 2. Ingredients and Occupational Exposure Limits

Tetraethyl lead, ca 98%. Impurities include ethylene dibromide, ethylene dichloride, dye (red, blue, orange), and kerosene.

1991 OSHA PEL (Skin)
8-hr TWA: 0.075 mg/m^3

1990 IDLH Level
40 mg/m^3

1990 NIOSH REL (Skin)
10-hr TWA: 0.075 mg/m^3

1992-93 ACGIH TLV* (Skin)
TWA: 0.1 mg/m^3

1990 DFG (Germany) MAK (Skin)
TWA: 0.01 ppm (0.075 mg/m^3)
Category II: substances with systemic effects
Half-Life: < 2 hr
Peak Exposure Limit: 0.02 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data†
Human, unreported route, TD_{Lo}: 1.47 mg/kg; toxic effects not yet reviewed.
Rat, oral, LD_{50}: 12.3 mg/kg caused aggression, altered sleep time, and convulsions or effect on seizure threshold.
Rat, inhalation, LC_{50}: 850 mg/m^3/1 hr; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 7.5 mg/kg administered from 12 to 14 days of pregnancy caused post-implantation mortality or effects on the developing fetus.

* Biologic monitoring is essential for personnel control.
† See NIOSH, *RTECS* (TP4550000), for additional reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: ~ 392 °F (200 °C); decomposes
Freezing Point: -214.2 °F (-136.8 °C)
Molecular Weight: 323.45
Specific Gravity: 1.59 at 51.8 °F (11 °C)
Ionization Potential: 11.10 eV
Surface Tension: 28.5 dyne/cm
Viscosity: 0.864 mPa.s at 68 °F (20 °C)
Water Solubility: Insoluble, 0.29 mg/L at 77 °F (25 °C)
Other Solubilities: Soluble in benzene, diethyl ether, gasoline, and petroleum ether. Slightly soluble in alcohol.
Vapor Pressure: 0.2 mm Hg at 68 °F (20 °C); 1 mm Hg at 101.12 °F (38.4 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): ~ same as air
Relative Evaporation Rate: 0.032 g/m^2 at 68 °F (20 °C) and wind speed of 4.5 meter /second
Refraction Index: 1.5198 at 68 °F (20 °C/D)

Appearance and Odor: Colorless liquid which may be dyed orange, red, blue or other color and has a slight musty odor.

Section 4. Fire and Explosion Data

Flash Point: 200 °F (93.3 °C), CC; 185 °F (85 °C), OC	**Autoignition Temperature:** None reported	**LEL:** 1.8% v/v	**UEL:** None reported

Extinguishing Media: A Class III B combustible liquid. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam.

Unusual Fire or Explosion Hazards: Container may explode in heat of fire (> 80 °C). Tetraethyl lead burns as an orange flame with a green margin and gives off extremely poisonous lead fumes.

Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is not effective for tetraethyl lead fires. Use clothing specifically recommended by manufacturer (be aware that these may or may not provide *thermal* protection). Apply cooling water to sides of fire-exposed containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if this is impossible, withdraw and let fire burn. Do not release runoff from fire control methods to sewers or waterways. Evacuate 1/3 mile radius if fire becomes uncontrollable.

Section 5. Reactivity Data

Stability/Polymerization: TEL decomposes slowly at room temperature and rapidly at 125 to 150 °C. It also decomposes when exposed to sun or allowed to evaporate in air. Exposure to air for several days can cause explosive decomposition. Hazardous polymerization cannot occur.

Chemical Incompatibilities: TEL solubilizes fatty materials and has solvent action on rubber. It is incompatible with strong oxidizers, sulfuryl chloride, potassium permanganate, and rust.

Conditions to Avoid: Exposure to heat, ignition sources, sunlight, air, strong oxidizers, and other incompatibles.

Hazardous Products of Decomposition: Thermal oxidative decomposition of TEL can produce carbon dioxide (CO_2) and toxic lead (Pb) fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list tetraethyl lead as a carcinogen. One study showed liver and blood tumors (Hodgkins disease) in mice, termed unreliable because these tumors tend to occur spontaneously at times in this particular strain of mice.

Summary of Risks: *Do not* confuse the effects of tetraethyl lead (TEL) with those caused by inorganic lead exposure. TEL is organic and while both are water insoluble, TEL is lipid soluble and easily enters the as brain while inorganic lead compounds can't. Neurologic symptoms are more prevalent than any others. Tetraethyl lead has a latency period from exposure time to onset of symptoms as it must first be metabolized to triethyl lead before toxicity results. The greater the exposure concentration, the faster symptoms develop. TEL's ability to produce chronic toxicity has been debated for years as is the efficacy of chelation therapy. Chronic toxicity was thought not to occur with organic lead compounds because they did not accumulate in the bone like inorganic lead.

Continue on next page

Section 6. Health Hazard Data

Recently, studies showed that TEL is first metabolized to triethyl lead, then over a period of months, converted to inorganic lead which is then deposited in bone. At this point chronic effects could resemble those caused by direct exposure to inorganic lead. If victim survives an acute exposure, recovery may take weeks to months. It is questionable whether all changes are reversible following heavy or long-term exposures. Teratogenic effects may occur; 'a syndrome with severe mental retardation has been seen among children of heavy gasoline sniffers'.(136)

Medical Conditions Aggravated by Long-Term Exposure: Mental disorders and hypertension. **Target Organs:** CNS, cardiovascular system, eyes, liver, kidneys. **Primary Entry Routes:** Eye, skin, inhalation, ingestion. **Acute Effects:** The primary target organ is the brain, and CNS effects occur in three categories; mild, moderate, and severe. Mild effects include anxiety, irritability, insomnia, lurid dreams, vomiting, metallic taste, paleness, cerebellar ataxia, and diarrhea. Moderate effects are disorientation, hyperexcitability, tremors, chorea (involuntary incoordination of face and limbs), bradycardia (slow heart action), hypotension (abnormally low blood pressure), and hypothermia (lowered body temperature). Severe symptoms include delusions, hallucinations, mania, convulsions, cerebellar edema (fluid in the brain), coma, and death. Ringing in the ears, impaired vision (due to weakening of the eye muscles), elevated liver enzymes, and anemia may also occur. **Chronic Effects:** May occur once TEL is metabolized to inorganic lead. Symptoms include anemia, appetite loss, weakness, insomnia, muscle and joint pain, and colic accompanied by severe abdominal pain. See *Genium* MSDS No. 713.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center an unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. Induce vomiting *only* if large amounts are ingested. **Note to Physicians:** Urine lead levels are better indicators of exposure than blood lead levels. Blood lead levels may not reflect exposure until toxicity is severe where as urine directly reflects amount of exposure. In severe acute toxicity, urine lead levels are usually > 350 µg/L but blood levels are < 50 µg/L. Chelation therapy can be useful for chronic exposure but not for acute. If blood levels are greater than 50 µg/dL begin chelation therapy with BAL, calcium EDTA, or D-penicillamine

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. For small spills, take up with earth, sand, vermiculite or charcoal absorbent (decreases evaporation) and place in suitable containers. Dike far ahead of large spill, neutralize with agricultural (slaked) lime, sodium bicarbonate, or crushed limestone and adjust to pH 7. Investigate reclamation or disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill, TLm = 2, 1.4, and 0.2 mg/L at 24, 48, and 96 hr, respectively. **Environmental Degradation:** In the atmosphere, TEL rapidly degrades by reaction with photochemically produced hydroxyl radicals and ozone molecules. The half-life is ~ 1.5 to 5 hr depending on solar intensity. In water, volatilization is expected. Half-life from a model river is 5.3 hr and 3 days in a model pond. It is also subject to hydrolysis and direct photolysis. Some TEL may degrade into dialkyl and trialkyl lead which may be more resistant in water than TEL itself. Bioaccumulation may occur in aquatic organisms. If released to soil, some TEL is expected to degrade to water soluble compounds and leach, although some may volatilize or undergo direct photolysis if exposed to sunlight. **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed (*as lead compounds*) as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a SARA Extremely Hazardous Substance (40 CFR 355), TPQ: 100 lbs
Listed as a RCRA Hazardous Waste (40 CFR 261.33): P110
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 10 lb (4.54 kg) [* per RCRA, Sec. 3001 & CWA, Sec. 311 (b)(4)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 0.75 mg/m^3, use any supplied-air respirator (SAR) or SCBA. For <1.875 mg/m^3, use any SAR operated in continuous-flow mode. For <3.75 mg/m^3, use any SCBA or SAR with a full facepiece or a SAR with a tight fitting facepiece operated in continuous-flow mode. For <40 mg/m^3, use any SAR operated in pressure-demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. *Do not* use rubber as material for PPE (TEL may degrade rubber). **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into work area by controlling it at the source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, dark, well-ventilated area (equipped with an automatic sprinkler system) away from heat, ignition sources, and incompatibles (Sec. 5). Keep containers tightly closed; exposure to air can lead to explosive decomposition. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use nonsparking tool for any maintenance procedures. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on the CNS, including personality changes. For greater assurance of individual protection, monitor urinary output of exposed workers.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetraethyl lead, liquid
DOT Hazard Class: 6.1
ID No.: NA1649
DOT Packing Group: I
DOT Label: Poison, Flammable liquid
Special Provisions (172.102): —

Packaging Authorizations
a) Exceptions: None
b) Non-bulk Packaging: 173.201
c) Bulk Packaging: None

Quantity Limitations
a) Passenger Aircraft or Railcar: Forbidden
b) Cargo Aircraft Only: Forbidden

Vessel Stowage Requirements
a) Vessel Stowage: E
b) Other: 40

MSDS Collection **References:** 23, 73, 89, 101, 103, 124, 126, 127, 132, 136, 140, 148, 149, 153, 159, 162, 163, 164, 167, 174, 175
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:

Sheet No. 317
Toluene

Issued: 8/79 Revision: E, 9/92 Errata: 2/94

Section 1. Material Identification

43

Toluene ($C_6H_5CH_3$) Description: Derived from petroleum i.e., dehydrogenation of cycloparaffin fractions followed by the aromatization of saturated aromatic hydrocarbons or by fractional distillation of coal-tar light oil and purified by rectification. Used widely as a solvent (replacing benzene in many cases) for oils, resins, adhesives, natural rubber, coal tar, asphalt, pitch, acetyl celluloses, cellulose paints and varnishes; a diluent for photogravure inks, raw material for organic synthesis (benzoyl & benzilidene chlorides, saccharine, TNT, toluene diisocyanate, and many dyestuffs), in aviation and high octane automobile gasoline, as a nonclinical thermometer liquid and suspension solution for navigational instruments.

Other Designations: CAS No. 108-88-3, Methacide, methylbenzene, methylbenzol, phenylmethane, toluol, Tolu-sol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Toluene is an eye, skin, and respiratory tract irritant becoming narcotic at high centrations. Liver and kidney damage has occurred. Pregnant women chronically exposed to toluene have shown teratogenic effects. Toluene is highly flammable.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA

HMIS
H 2- Chronic effects
F 3
R 0
PPE-Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Toluene, < 100%; may contain a small amount of benzene (~ 1%), xylene, and nonaromatic hydrocarbons.

1991 OSHA PELs
8-hr TWA: 100 ppm (375 mg/m^3)
15-min STEL: 150 ppm (560 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH RELs
TWA: 100 ppm (375 mg/m^3)
STEL: 150 ppm (560 mg/m^3)

1992-93 ACGIH TLV (Skin)
TWA: 50 ppm (188 mg/m^3)

1990 DFG (Germany) MAK*
TWA: 100 ppm (380 mg/m^3)
Half-life: 2 hr to end of shift
Category II: Substances with systemic effects
Peak Exposure Limit: 500 ppm, 30 min average value, 2/shift

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: 100 ppm caused hallucinations, and changes in motor activity and changes in psychophysiological tests.
Human, oral, LD_{Lo}: 50 mg/kg; toxic effects not yet reviewed
Human, eye: 300 ppm caused irritation.
Rat, oral, LD_{50}: 5000 mg/kg
Rat, liver: 30 µmol/L caused DNA damage.

* Available information suggests damage to the developing fetus is probable.
†See NIOSH, *RTECS* (XS5250000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 232 °F (110.6 °C)
Melting Point: -139 °F (-95 °C)
Molecular Weight: 92.15
Density: 0.866 at 68 °F (20/4 °C)
Surface Tension: 29 dyne/cm at 68 °F (20 °C)
Viscosity: 0.59 cP at 68 °F (20 °C)
Refraction Index: 1.4967 at 20 °C/D
Water Solubility: Very slightly soluble, 0.6 mg/L at 68 °F (20 °C)
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, chloroform, glacial acetic acid, petroleum ether, and carbon disulfide.
Vapor Pressure: 22 mm Hg at 68 °F (20 °C); 36.7 mm Hg at 86 °F (30 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0797 lb/ft^3 or 1.2755 kg/m^3
Odor Threshold (range of all referenced values): 0.021 to 69 ppm

Appearance and Odor: Colorless liquid with a sickly sweet odor.

Section 4. Fire and Explosion Data

Flash Point: 40 °F (4.4 °C) CC	**Autoignition Temperature:** 896 °F (480 °C)	**LEL:** 1.27% v/v	**UEL:** 7.0% v/v

Extinguishing Media: Toluene is a Class 1B flammable liquid. To fight fire, use dry chemical carbon dioxide, or 'alcohol-resistant' foam. Water spray may be ineffective as toluene floats on water and may actually spread fire. **Unusual Fire or Explosion Hazards:** Concentrated vapors are heavier than air and may travel to an ignition source and flash back. Container may explode in heat of fire. Toluenes' burning rate = 5.7 mm/min and its flame speed = 37 cm/sec. Vapor poses an explosion hazard indoors, outdoors, and in sewers. May accumulate static electricity. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire because a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Toluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can't occur. **Chemical Incompatibilities:** Strong oxidizers, concentrated nitric acid, nitric acid + sulfuric acid, dinitrogen tetroxide, silver perchlorate, bromine trifluoride, tetranitromethane, and 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione. **Conditions to Avoid:** Contact with heat, ignition sources, or incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of toluene can produce carbon dioxide, and acrid, irritating smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list toluene as a carcinogen. **Summary of Risks:** Toluene is irritating to the eyes, nose, and respiratory tract. Inhalation of high concentrations produces a narcotic effect sometimes leading to coma as well as liver and kidney damage. 93% of inhaled toluene is retained in the body of which 80% is metabolized to benzoic acid, then to hippuric acid and excreted in urine. The remainder is metabolized to *o*-cresol and excreted or exhaled unchanged. Toluene metabolism is inhibited by alcohol ingestion and is synergistic with benzene, asphalt fumes, or chlorinated hydrocarbons (i.e. perchloroethylene). Toluene is readily absorbed through the skin at 14 to 23 mg/cm^2/hr. Toluene is absorbed quicker during exercise than at rest and appears to be retained longer in obese versus thin victims; presumably due to its lipid solubility. There is inconsistent data on toluene's ability to damage bone marrow; chronic poisoning has resulted in anemia and leucopenia with biopsy showing bone marrow hypo-plasia. These reports are few and some authorities argue that the effects may have been due to benzene contaminants. Chronic inhalation during pregnancy has been associated with teratogenic effects on the fetus including microcephaly, CNS dysfunction, attentional deficits, developmental delay + language impairment, growth retardation, and physical defects including a small midface, short palpebral fissures, with deep-set eyes, low-set ears, flat nasal bridge with a small nose, micrognathia, and blunt fingertips. There is some evidence that toluene causes an autoimmune illness in which the body produces antibodies that cause inflammation of its own kidney.

Continue on next page

Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism and CNS, kidney, skin, or liver disease. **Target Organs:** CNS, liver, kidney, skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Acute Effects:** Vapor inhalation causes respiratory tract irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, watering eyes, nervousness, insomnia, parasthesis, and vertigo progressing to narcotic coma. Death may result from cardiac arrest due to ventricular fibrillation with catecholamines loss. Liquid splashed in the eye causes conjunctival irritation, transient corneal damage and possible burns. Prolonged skin contact leads to drying and fissured dermatitis. Ingestion causes GI tract irritation and ptoms associated with inhalation. **Chronic Effects:** Symptoms include mucous membrane irritation, headache, vertigo, nausea, appetite loss and alcohol intolerance. Repeated heavy exposure may result in encephalopathies (cerebellar ataxia and cognitive dysfunction), liver enlargement, and kidney dystrophy (wasting away). Symptoms usually appear at workdays end, worsen at weeks end and decrease or disappear over the weekend.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of danger of aspiration into the lungs. Gastric lavage may be indicated if large amounts are swallowed; potential toxicity needs to be weighed against aspiration risk when deciding for or against gastric lavage. **Note to Physicians:** Monitor cardiac function. If indicated, use epinephrine and other catecholamines carefully, because of the possibility of a lowered myocardial threshold to the arrhythmogenic effects of such substances. Obtain CBC, electrolytes, and urinalysis. Monitor arterial blood gases. If toluene has > 0.02% (200 ppm) benzene, evaluate for potential benzene toxicity. BEI: hippuric acid in urine, sample at shift end (2.5 g/g creatinine); Toluene in venous blood, sample at shift end (1.0 mg/L).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel protect against inhalation and skin/eye contact. Use water spray to cool and disperse vapors but it may not prevent ignition in closed spaces. Cellosolve, hycar absorbent materials, and fluorocarbon water can also be used for vapor suppression/containment. Take up small spill with earth, sand, vermiculite, or other absorbent, noncombustible material. Dike far ahead of large spills for later reclamation or disposal. For water spills, (10 ppm or greater) apply activated carbon at 10X the spilled amount and remove trapped material with suction hoses or use mechanical dredges/lifts to remove immobilized masses of pollutants and precipitates. Toluene can undergo fluidized bed incineration at 842 to 1796 °F (450 to 980 °C), rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), or liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C). Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue gill, LC_{50} = 17 mg/L/24 hr; shrimp (*Crangonfracis coron*), LC_{50} = 4.3 ppm/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 36.2 mg/L/96 hr. **Environmental Degradation:** If released to land, toluene evaporates and undergoes microbial degradation. In water, toluene volatilizes and biodegrades with a half-life of days to several weeks. In air, toluene degrades by reaction with photochemically produced hydroxyl radicals.

Disposal: Treat contaminated water by gravity separation of solids, followed by skimming of surface. Pass through dual media filtration and carbon absorption units (carbon ratio 1 kg to 10 kg soluble material). Return waste water from backwash to gravity separator. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U220
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)
per RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307 (a)]
ed as a SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses with shatter-resistant glass and side-shields or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 2000 ppm, use any SAR operated in continuous-flow mode, any SAR or SCBA with a full facepiece, or any air-purifying respirator with a full facepiece having a chin-style, front or back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol with a breakthrough time of > 8 hr, Teflon and Viton are recommended as suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove toluene from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Outside or detached storage is preferred. If stored inside, use a standard flammable liquids warehouse, room, or cabinet. To prevent static sparks, electrically ground and bond all equipment used with toluene. Do not use open lights in toluene areas. Install Class 1, Group D electrical equipment. Check that toluene is free of or contains < 1% benzene before use. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Adopt controls for confined spaces (29 CFR 1910.146) if entering areas of unknown toluene levels (holes, wells, storage tanks). Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, liver, kidney, and skin. Include hemocytometric and thrombocyte count in cases where benzene is a contaminant of toluene. Monitor air at regular intervals to ensure effective ventilation.

Transportation Data (49 CFR 172.101)

	Packaging Authorizations	Quantity Limitations	Vessel Stowage Requirements
DOT Shipping Name: Toluene	**a) Exceptions:** 150	**a) Passenger Aircraft or Railcar:** 5L	**Vessel Stowage:** B
DOT Hazard Class: 3	**b) Non-bulk Packaging:** 202	**b) Cargo Aircraft Only:** 60L	**Other:** --
o.: UN1294	**c) Bulk Packaging:** 242		
DOT Packing Group: II			
DOT Label: Flammable Liquid			
Special Provisions (172.102): T1			

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 140, 148, 153, 159, 163, 164, 167, 169, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, CIH, MPH; **Medical Review:** AC Darlington, MD, MPH

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Material Safety Data Sheets Collection:

Sheet No. 312
Trichloroethylene

Issued: 7/79 Revision: F, 9/92

Section 1. Material Identification 39

Trichloroethylene (C_2HCl_3) Description: Derived by treating tetrachloroethane with lime or other alkali in the presence of water, or by thermal decomposition of tetrachloroethane followed by steam distillation. Stabilizers such as epichlorohydrin, isobutanol, carbon tetrachloride, chloroform, benzene, or pentanol-2-triethanolamine are then added. Used as a degreasing solvent in electronics and dry cleaning, a chemical intermediate, a refrigerant and heat-exchange liquid, and a diluent in paint and adhesives; in oil, fat, and wax extraction and in aerospace operations (flushing liquid oxygen). Formerly used as a fumigant (food) and anesthetic (replaced due to its hazardous decomposition in closed-circuit apparatus).

Other Designations: CAS No. 79-01-6; acetylene trichloride; Algylen; Anamenth; Benzinol; Cecolene; Chlorylen; Dow-Tri; ethylene trichloride; Germalgene; Narcogen; Triasol; trichloroethene; TCE; 1,1,3-trichloroethylene.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: TCE is irritating and toxic to the central nervous system (CNS). Inhalation of high concentrations have lead to death due to ventricular fibrillation. Chronic exposure may lead to heart, liver, and kidney damage. The liquid is absorbed through the skin. Although it has a relatively low flash point, TCE burns with difficulty.

R 1
I 2
S 2*
K 3
* Skin absorption

NFPA

HMIS
H 2†
F 2
R 0
PPE‡
† Chronic Effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Trichloroethylene, < 100% [contains stabilizers (Sec. 1)].

1991 OSHA PELs
8-hr TWA: 50 ppm (270 mg/m^3)
15-min STEL: 200 ppm (1080 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
10-hr TWA: 25 ppm (~135 mg/m^3)

1992-93 ACGIH TLVs
TWA: 50 ppm (269 mg/m^3)
STEL: 200 ppm (1070 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 50 ppm (270 mg/m^3)
Category II: Substances with systemic effects
Half-life: 2 hr to shift length
Peak Exposure Limit: 250 ppm, 30 min average value; 2 peaks/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 160 ppm/83 min caused hallucinations and distorted perceptions.
Human, lymphocyte: 5 mL/L caused DNA inhibition.
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.
Mouse, oral, TD_{Lo}: 455 mg/kg administered intermittently for 78 weeks produced liver tumors.

* See NIOSH, *RTECS* (KX4550000), for additional irritation, mutation, reproductive, tumorigenic and toxicity data.

Section 3. Physical Data

Boiling Point: 189 °F (87 °C)
Freezing Point: -121 °F (-85 °C)
Viscosity: 0.0055 Poise at 77 °F (25 °C)
Molecular Weight: 131.38
Density: 1.4649 at 20/4 °C
Refraction Index: 1.477 at 68 °F (20 °C/D)
Odor Threshold: 82 to 108 ppm (*not an effective warning*)
Vapor Pressure: 58 mm Hg at 68 °F (20 °C); 100 mm Hg at 32 °F (0 °C)
Saturated Vapor Density (Air = 0.075 lbs/ft^3; 1.2 kg/m^3): 0.0956 lbs/ft^3; 1.53 kg/m^3
Water Solubility: Very slightly soluble; 0.1% at 77 °F (25 °C)
Other Solubilities: Highly soluble in organic solvents (alcohol, acetone, ether, carbon tetrachloride, & chloroform) and lipids.
Surface Tension: 29.3 dyne/cm

Appearance and Odor: Clear, colorless (sometimes dyed blue), mobile liquid with a sweet chloroform odor.

Section 4. Fire and Explosion Data

Flash Point: 90 °F (32 °C) CC	**Autoignition Temperature:** 788 °F (420 °C)	**LEL:** 8% (25 °C); 12.5% (100 °C)	**UEL:** 10% (25 °C); 90% (100 °C)

Extinguishing Media: A Class 1C Flammable Liquid. Although it has a flash point of 90 °F, TCE burns with difficulty. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapor/air mixtures may explode when ignited. Container may explode in heat of fire. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection against TCE. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE slowly decomposes in the presence of light and moisture to form corrosive hydrochloric acid. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include alkalis (sodium hydroxide), chemically active metals (aluminum, beryllium, lithium, magnesium, sodium, potassium, and titanium), epoxides, and oxidants (nitrogen tetraoxide, perchloric acid). Contact with 1-chloro-2,3-epoxy propane or the mono and di 2,3-epoxypropyl ethers of 1,4-butanediol + 2,2-bis-4(2',3'-epoxypropoxy)-phenylpropane can, in the presence of catalytic quantities of halide ions, cause dehydrochlorination of TCE to explosive dichloroacetylene. **Conditions to Avoid:** Exposure to light, moisture, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of TCE (above 300 °C) or exposure to ultraviolet light can produce carbon dioxide (CO_2) and toxic dichloro acetylene (explosive), chlorine, hydrogen chloride, and phosgene gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies have rated TCE's carcinogenicity: IARC (Class 3, limited animal evidence & insufficient human data), Germany MAK (Class B, justifiably suspected of having carcinogenic potential), & NIOSH (Class X, carcinogen defined with no further categorization). **Summary of Risks:** TCE vapor is irritating to the eyes, nose, and respiratory tract and inhalation of high concentrations can lead to severe CNS effects such as unconsciousness, ventricular arrythmias, and death due to cardiac arrest. Mild liver dysfunction was also seen at levels high enough to produce CNS effects. Contact with the liquid is irritating to the skin and can lead to dermatitis by defatting the skin. Chronic toxicity is observed in the victims increasing intolerance to alcohol characterized by 'degreasers flush', a transient redness of the face, trunk, and arms. The euphoric effect of TCE has led to craving, and habitual sniffing of its vapors.

Continue on next page

Section 6. Health Hazard Data, *Continued*

TCE crosses the placental barrier and thus exposes the fetus (any effects are yet unknown). There are increased reports of menstrual disorders in women workers and decreased libido in males at exposures high enough to cause CNS effects. TCE is eliminated unchanged in expired air and as metabolites (trichloroacetic acid & trichloroethanol) in blood and urine. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of the nervous system, skin, heart, liver, and kidney. **Target Organs:** Respiratory, central & peripheral nervous, and cardiovascular (heart) systems, liver, kidney, and skin. **Primary Entry Routes:** Inhalation, skin and eye contact, and ingestion (rarely). **Acute Effects:** Vapor inhalation can cause eye, nose, and throat irritation, nausea, blurred vision, overexcitement, headache, drunkenness, memory loss, irregular heartbeat (resulting in sudden death), unconsciousness, and death due to cardiac failure. Skin contact with the liquid can cause dryness and cracking and prolonged exposure (generally if the victim is unconscious) can cause blistering. Eye contact can cause irritation and watering, with corneal epithelium injury in some cases. Ingestion of the liquid can cause lip, mouth, and gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Effects may persist for several weeks or months after repeated exposure. Symptoms include giddiness, irritability, headache, digestive disturbances, mental confusion, intolerance to alcohol (degreasers flush), altered color perception, loss or impairment of sense of smell, double vision, and peripheral nervous system function impairment including persistent neuritis, temporary loss of sense of touch, and paralysis of the fingers from direct contact with TCE liquid.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Do not give milk, as its fat content (TCE is lipid soluble) may inhance gastrointestinal absorption of TCE. **Note to Physicians:** TCE elimination seems to be triphasic with half lives at 20 min, 3 hr, and 30 hr. Some success is seen in treating patients with propranolol, atropine, and disulfiram. Monitor urine and blood (lethal level = 3 to 110 µg/mL) metabolites. BEI = 100 mg/g creatinine (trichloroacetic acid) in urine, *sample at end of workweek.* BEI = 4 mg/L (trichloroethanol) in blood, *sample at end of shift at end of the workweek.* These tests are not 100% accurate indicators of exposure; monitor TCE in expired air as a confirmatory test.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container for later disposal. For large spills, flush to containment area where density stratification will form a bottom TCE layer which can be pumped and containerized. Report any release in excess of 1000 lbs. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill sunfish, LC$_{50}$ = 44,700 µg/L/96 hr; fathead minnow (*Pimephales promelas*), LC$_{50}$ = 40.7 mg/L/96 hr. **Environmental Degradation:** In air, TCE is photooxidized with a half-life of 5 days and reported to form phosgene, dichloroacetyl chloride, and formyl chloride. In water it evaporates rapidly in minutes to hours. TCE rapidly evaporates and may leach since it does not absorb to sediment. **Soil Absorption/Mobility:** TCE has a Log K$_{oc}$ of 2, indicating high soil mobility. **Disposal:** Waste TCE can be poured on dry sand and allowed to vaporize in isolated location, purified by distillation, or returned to supplier. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) with an acid scrubber to remove halo acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33 & 261.31): No. U228 & F002 (*spent solvent*)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001, CWA Sec. 311 (b)(4), & CWA Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles (cup-type or rubber framed, equipped with impact-resistant glass), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. At any detectable concentration, wear a SCBA with a full facepiece operated in pressure demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made from Viton or Neoprene to prevent skin contact. *Do not* use natural rubber or polyvinyl chloride (PVC). **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in steel drums, in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, and incompatibles (Sec. 5). Store large quantities in galvanized iron, black iron, or steel containers; small amounts in dark (amber) colored glass bottles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Design processes so that the operator is not directly exposed to the solvent or its vapor. Do not use open electric heaters, high-temperature processes, arc-welding or open flames in TCE atmospheres. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, respiratory, cardiac, central and peripheral nervous systems, and liver and kidney function. Employ air and biological monitoring (BEIs). Instruct employees on safe handling of TCE.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Trichloroethylene
DOT Hazard Class: 6.1
No.: UN1710
DOT Packing Group: III
DOT Label: Keep Away From Food
DOT Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60L
b) Cargo Aircraft Only: 220L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 708
Vinylidene Chloride

Issued: 4/90

Section 1. Material Identification

31

Vinylidene Chloride Description: Prepared from ethylene chloride. Also prepared from vinyl chloride by successive chlorination and dehydrochlorination steps. Used primarily as a co-monomer in producing vinylidene copolymers (Saran®, Velon®) for films and coatings. Also used in producing methyl chloroform, vinyl chloride resins, plastics, chloracetyl chloride; in adhesives; as a component of synthetic fibers; a chemical intermediate in vinylidene fluoride synthesis; and for 1,1,1-trichloroethane. A common constituent in our environment, measurable quantities of vinylidene chloride are found in poorly ventilated areas with a high concentration of plastics. It is a notable contaminant in recycled air environments such as nuclear submarines and spacecraft.
Other Designations: CAS No. 0075-35-4; $C_2H_2Cl_2$; 1,1-DCE; 1,1-dichloroethene; *asym*-dichloroethylene; VDC; vinylidene dichloride.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.
Comment: At temperatures above 32 °F/0 °C and especially in the presence of oxygen or other suitable catalysts, vinylidene chloride polymerizes to a plastic. Therefore, commercial products may contain small proportions of inhibitors to preserve the monomer.

R 3
I 4
S 2
K 4

NFPA

HMIS
H 2
F 4
R 2
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Vinylidene chloride, ca 100%

OSHA PEL	ACGIH TLVs, 1989-90	Toxicity Data*
8-hr TWA: 1 ppm, 4 mg/m^3	TLV-TWA: 5 ppm, 20 mg/m^3	Mouse, skin, TD_{Lo}: 4840 mg/kg has tumorigenic effects on skin, appendages, lungs, thorax, and respiration
	TLV-STEL: 20 ppm, 79 mg/m^3	Rat, inhalation, LC_{50}: 6350 ppm/4 hr
	NIOSH REL, 1987 None established	Human, inhalation, TC_{Lo}: 25 ppm produces changes in behavior (general anesthetic), the liver, kidney, ureter, and bladder

* See NIOSH, *RTECS* (YZ8061000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 89.1 °F/31.7 °C at 760 mm Hg
Melting Point: -188.5 °F/-122.5 °C
Vapor Pressure: 591 mm Hg at 77 °F/25 °C
Vapor Density (Air = 1): 3.4
Molecular Weight: 96.94 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.2129 at 68 °F/20 °C
Water Solubility: Sparingly soluble (0.04 % wt/vol in water at 68 °F/20 °C)

Appearance and Odor: Colorless, volatile liquid with a mild, sweet odor that resembles chloroform. Most persons can detect vinylidene chloride at 1000 ppm, but others can detect it at less than 500 ppm. Neither odor is adequate to warn of excessive exposure.

Section 4. Fire and Explosion Data

Flash Point: -19 °F/-28 °C	**Autoignition Temperature:** 1058 °F/570 °C	**LEL:** 5.6% v/v	**UEL:** 11.4% v/v

Extinguishing Media: Use dry chemical, alcohol foam, or carbon dioxide. Use water to cool fire-exposed containers.
Unusual Fire or Explosion Hazards: Vinylidene chloride is a very flammable and volatile liquid with a burning rate of 2.7 mm/min. This material is a very dangerous fire hazard and moderately explosive when exposed to heat or flame. It may explode spontaneously since the vapor forms explosive mixtures with air. At elevated temperatures, polymerization may take place and containers may rupture.
Special Fire-fighting Procedures: Since vinylidene chloride may be poisonous if inhaled or absorbed through the skin, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode with a fully encapsulating suit. Keep unnecessary people away from the hazard area. Vapors may travel to an ignition source and flash back. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Vinylidene chloride is self-reactive. If stored between -40 °F/-40 °C and 77 °F/25 °C in air without an inhibitor, this material rapidly absorbs oxygen and forms a violently explosive peroxide. The heat of polymerization is -185 cal/g (inhibited). When unstable, vinylidene chloride decomposes into chlorine, hydrogen chloride, phosgene, and formaldehyde. Hazardous polymerization can occur if exposed to sunlight, air, copper, aluminum, or heat.
Chemical Incompatibilities: This material reacts violently with chlorosulfonic acid, nitric acid, and oleum; and vigorously with oxidizing materials.
Hazardous Products of Decomposition: Thermal oxidative decomposition of vinylidene chloride can produce highly toxic fumes of chlorine (Cl_2) and hydrogen chloride (HCl).

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists vinylidene chloride as a carcinogen, although the ACGIH suggests it is a suspected carcinogen. Various animal studies suggest a high rate of cancer in species-specific testing; application to humans does not appear valid.
Summary of Risks: Vinylidene chloride is an irritant to the skin, eyes, and mucous membranes, although any inhibitor in vinylidene chloride may partly cause the irritation. VDC is narcotic at concentrations greater than 4000 ppm, and has caused liver and kidney injury in experimental animals. Solutions containing the inhibitor MEHQ (monomethyl ether of hydroquinone) may cause leucoderma (white skin) and serious eye injury.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous system, liver, and kidneys.
Primary Entry Routes: Inhalation.
Acute Effects: Inhalation of VDC causes narcosis and respiratory irritation. Concentrations of 4000 ppm lead to symptoms of drunkenness and eventually unconsciousness if the exposure continues. In monkey studies, exposure to 200 ppm caused acute liver injury with a mechanism similar to carbon tetrachloride. Animal studies indicate acute kidney changes in high-level exposures. Eye contact may cause conjunctivitis, transient corneal injury, and iritis. VDC also causes skin and mucous membrane irritation.
Chronic Effects: With chronic inhalation, vinylidene chloride may cause hepatic and renal dysfunction. In monkey studies, long-term inhalation at a 48-ppm level caused liver and kidney damage and death.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Solutions containing increased MEHQ concentrations are caustic and should not be removed by emesis. There is no specific treatment for VDC intoxication, but if significant amounts have been ingested, monitor the patient for liver and kidney failure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a vinylidene chloride spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel from hazard area, remove all heat and ignition sources, and ventilate area. Cleanup personnel should protect against inhalation and skin and eye contact. For lab spills, absorb the spill with paper towels and place in a hood to allow liquid to evaporate. For large spills, absorb bulk spill with cement powder, fly ash, sawdust, or commercial sorbents. Place waste in appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, Sec. 31 (b)(4), Sec. 307(a); per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Respiratory canisters containing alkaline materials should not be used because dichloro acetylene can be formed. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Rubber gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLVs (Sec. 2). Local explosion-proof exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store vinylidene chloride in tanks with nickel, glass, or baked phenolic linings at 14 °F/-10 °C in the absence of light, air, water, and other polymerization initiators under a nitrogen blanket (at 10-psi pressure and an oxygen content less than 100 ppm). Outside or detached storage is preferable. If stored inside, store in a standard flammable liquids storage cabinet separate from oxidizing materials and incompatible materials (Sec. 5).

Engineering Controls: VDC requires special handling, precautions, and employee training. Do not handle VDC without adequate ventilation and personal protective gear. Limit exposures to vinylidene chloride by improving housekeeping procedures. Keep VDC away from all heat and ignition sources. All engineering systems should be of maximum explosion-proof design, electrically grounded, and bonded.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Vinylidene chloride, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN1303
DOT Label: Flammable liquid
DOT Packaging Requirements: 173.119
DOT Packaging Exceptions: 173.118

IMO Shipping Name: Vinylidene chloride, inhibited
IMO Hazard Class: 3.1
IMO Label: Flammable liquid
IMDG Packaging Group: I
ID No.: UN1303

***MSDS Collection* References:** 7, 26, 38, 53, 73, 84, 85, 87, 89, 100, 103, 124, 126, 127, 129, 134, 136
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD

M8

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Material Safety Data Sheets Collection:

Sheet No. 318
Xylene *(Mixed Isomers)*

Issued: 11/80 Revision: E, 9/92 Errata: 12/94

Section 1. Material Identification

Xylene (Mixed Isomers) (C_8H_{10}) Description: The commercial product is a blend of the three isomers [*ortho*-(*o*-), *meta*-(*m*-), *para*-(*p*-)] with the largest proportion being *m*- xylene. Xylene is obtained from coal tar, toluene by transalkylation, and pseudocumene. Used in the manufacture of dyes, resins, paints, varnishes, and other organics; as a general solvent for adhesives, a cleaning agent in microscope technique; as a solvent for Canada balsam microscopy; as a fuel component; in aviation gasoline, protective coatings, sterilizing catgut, hydrogen peroxide, perfumes, insect repellants, pharmaceuticals, and the leather industry; in the production of phthalic anhydride, isophthalic, and terephthalic acids and their dimethyl esters which are used in the manufacture of polyester fibers; and as an indirect food additive as a component of adhesives. Around the home, xylene is found as vehicles in paints, paint removers, degreasing cleaners, lacquers, glues and cements and as solvent/vehicles for pesticides.

Other Designations: CAS No. 1330-20-7 [95-47-6; 108-38-3; 106-42-3 (*o*-, *m*-, *p*-isomers)], dimethylbenzene, methyltoluene, NCI-C55232, Violet 3, xylol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Xylene is an eye, skin, and mucous membrane irritant and may be narcotic in high concentrations. It is a dangerous fire hazard.

R	1
I	2
S	2
K	3

NFPA

HMIS

H	2†
F	3
R	0
PPE	‡

† Chronic Effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Xylene (mixed isomers): the commercial product generally contains ~ 40% *m*-xylene; 20% each of *o*-xylene, *p*-xylene, and ethylbenzene; and small quantities of toluene. Unpurified xylene may contain pseudocumene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 150 ppm (655 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH RELs
TWA: 100 ppm (435 mg/m^3)
STEL: 150 ppm (655 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 150 ppm (651 mg/m^3)
BEI (Biological Exposure Index): Methylhippuric acids in urine at end of shift: 1.5 g/g creatinine

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category II: Substances with systemic effects
Half-life: < 2 hr
Peak Exposure: 200 ppm, 30 min, average value, 4 peaks per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 200 ppm produced olfaction effects, conjunctiva irritation, and other changes involving the lungs, thorax, or respiration.
Man, inhalation, LC_{Lo}: 10000 ppm/6 hr; toxic effects not yet reviewed.
Human, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted.
Rat, oral, LD_{50}: 4300 mg/kg; toxic effect not yet reviewed.
Rat, inhalation, LC_{50}: 5000 ppm/4 hr; toxic effects not yet reviewed.

* See NIOSH, *RTECS* (XE2100000), for additional toxicity data.

Section 3. Physical Data

Boiling Point Range: 279 to 284 °F (137 to 140 °C)*
Boiling Point: *ortho:* 291 °F (144 °C); *meta:* 281.8 °F (138.8 °C); *para:* 281.3 °F (138.5 °C)
Freezing Point/Melting Point: *ortho:* -13 °F (-25 °C); *meta:* -53.3 °F (- 47.4 °C); *para:* 55 to 57 °F (13 to 14 °C)
Vapor Pressure: 6.72 mm Hg at 70 °F (21 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): 1.23 kg/m^3, 0.077 lbs/ft^3

Appearance and Odor: Clear, sweet-smelling liquid.
* Materials with wider and narrower boiling ranges are commercially available.

Molecular Weight: 106.16
Specific Gravity: 0.864 at 20 °C/4 °C
Water Solubility: Practically insoluble
Other Solubilities: Miscible with absolute alcohol, ether, and many other organic liquids.
Octanol/Water Partition Coefficient: logKow = 3.12-3.20
Odor Threshold: 1 ppm
Viscosity: <32.6 SUS

Section 4. Fire and Explosion Data

Flash Point: 63 to 77 °F (17 to 25 °C) CC	**Autoignition Temperature:** 982 °F (527 °C) (*m*-)	**LEL:** 1.1 (*m*-, *p*-); 0.9 (*o*-)	**UEL:** 7.0 (*m*-, *p*-); 6.7 (*o*-)

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray or regular foam. For large fires, use water spray, fog or regular foam. Water may be ineffective. Use water spray to cool fire-exposed containers. **Unusual Fire or Explosion Hazards:** Xylene vapors or liquid (which floats on water) may travel to an ignition source and flash back. The heat of fire may cause containers to explode and/or produce irritating or poisonous decomposition products. Xylene may present a vapor explosion hazard indoors, outdoors, or in sewers. Accumulated static electricity may occur from vapor or liquid flow sufficient to cause ignition. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide limited protection. If feasible and without risk, move containers from fire area. Otherwise, cool fire-exposed containers until well after fire is extinguished. Stay clear of tank ends. Use unmanned hose holder or monitor nozzles for massive cargo fires. If impossible, withdraw from area and let fire burn. Withdraw immediately in case of any tank discoloration or rising sound from venting safety device. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Xylene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Xylene is easily chlorinated, sulfonated, or nitrated. **Chemical Incompatibilities:** Incompatibilities include strong acids and oxidizers and 1,3-dichloro-5,5-dimethyl-2,4-imidazolidindione (dichlorohydrantoin). Xylene attacks some forms of plastics, rubber, and coatings. **Conditions to Avoid:** Avoid heat and ignition sources and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of xylene can produce carbon dioxide, carbon monoxide, and various hydrocarbon products.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list xylene as a carcinogen. **Summary of Risks:** Xylene is an eye, mucous membrane, and respiratory tract irritant. Irritation starts at 200 ppm; severe breathing difficulties which may be delayed in onset can occur at high concentrations. It is a central nervous system (CNS) depressant and at high concentrations can cause coma. Kidney and liver damage can occur with xylene exposure. With prolonged or repeated cutaneous exposure, xylene produces a defatting dermatitis. Chronic toxicity is not well defined, but it is less toxic than benzene. Prior to the 1950s, benzene was often found as a contaminant of xylene and the effects attributed to xylene such as blood dyscrasias are questionable. Since the late 1950s, xylenes have been virtually benzene-free and blood dyscrasias have not been associated with xylenes. Chronic exposure to high concentrations of xylene in animal studies have demonstrated mild reversible decrease in red and white cell counts as well as increases in platelet counts.

Continue on next page

Section 6. Health Hazard Data, *continued*

Menstrual irregularity was reported in association with workplace exposure to xylene perhaps due to effects on liver metabolism. Xylene crosses the human placenta, but does not appear to be teratogenic under conditions tested to date. **Medical Conditions Aggravated by Long-Term Exposure:** CNS, respiratory, eye, skin, gastrointestinal (GI) , liver and kidney disorders. **Target Organs:** CNS, eyes, GI tract, liver, kidneys, and skin. **Primary Entry Routes:** Inhalation, skin absorption (slight), eye contact, ingestion. **Acute Effects:** Inhalation of high xylene concentrations may cause dizziness; nausea, vomiting, and abdominal pain; eye, nose, and throat irritation; respiratory tract irritation leading to pulmonary edema (fluid in lung); drowsiness; and unconsciousness. Direct eye contact can result in conjunctivitis and corneal burns. Ingestion may cause a burning sensation in the oropharynx and stomach and transient CNS depression. **Chronic Effects:** Repeated or prolonged skin contact may cause drying and defatting of the skin leading to dermatitis. Repeated eye exposure to high vapor concentrations may cause reversible eye damage, peripheral and central neuropathy, and liver damage. Other symptoms of chronic exposure include headache, fatigue, irritability, chronic bronchitis, and GI disturbances such as nausea, loss of appetite, and gas.

FIRST AID *Emergency personnel should protect against exposure.* **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing as it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. Monitor exposed person for respiratory distress. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, *do not induce vomiting!* If spontaneous vomiting should occur, keep exposed person's head below the hips to prevent aspiration (breathing liquid xylene into the lungs). *Aspiration of a few millimeters of xylene can cause chemical pneumonitis, pulmonary edema, and hemorrhage.* **Note to Physicians:** Hippuric acid or the ether glucuronide of *ortho*-toluic acid may be useful in diagnosis of *meta-*, *para-* and *ortho*-xylene exposure, respectively. Consider gastric lavage if a large quantity of xylene was ingested. Proceed gastric lavage with protection of the airway from aspiration; consider endotracheal intubation with inflated cuff.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and ventilate spill area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If feasible and without undue risk, stop leak. Use appropriate foam to blanket release and suppress vapors. Water spray may reduce vapor, but does not prevent ignition in closed spaces. For small spills, absorb on paper and evaporate in appropriate exhaust hood or absorb with sand or some non-combustible absorbent and place in containers for later disposal. For large spills dike far ahead of liquid to contain. Do not allow xylene to enter a confined space such as sewers or drains. On land, dike to contain or divert to impermeable holding area. Apply water spray to control flammable vapor and remove material with pumps or vacuum equipment. On water, contain material with natural barriers, booms, or weirs; apply universal gelling agent; and use suction hoses to remove spilled material. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** Little bioconcentration is expected. Biological oxygen demand 5 (after 5 days at 20 °C): 0.64 (no stated isomer). **Ecotoxicity values:** LD_{50}, Goldfish, 13 mg/L/24 hr, conditions of bioassay not specified, no specific isomer. **Environmental Degradation:** In the atmosphere, xylenes degrade by reacting with photochemically produced hydroxyl radicals with a half-life ranging from 1-1.7 hr. in the summer to 10-18 hr in winter or a typical loss of 67-86% per day. Xylenes are resistant to hydrolysis. **Soil Absorption/Mobility:** Xylenes have low to moderate adsorption to soil and when spilled on land, will volatilize and leach into groundwater. **Disposal:** As a hydrocarbon, xylene is a good candidate for controlled incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U239, F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act, Sec. 311(b)(4); per RCRA, Sec. 3001]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations >1000 ppm, use any chemical cartridge respirator with organic vapor cartridges; any powered, air-purifying respirator with organic vapor cartridges; any supplied-air respirator; or any self-contained breathing apparatus. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. With breakthrough times > 8 hr, consider polyvinyl alcohol and fluorocarbon rubber (Viton) as materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in clearly labelled, tightly closed, containers in a cool, well-ventilated place, away from strong oxidizing materials and heat and ignition sources. During transferring operations, electrically ground and bond metal containers. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use hermetically sealed equipment, transfer xylene in enclosed systems, avoid processes associated with open evaporating surfaces, and provide sources of gas release with enclosures and local exhaust ventilation. Use Class I, Group D electrical equipment. **Administrative Controls:** Establish air and biological monitoring programs and evaluate regularly. Consider preplacement and periodic medical examinations including a complete blood count, a routine urinalysis, and liver function tests. Consider hematologic studies if there is any significant contamination of the solvent with benzene. If feasible, consider the replacement of xylene by less toxic solvents such as petrol (motor fuel) or white spirit. Before carrying out maintenance and repair work, steam and flush all equipment to remove any xylene residues.

Transportation Data (49 CFR 172.101)

	Packaging Authorizations	**Quantity Limitations**	**Vessel Stowage Requirements**
DOT Shipping Name: Xylenes			
DOT Hazard Class: 3	a) Exceptions: 173.150	a) Passenger, Aircraft, or Railcar: 5L	a) Vessel Stowage: B
ID No.: UN1307	b) Nonbulk Packaging : 173.202	b) Cargo Aircraft Only: 60L	b) Other: –
DOT Packing Group: II	c) Bulk Packaging: 173.242		
DOT Label: Flammable Liquid			
Special Provisions (172.102): T1			

***MSDS Collection* References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 171, 174, 176, 180.
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

Occupational Health Guideline for Coal Tar Pitch Volatiles

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

Anthracene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Pale green solid with a faint aromatic odor.

Phenanthrene

- Formula: $C_{14}H_{10}$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Pyrene

- Formula: $C_{16}H_{10}$
- Synonyms: None
- Appearance: Bright yellow solid

Carbazole

- Formula: $C_{12}H_9N$
- Synonyms: None
- Appearance and odor: Colorless solid with a faint aromatic odor.

Benzo(a)pyrene

- Formula: $C_{20}H_{12}$
- Synonyms: BaP, 3,4-benzopyrene
- Appearance and odor: Colorless solid with a faint aromatic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for coal tar pitch volatiles is 0.2 milligram of coal tar pitch volatiles per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit for coal tar products be reduced to 0.1 mg/m^3 (cyclohexane-extractable fraction) averaged over a work shift of up to 10 hours per day, 40 hours per week, and that coal tar products be regulated as occupational carcinogens. The NIOSH Criteria Document for Coal Tar Products and NIOSH Criteria Document for Coke Oven Emissions should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Coal tar pitch volatiles can affect the body if they are inhaled or if they come in contact with the eyes or skin.

- **Effects of overexposure**

Repeated exposure to coal tar pitch volatiles has been associated with an increased risk of developing bronchitis and cancer of the lungs, skin, bladder, and kidneys. Pregnant women may be especially susceptible to exposure effects associated with coal tar pitch volatiles. Repeated exposure to these materials may also cause sunlight to have a more severe effect on a person's skin. In addition, this type of exposure may cause an allergic skin rash.

- **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 coal tar pitch volatiles.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to coal tar pitch volatiles at potentially hazardous levels:

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

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 stablish a baseline for future health monitoring. Examination of the oral cavity, respiratory tract, bladder, and kidneys should be stressed. The skin should be examined for evidence of chronic disorders, for premalignant and malignant lesions, and evidence of hyperpigmentation or photosensitivity.

—Urinalysis: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. A urinalysis should be obtained to include at a minimum specific gravity, albumin, glucose, and a microscopic on centrifuged sediment, as well as a test for red blood cells.

—Urinary cytology: Coal tar pitch volatiles are associated with an excess of kidney and bladder cancer. Employees having 5 or more years of exposure or who are 45 years of age or older should have a urinary cytology examination.

—Sputum cytology: Coal tar pitch volatiles are associated with an excess of lung cancer. Employees having 10 or more years of exposure or who are 45 years of age or older should have a sputum cytology examination.

—14" x 17" chest roentgenogram: Coal tar pitch volatiles are associated with an excess of lung cancer. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Coal tar pitch volatiles are reported to cause an excess of bronchitis. Periodic surveillance is indicated.

—A complete blood count: Due to the possibility of enzene exposure associated with coal tar pitch volatiles, a complete blood count is considered necessary to search for leukemia and aplastic anemia.

—Skin disease: Coal tar pitch volatiles are defatting agents and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of these agents.

2. Periodic Medical Examination: The aforementioned medical examinations should be repeated on an annual basis, and semi-annually for employees 45 years of age or older or with 10 or more years' exposure to coal tar pitch volatiles.

- **Summary of toxicology**

Coal tar pitch volatiles (CTPV) are products of the destructive distillation of bituminous coal and contain polynuclear aromatic hydrocarbons (PNA's). These hydrocarbons sublime readily, thereby increasing the amounts of carcinogenic compounds in working areas. Epidemiologic evidence suggests that workers intimately exposed to the products of combustion or distillation of bituminous coal are at increased risk of cancer at many sites. These include cancer of the respiratory tract, kidney, bladder, and skin. In a study of coke oven workers, the level of exposure to CTPV and the length of time exposed were related to the development of cancer. Coke oven workers with the highest risk of ancer were those employed exclusively at topside jobs r 5 or more years, for whom the increased risk of dying from lung cancer was 10-fold; all coke oven workers had a 7-½-fold increase in risk of dying from kidney cancer. Although the causative agent or agents of the cancer in coke oven workers is unidentified, it is suspected that several PNA's in the CTPV generated during the coking process are involved. Certain industrial populations exposed to coal tar products have a demonstrated risk of skin cancer. Substances containing PNA's which may produce skin cancer also produce contact dermatitis; examples are coal tar, pitch, and cutting oils. Although allergic dermatitis is readily induced by PNA's in guinea pigs, it is only rarely reported in humans from occupational contact with PNA's; these have resulted largely from the therapeutic use of coal tar preparations. Components of pitch and coal tar produce cutaneous photosensitization; skin eruptions are usually limited to areas exposed to the sun or ultraviolet light. Most of the phototoxic agents will induce hypermelanosis of the skin; if chronic photodermatitis is severe and prolonged, leukoderma may occur. Some oils containing PNA's have been associated with changes of follicular and sebaceous glands which commonly take the form of acne. There is evidence that exposures to emissions at coke ovens and gas retorts may be associated with an increased occurrence of chronic bronchitis. Coal tar pitch volatiles may be associated with benzene, an agent suspected of causing leukemia and known to cause aplastic anemia.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data—Anthracene**

1. Molecular weight: 178.2
2. Boiling point (760 mm Hg): 340 C (644 F)
3. Specific gravity (water = 1): 1.24
4. Vapor density (air = 1 at boiling point of anthracene): 6.15
5. Melting point: 217 C (423 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Phenanthrene**

1. Molecular weight: 178.2
2. Boiling point (760 mm Hg): 340 C (644 F)
3. Specific gravity (water = 1): 1.18
4. Vapor density (air = 1 at boiling point of phenanthrene): 6.15
5. Melting point: 100.5 C (213 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Pyrene**

1. Molecular weight: 202.3
2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)

3. Specific gravity (water = 1): 1.28
4. Vapor density (air = 1 at boiling point of pyrene): 6.9
5. Melting point: 150.4 C (303 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Carbazole**

1. Molecular weight: 167.2
2. Boiling point (760 mm Hg): 355 C (671 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of carbazole): 5.8
5. Melting point: 246 C (475 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Benzo(a)pyrene**

1. Molecular weight: 252.3
2. Boiling point (760 mm Hg): Greater than 360 C (greater than 680 F)
3. Specific gravity (water = 1): Greater than 1
4. Vapor density (air = 1 at boiling point of benzo(a)pyrene): 8.7
5. Melting point: 179 C (354 F)
6. Vapor pressure at 20 C (68 F): Less than 1 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Reactivity**

1. Conditions contributing to instability: None hazardous
2. Incompatibilities: Contact with strong oxidizers may cause fires and explosions.
3. Hazardous decomposition products: None
4. Special precautions: None

- **Flammability**

1. Flash point: Anthracene: 121 C (250 F) (closed cup); Others: Data not available
2. Autoignition temperature: Anthracene: 540 C (1004 F); Others: Data not available
3. Flammable limits in air, % by volume: Anthracene: Lower: 0.6; Others: Data not available
4. Extinguishant: Foam, dry chemical, and carbon dioxide

- **Warning properties**

Grant states that "coal tar and its various crude fractions appear principally to cause reddening and squamous eczema of the lid margins, with only small erosions of the corneal epithelium and superficial changes in the stroma, which disappear in a month following exposure. Chronic exposure of workmen to tar fumes nd dust has been reported to cause conjunctivitis and discoloration of the cornea in the palpebral fissure, either near the limbus or, in extreme cases, across the whole cornea. Occasionally, epithelioma of the lid margin has been attributed to contact with coal tar."

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**

Coal tar products may be sampled by collection on a glass fiber filter with subsequent ultrasonic extraction and weighing. An analytical method for coal tar pitch volatiles is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 1, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00267-3).

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 skin contact with condensed coal tar pitch volatiles, where skin contact may occur.
- If employees' clothing may have become contaminated with coal tar pitch volatiles, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing contaminated with coal tar pitch volatiles

should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of coal tar pitch volatiles from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the coal tar pitch volatiles, the person performing the operation should be informed of coal tar pitch volatiles's hazardous properties.

- Employees should be provided with and required to use splash-proof safety goggles where condensed coal tar pitch volatiles may contact the eyes.

SANITATION

- Workers subject to skin contact with coal tar pitch volatiles should wash with soap or mild detergent and water any areas of the body which may have contacted coal tar pitch volatiles at the end of each work day.
- Employees who handle coal tar pitch volatiles should wash their hands thoroughly with soap or mild detergent and water before eating, smoking, or using toilet facilities.
- Areas in which exposure to coal tar pitch volatiles may occur should be identified by signs or other appropriate means, and access to these areas should be limited to authorized persons.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Liberation from extraction and packaging from coal tar fraction of coking	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use as a binding agent in manufacture of coal briquettes used for fuel; use as a dielectric in the manufacture of battery electrodes, electric-arc furnace electrodes, and electrodes for alumina reduction	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture of roofing felts and papers and roofing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use for protective coatings for pipes for underground conduits and drainage; use as a coating on concrete as waterproofing and corrosion-resistant material; use in road paving and sealing	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in manufacture and repair of refractory brick; use in production of foundry cores; use in manufacture of carbon ceramic items	Process enclosure; local exhaust ventilation; general dilution 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 condensed coal tar pitch volatiles get into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation is present after washing, get medical attention. Contact lenses should not be worn when working with these chemicals.

- **Skin Exposure**

If condensed coal tar pitch volatiles get on the skin, wash the contaminated skin using soap or mild detergent and water. Be sure to wash the hands before eating or smoking and to wash thoroughly at the close of work.

- **Breathing**

If a person breathes in large amounts of coal tar pitch volatiles, 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.

- **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 releases until cleanup has been completed.
- If coal tar pitch volatiles are released in hazardous concentrations, the following steps should be taken:

1. Ventilate area of spill.

2. Collect released material in the most convenient and safe manner for reclamation or for disposal in sealed containers in a secured sanitary landfill.

- Waste disposal method:

Coal tar pitch volatiles may be disposed of in sealed containers in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR COAL TAR PITCH VOLATILES

Condition	Minimum Respiratory Protection* Required Above 0.2 mg/m³
Particulate and Vapor Concentration	
2 mg/m³ or less	A chemical cartridge respirator with an organic vapor cartridge(s) and with a fume or high-efficiency filter. Any supplied-air respirator. Any self-contained breathing apparatus.
10 mg/m³ or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s) and with a fume or high-efficiency filter. A gas mask with a chin-style or a front- or back-mounted organic vapor canister and with a full facepiece and a fume or high-efficiency filter. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
200 mg/m³ or less	A Type C supplied-air respirator operated in pressure-demand or other positive pressure or continuous-flow mode. A powered air-purifying respirator with an organic vapor cartridge and a high-efficiency particulate filter.
400 mg/m³ or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 400 mg/m³ 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, including pesticide respirators which meet the requirements of this class. Any escape self-contained breathing apparatus.

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

Occupational Health Guideline for Cyanide

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.

APPLICABILITY

The general guidelines contained in this document apply to all cyanides. Physical and chemical properties of two specific compounds are provided for illustrative purposes.

SUBSTANCE IDENTIFICATION

Potassium cyanide

- Formula: KCN
- Synonyms: None
- Appearance and odor: White solid with a faint almond odor.

Sodium cyanide

- Formula: NaCN
- Synonyms: None
- Appearance and odor: White solid with a faint almond odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for cyanide is 5 milligrams of cyanide per cubic meter of air (mg/m^3) averaged over an eight-hour work shift. NIOSH has recommended that the permissible exposure limit be changed to a ceiling of 5 milligrams cyanide per cubic meter of air averaged over a 10-minute period. The NIOSH Criteria Document for Hydrogen Cyanide and Cyanide Salts should be consulted for more detailed information.

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Cyanide can affect the body if it is inhaled, if it comes in contact with the eyes or skin, or if it is swallowed. Sufficient cyanide may be absorbed through the skin, especially if there are cuts to cause fatal poisoning.

- **Effects of overexposure**

1. *Short-term Exposure:* Inhalation or ingestion of cyanide salts may be rapidly fatal. Larger doses by inhalation or swallowing may cause the person to rapidly lose consciousness, stop breathing, and die. In some cases, there are convulsions. At lower levels of exposure, the earlier symptoms include weakness, headache, confusion, nausea, and vomiting. These symptoms may be followed by unconsciousness and death. Occasionally, convulsions occur. Milder forms of intoxication may result only in weakness, dizziness, headache, and nausea. The dust of cyanide salts is irritating to the eyes. In the presence of tears, it may cause the symptoms of poisoning described above. The dust of cyanide salts may produce irritation of the nose and skin. Strong solutions of cyanide salts are corrosive and may produce ulcers.
2. *Long-term Exposure:* Effects from chronic exposure to cyanide are non-specific and rare.
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 cyanide.

- **Recommended medical surveillance**

The following medical procedures should be made available to each employee who is exposed to cyanide 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 fainting spells, such as occur in various types of cardiovascular and nervous disorders,

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and those unusually susceptible to effects of anoxia or with anemia would be expected to be at increased risk from exposure. Examination of the cardiovascular, nervous, and upper respiratory systems, and thyroid should be stressed. The skin should be examined for evidence of chronic disorders.

—Skin disease: Cyanide is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—14" x 17" chest roentgenogram: Cyanide causes human lung damage. Surveillance of the lungs is indicated.

—FVC and FEV (1 sec): Cyanide is a respiratory irritant. Persons with impaired pulmonary function may be at increased risk from exposure. Periodic surveillance is indicated.

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

3. *First Aid Kits:* First aid kits should be readily available in workplaces where there is a potential for the release of cyanide. These kits should contain a minimum of 48 ampules, each of 0.3 ml amyl nitrate, and complete instructions for use. In addition, 2 physician's kits should be immediately available to trained medical personnel. These kits should contain the above quantity of amyl nitrate as well as sterile sodium nitrite solution (3%) and sterile sodium thiosulfate solution (25%). All of the above drugs should be replaced at least biannually to ensure their potency.

- **Summary of toxicology**

The dust of cyanide salts, a source of cyanide ion, is an asphyxiant due to an inhibitory action on metabolic enzyme systems and can be rapidly fatal. Cyanide exerts this effect because it inactivates certain enzymes by forming very stable complexes with the metal in them. Cytochrome oxidase is probably the most important of these, since it occupies a fundamental position in the respiratory process and is involved in the ultimate electron transfer to molecular oxygen. Since cytochrome oxidase is present in practically all cells that function under aerobic conditions, and since the cyanide ion diffuses easily to all parts of the body, it is capable of suddenly bringing to a halt practically all cellular respiration. In the presence of even weak acids, hydrocyanic acid (HCN) gas is liberated from cyanide salts; a few inhalations of higher concentrations of HCN may be followed by almost instantaneous collapse and cessation of respiration; 270 ppm HCN is immediately fatal to humans, 181 ppm is fatal after 10 minutes, 135 ppm after 30 minutes, and 110 ppm may be fatal in 1 hour. The ingestion by humans of 50 to 100 mg of sodium or potassium cyanide may also be fatal. At lower levels of exposure to HCN, the earliest symptoms of intoxication may include weakness, headache, confusion, and occasionally nausea and vomiting; respiratory rate and depth is usually increased initially and at later stages becomes slow and gasping; if cyanosis is present, it usually indicates that respiration has either ceased or has been very inadequate for a few minutes. Humans tolerate 45 to 54 ppm for ½ to 1 hour without immediate or delayed effects, while 18 to 36 ppm may result in some symptoms after an exposure of several hours. Sodium cyanide dust is irritating to the eyes; in the presence of tears it may liberate HCN, which can be absorbed and cause systemic intoxication. Skin contact with dust may be irritating; strong solutions on the skin produce ulcers which are slow in healing. Cyanide is one of the few toxic materials for which an antidote exists; it functions as follows: First, amyl nitrite (inhalation) and sodium nitrite (intravenously) are administered to form methemoglobin, which binds firmly with free cyanide ions. This traps any circulating cyanide ions. The formation of 10 to 20% methemoglobin usually does not involve appreciable risk, yet provides a large amount of cyanide-binding substance. Second, sodium thiosulfate is administered intravenously to increase the rate of conversion of cyanide to the less toxic thiocyanate. Methylene blue should not be administered, because it is a poor methemoglobin former and, moreover, promotes the conversion of methemoglobin back to hemoglobin.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data—Potassium cyanide**

1. Molecular weight: 65.1
2. Boiling point (760 mm Hg): Data not available
3. Specific gravity (water = 1): 1.55
4. Vapor density (air = 1 at boiling point of potassium cyanide): Not applicable
5. Melting point: 635 C (1175 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 71.6
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Physical data—Sodium cyanide**

1. Molecular weight: 49
2. Boiling point (760 mm Hg): 1500 C (2732 F) (extrapolated)
3. Specific gravity (water = 1): 1.6
4. Vapor density (air = 1 at boiling point of sodium cyanide): Not applicable
5. Melting point: 560 C (1040 F)
6. Vapor pressure at 20 C (68 F): Essentially zero
7. Solubility in water, g/100 g water at 20 C (68 F): 58
8. Evaporation rate (butyl acetate = 1): Not applicable

- **Reactivity**

1. Conditions contributing to instability: None. Hazardous if kept in closed containers. It may form toxic concentrations of hydrogen cyanide gas when in prolonged contact with air in a closed area.

2. Incompatibilities: Contact with strong oxidizers such as nitrates and chlorates may cause fires and

explosions. Contact with acids and acid salts causes immediate formation of toxic and flammable hydrogen cyanide gas.

3. Hazardous decomposition products: Toxic gases and vapors (such as hydrogen cyanide and carbon monoxide) may be released when cyanide decomposes.

4. Special precautions: Cyanide may react with carbon dioxide in ordinary air to form toxic hydrogen cyanide gas.

- **Flammability**

1. Not combustible

- **Warning properties**

1. Odor Threshold: No quantitative information is available concerning the odor threshold of sodium or potassium cyanide. HCN, however, is evolved from these substances in the presence of moisture. The Manufacturing Chemists Association states that "although HCN has a characteristic odor, its toxic action at hazardous concentrations is so rapid that it is of no value as a warning property."

2. Eye Irritation Level: Cyanide (as CN) is not known to be an eye irritant. However, according to Grant, HCN can produce eye irritation after chronic exposures.

3. Evaluation of Warning Properties: Although cyanide (as CN) has a negligible vapor pressure, in the presence of moisture HCN can be given off. HCN does not have adequate 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 cyanide. Each measurement should consist of a ten (10) minute sample or series of consecutive samples totalling ten (10) 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 cyanide with a cellulose membrane filter and an impinger containing sodium hydroxide, followed by analysis by direct potentiometry. An analytical method for cyanide is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).

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 cyanide or liquids containing cyanide.
- If employees' clothing has had any possibility of being contaminated with cyanide, employees should change into uncontaminated clothing before leaving the work premises.
- Clothing which has had any possibility of being contaminated with cyanide should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of cyanide from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the cyanide, the person performing the operation should be informed of cyanide's hazardous properties.
- Where there is any possibility of exposure of an employee's body to cyanide or liquids containing cyanide, 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 cyanide should be removed immediately and not reworn until the cyanide 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 cyanide or liquids containing cyanide contacting the eyes.

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

SANITATION

- Skin that becomes contaminated with cyanide should be immediately washed or showered with soap or mild detergent and water to remove any cyanide.
- Workers subject to skin contact with cyanide should wash with soap or mild detergent and water any areas of the body which may have contacted cyanide at the end of each work day.
- Eating and smoking should not be permitted in areas where cyanide or liquids containing cyanide are handled, processed, or stored.
- Employees who handle cyanide or liquids containing cyanide 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 cyanide may occur and control methods which may be effective in each case:

Operation	Controls
Use as fumigants and pesticides in greenhouses, ships, mills, and warehouses; use of cyanogen chloride as a warning agent in fumigant gases	Local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in metal treatment in nitriding, tempering, and case hardening steel; coloring of metals by chemical or electrolytic process; cleaning and coating metals; welding and cutting of heat-resistant metals; liberation during ore extraction and metal purification	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use of calcium cyanamid in fertilizer on soil; during chemical synthesis for manufacture of intermediates in pharmaceuticals, dyes, vitamins, plastics, and sequestering agents; preparation of nitriles, carbylamines, cyano fatty acids, and inorganic cyanides	Process enclosure; local exhaust ventilation; general dilution ventilation; personal protective equipment
Use in cellulose technology; paper manufacture; in dyeing; as cement stabilizers; use in photography as fixatives, and in blueprinting and process engraving; liberation in blast furance gases or in handling of illuminating gas	Process enclosure; local exhaust ventilation; general dilution 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 cyanide gets 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 cyanides.

- **Skin Exposure**

If cyanide gets on the skin, immediately wash the contaminated skin using soap or mild detergent and water. If cyanide penetrates 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 cyanide, 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 cyanide has 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 cyanide is spilled, the following steps should be taken:

1. Ventilate area of spill.
2. Collect spilled material in the most convenient and safe manner for reclamation, or for treatment in a cyanide disposal system.

- Waste disposal method:

After treatment as in above, cyanide may be disposed of in a secured sanitary landfill.

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RESPIRATORY PROTECTION FOR CYANIDE

Condition	Minimum Respiratory Protection* Required Above 5 mg/m³
Particulate Concentration	
50 mg/m³ or less	Any supplied-air respirator. Any self-contained breathing apparatus.
Greater than 50 mg/m³ 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 hydrogen cyanide and particulates. Any escape self-contained breathing apparatus.

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

Occupational Health Guideline for Naphtha (Coal Tar)

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: $C_7H_8 - C_8H_{10}$ (approximately)
- Synonyms: Naphtha, 49 degrees Be-coal tar type; crude solvent coal tar naphtha; high-solvent coal tar naphtha
- Appearance and odor: Reddish-brown, mobile liquid with an aromatic odor.

PERMISSIBLE EXPOSURE LIMIT (PEL)

The current OSHA standard for coal tar naphtha is 100 parts of coal tar naphtha per million parts of air (ppm) averaged over an eight-hour work shift. This may also be expressed as 400 milligrams of coal tar naphtha per cubic meter of air (mg/m³).

HEALTH HAZARD INFORMATION

- **Routes of exposure**

Coal tar naphtha can affect the body if it is inhaled, comes in contact with the eyes or skin, or is swallowed.

- **Effects of overexposure**

1. Short-term Exposure: Overexposure to coal tar naphtha can cause lightheadedness, drowsiness, and unconsciousness. It also may cause mild irritation of the eyes, nose, and skin.

2. Long-term Exposure: Prolonged overexposure to coal tar naphtha may cause irritation of the skin.

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 coal tar naphtha.

- **Recommended medical surveillance**

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

1. Initial Medical Screening: Employees should be screened for history of certain medical conditions (listed below) which might place the employee at increased risk from coal tar naphtha exposure.

—Skin disease: Coal tar naphtha is a defatting agent and can cause dermatitis on prolonged exposure. Persons with pre-existing skin disorders may be more susceptible to the effects of this agent.

—Liver disease: Although coal tar naphtha is not known as a liver toxin in humans, the importance of this organ in the biotransformation and detoxification of foreign substances should be considered before exposing persons with impaired liver function.

—Kidney disease: Although coal tar naphtha is not known as a kidney toxin in humans, the importance of this organ in the elimination of toxic substances justifies special consideration in those with impaired renal function.

—Chronic respiratory disease: In persons with impaired pulmonary function, especially those with obstructive airway diseases, the breathing of coal tar naphtha might cause exacerbation of symptoms due to its irritant properties.

2. Periodic Medical Examination: Any employee developing the above-listed conditions should be referred for further medical examination.

- **Summary of toxicology**

Coal tar naphtha vapor is narcotic. Rats survived continuous exposure at 3200 ppm for two months; at 1800 ppm some animals showed damage to the liver and kidneys; above 1000 ppm there was evidence of narcotic action. Rats exposed at 567 ppm and 312 ppm for 18 to 20 hours a day for 7 days had some reduction in blood leukocytes, possibly the result of the presence of benzene. There are few if any well documented reports of industrial injury resulting from the inhalation of

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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.

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Public Health Service Centers for Disease Control
National Institute for Occupational Safety and Health

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

naphtha. However, exposure to high concentrations might be expected to cause lightheadedness, drowsiness, and possibly irritation of the eyes, nose, and throat. Repeated or prolonged contact with the liquid may result in drying and cracking skin due to defatting action. Coal tar (naphtha) is a non-uniform mixture of aromatic hydrocarbons and may contain benzene.

CHEMICAL AND PHYSICAL PROPERTIES

- **Physical data**

1. Molecular weight: 110 (approximately)
2. Boiling point (760 mm Hg): 110 to 190 C (230 to 374 F)
3. Specific gravity (water = 1): 0.97
4. Vapor density (air = 1 at boiling point of coal tar naphtha): 3 (approximately)
5. Melting point: Data not available
6. Vapor pressure at 20 C (68 F): Less than 5 mm Hg
7. Solubility in water, g/100 g water at 20 C (68 F): Insoluble
8. Evaporation rate (butyl acetate = 1): Greater than 1

- **Reactivity**

1. Conditions contributing to instability: Heat
2. Incompatibilities: Contact with strong oxidizing agents may cause fires and explosions.
3. Hazardous decomposition products: Toxic gases and vapors (such as carbon monoxide) may be released in a fire involving coal tar naphtha.
4. Special precautions: Coal tar naphtha will attack some forms of plastics, rubber, and coatings.

- **Flammability**

1. Flash point: 38 to 43 C (100 to 109 F) (closed cup)
2. Autoignition temperature: 482 to 510 C (900 to 950 F)
3. Flammable limits in air, % by volume: Data not available
4. Extinguishant: Dry chemical, foam, carbon dioxide

- **Warning properties**

1. Odor Threshold: Since the odor thresholds of the main constituents of coal tar naphtha are below their permissible exposure limits, the odor threshold of coal tar naphtha is assumed to be below the permissible exposure limit.

2. Eye Irritation Level: According to Grant, Gafafer states that the naphthas cause conjunctival irritation. Two of the main constituents of coal tar naphtha, xylene and toluene, cause noticeable eye irritation at concentrations of 200 and 300 ppm, respectively.

3. Evaluation of Warning Properties: Since the odor threshold of the main constituents of coal tar naphtha are well below their permissible exposure limits, coal tar naphtha is treated as a material with adequate 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**

Sampling and analyses may be performed by collection of coal tar naphtha vapors using an adsorption tube with subsequent desorption with carbon disulfide and gas chromatographic analysis. Also, detector tubes certified by NIOSH under 42 CFR Part 84 or other direct-reading devices calibrated to measure coal tar naphtha may be used. An analytical method for coal tar naphtha is in the *NIOSH Manual of Analytical Methods*, 2nd Ed., Vol. 3, 1977, available from the Government Printing Office, Washington, D.C. 20402 (GPO No. 017-033-00261-4).
026).

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 repeated or prolonged skin contact with liquid coal tar naphtha.
- Clothing wet with liquid coal tar naphtha should be placed in closed containers for storage until it can be discarded or until provision is made for the removal of

coal tar naphtha from the clothing. If the clothing is to be laundered or otherwise cleaned to remove the coal tar naphtha, the person performing the operation should be informed of coal tar naphtha's hazardous properties.

- Non-impervious clothing which becomes wet with liquid coal tar naphtha should be removed promptly and not reworn until the coal tar naphtha is removed from the clothing.
- Employees should be provided with and required to use splash-proof safety goggles where liquid coal tar naphtha may contact the eyes.

SANITATION

- Skin that becomes wet with liquid coal tar naphtha should be promptly washed or showered with soap or mild detergent and water to remove any coal tar naphtha.

COMMON OPERATIONS AND CONTROLS

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

Operation	Controls
Use in preparation of coal-tar paints	Process enclosure; general dilution ventilation; personal protective equipment
Use in preparation of coumarone and indene	General dilution ventilation; personal protective equipment
Use as a solvent in rubber industry in manufacture of water-proof cloth, shoe adhesives, and rubber tires	Process enclosure; general dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a solvent, diluent, or thinner in paint, varnish, and lacquer industries	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use in formulations of nitrocellulose and ethylcellulose	General dilution ventilation; local exhaust ventilation; personal protective equipment
Use as a solvent for polymerized styrol, short-oil phenolic varnishes, urea, resins, melamine, and other synthetic resins; use as a solvent for pesticides as DDT and Gammexane	General dilution ventilation; 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 coal tar naphtha gets into the eyes, wash eyes immediately with large amounts of water, lifting the lower and upper lids occasionally. If irritation persists after washing, get medical attention. Contact lenses should not be worn when working with this chemical.

- **Skin Exposure**

If coal tar naphtha gets on the skin, promptly wash the contaminated skin using soap or mild detergent. If coal tar naphtha soaks through the clothing, remove the clothing immediately and wash the skin using soap or mild detergent. If irritation persists after washing, get medical attention.

- **Breathing**

If a person breathes in large amounts of coal tar naphtha, 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**

If coal tar naphtha has been swallowed, do not induce vomiting. 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 coal tar naphtha is spilled or leaked, the following steps should be taken:

1. Remove all ignition sources.
2. Ventilate area of spill or leak.
3. 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. Coal tar naphtha should not be allowed to enter a confined space, such as a sewer, because of the possibility of an explosion.

- Waste disposal methods:

Coal tar naphtha may be disposed of:

1. By absorbing it in vermiculite, dry sand, earth or a similar material and disposing in a secured sanitary landfill.
2. By atomizing in a suitable combustion chamber.

REFERENCES

- American Conference of Governmental Industrial Hygienists: "Naphtha (Coal Tar)," *Documentation of the Threshold Limit Values for Substances in Workroom Air* (3rd ed., 2nd printing), Cincinnati, 1974.
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- Browning, E.: *Toxicity and Metabolism of Industrial Solvents*, Elsevier, New York, 1965.
- Grant, W. M.: *Toxicology of the Eye* (2nd ed.), C. C. Thomas, Springfield, Illinois, 1974.
- Sax, N. I.: *Dangerous Properties of Industrial Materials* (3rd ed.), Van Nostrand Reinhold, New York, 1968.

RESPIRATORY PROTECTION FOR NAPHTHA (COAL TAR)

Condition	Minimum Respiratory Protection* Required Above 100 ppm
Vapor Concentration	
1000 ppm or less	A chemical cartridge respirator with a full facepiece and an organic vapor cartridge(s).
5000 ppm or less	A gas mask with a chin-style or a front- or back-mounted organic vapor canister. Any supplied-air respirator with a full facepiece, helmet, or hood. Any self-contained breathing apparatus with a full facepiece.
10,000 ppm or less	A Type C supplied-air respirator with a full facepiece operated in pressure-demand or other positive pressure mode or with a full facepiece, helmet, or hood operated in continuous-flow mode.
Greater than 10,000 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. Any escape self-contained breathing apparatus.

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

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Material Safety Data Sheets Collection:

Sheet No. 683
Polychlorinated Biphenyls (PCBs)

Issued: 11/88 Revision: A, 9/92

Section 1. Material Identification

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Polychlorinated Biphenyls [$C_{12}H_{10-n}Cl_n$ (n=3, 4, 5)] Description: A class of nonpolar chlorinated hydrocarbons with a biphenyl nucleus (two benzene nuclei connected by a single C-C bond) in which any or all of the hydrogen atoms have been replaced by chlorine. Commercial PCBs are mixtures of chlorinated biphenyl isomers with varying degrees of chlorination. Prepared industrially by the chlorination of biphenyl with anhydrous chlorine in the presence of a catalyst such as ferric chloride or iron filings. Except for limited research and development applications, PCBs have not been produced in the US since 1977. When large quantities of PCBs were manufactured in the US, they were marketed under the tradename Aroclor (Monsanto) and were characterized by four digit numbers. The first two digits indicating biphenyls (12), triphenyls (54), or both (25, 44); the last two digits indicating the weight percent of chlorine. PCBs' thermal stability, nonflammability, and high dielectric capability made them very useful in electrical equipment. Formerly used as additives in hydraulic fluids, heat transfer systems, lubricants, cutting oils, printer's ink, fire retardants, asphalt, brake linings, automobile body sealants, plasticizers, adhesives, synthetic rubber, floor tile, wax extenders, dedusting agents, pesticide extenders, and carbonless reproducing paper. PCBs are still used in certain existing electrical capacitors and transformers that require enhanced electrical protection to avoid heating from sustained electric faults.

Other Designations: CAS No. 1336-36-3, Aroclor, Clophen, Chlorextol, chlorinated biphenyls, chlorinated diphenyl, chlorinated diphenylene, chloro biphenyl, chloro-1,1-biphenyl, Dykanol, Fenclor, Inerteen, Kaneclor, Montar, Noflamol, Phenoclor, Pyralene, Pyranol, Santotherm, Sovol, Therminol FR-1

R 1
I 4
S 3*
K 1
* Skin absorption

NFPA
1
2 0
–

HMIS
H 2‡
F 1
R 0
PPE†
† Sec. 8
‡ Chronic Effects

Cautions: PCBs are potent liver toxins that may be absorbed through skin. Potentially, chronic or delayed toxicity is significant because PCBs accumulate in fatty tissue and may reasonably be anticipated to be carcinogens. PCBs are a bioaccumulative environmental hazard. When burned, decomposition products may be more hazardous than the PCBs.

Section 2. Ingredients and Occupational Exposure Limits

PCBs, contain various levels of polychlorinated dibenzofurans and chlorinated naphthalenes as contaminants

1991 OSHA PELs, Skin
8-hr TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m^3
8-hr TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m^3

1990 DFG (Germany) MAK, Danger of Cutaneous Absorption
TWA (Chlorodiphenyl, 42% chlorine): 0.1 ppm (1 mg/m^3)
Category III: Substances with systemic effects, onset of effect > 2 hr., half-life > shift length (strongly cumulative)
Short-term Level: 1 ppm, 30 min., average value, 1 per shift

TWA (Chlorodiphenyl, 54% chlorine): 0.05 ppm (0.5 mg/m^3)
Category III: (see above)
Short-term Level: 0.5 ppm, 30 min., average value, 1 per shift

1985-86 Toxicity Data*
Rat, oral, TD: 1250 mg/kg administered intermittently for 25 weeks produced liver tumors.
Mammal, oral, TD_{Lo}: 325 mg/kg administered to female for 30 days prior to mating and from the 1st to the 36th day of gestation produced effects on newborn (stillbirth; live birth index; viability index).

1990 NIOSH REL
TWA (Chlorodiphenyl, 42% chlorine): 0.001 mg/m^3
TWA (Chlorodiphenyl, 54% chlorine): 0.001 mg/m^3

1992-93 ACGIH TLVs, Skin *
TWA (Chlorodiphenyl, 42% chlorine): 1 mg/m^3
TWA (Chlorodiphenyl, 54% chlorine): 0.5 mg/m^3

* These guidelines offer reasonably good protection against systemic intoxication, but may not guarantee that chloroacne won't occur.
† See NIOSH, *RTECS* (TQ1350000), for additional reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data*

Boiling Point: 644-707 °F (340-375 °C)
Melting Point: 42%: -2.2 °F (-19°C); 54%: 14 °F (-10 °C)
Vapor Pressure: 1 mm Hg at 100 °F (38 °C); 10^{-6} to 10^{-3} mm at 20 °C
Molecular Weight: 188.7 to 398.5
Specific Gravity: 1.3 to 1.8 at 20 °C
Water Solubility: Low solubility (0.007 to 5.9 mg/L)
Other Solubilities: Most common organic solvents, oils, and fats; slightly soluble in glycerol and glycols.

Appearance and Odor: PCBs vary from mobile oily liquids to white crystalline solids and hard non-crystalline resins, depending upon chlorine content.

* Physical and chemical properties vary widely according to degree and to the position of chlorination.

Section 4. Fire and Explosion Data

Flash Point: 286-385 °F (141-196 °C) OC*	**Autoignition Temperature:** 464 °F (240 °C)	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Use extinguishing media suitable to the surrounding fire. Use dry chemical, foam, carbon dioxide (CO_2), or water spray. Water spray may be ineffective. Use water spray to cool fire-exposed containers or transformers. Do not scatter PCBs with high-pressure water streams. **Unusual Fire or Explosion Hazards:** Combustion products (hydrogen chloride, phosgene, polychlorinated dibenzofurans, and furans) are more hazardous than the PCBs themselves. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Approach fire from upwind to avoid highly toxic decomposition products. Structural firefighter's protective clothing will provide *limited* protection. Do not release runoff from fire control methods to sewers or waterways. Dike for later disposal.

* Flash points shown are a range for various PCBs. Some forms do not have flash points.

Section 5. Reactivity Data

Stability/Polymerization: PCBs are very stable materials but are subject to photodechlorination when exposed to sunlight or UV (spectral region above 290 nanometers). Hazardous polymerization cannot occur. **Chemical Incompatibilities:** PCBs are chemically inert and resistant to oxidation, acids, and bases. **Conditions to Avoid:** Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition [1112-1202 °F (600-650 °C)] of PCBs can produce highly toxic derivatives, including polychlorinated dibenzo-para-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), hydrogen chloride, phosgene and other irritants.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] and NTP[169] list PCBs as an IARC probable carcinogen (overall evaluation is 2A; limited human data; sufficient animal data) and NTP anticipated carcinogen, respectively. **Summary of Risks:** PCBs are potent liver toxins that can be absorbed through unbroken skin in toxic amounts without immediate pain or irritation. PCBs have low acute toxicity, but can accumulate in fatty tissue and severe health effects may develop later. Generally, toxicity increases with a higher chlorine content; PCB-oxides are more toxic. The toxic action on the liver also increases with simultaneous exposure to other liver toxins, e.g. chlorinated solvents, alcohol, and certain drugs. Pathological pregnancies (abnormal pigmentations, abortions, stillbirths, and underweight births) have been associated with increased PCB serum levels in mothers; PCBs can be passed in breast milk. PCBs can affect the reproductive system of adults. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, liver, and respiratory disease. **Target Organs:** Skin, liver, eyes, mucous membranes, and respiratory tract. **Primary Entry Routes:** Inhalation, dermal contact, ingestion. **Acute Effects:** Exposure to PCB vapor or mist is severely irritating to the skin, eyes, nose, throat, and upper respiratory tract. Intense acute exposure to high concentrations may result in eye, lung, and liver injury. Systemic effects include nausea, vomiting, increased blood pressure, fatigue, weight loss, jaundice, edema and abdominal pain. Cognitive, neurobehavior and psychomotor impairment and memory loss have also been seen after acute exposure. **Chronic Effects:** Repeated exposure to PCBs can cause chloroacne; redness, swelling, dryness, thickening and darkening of the skin and nails; swelling and burning of the eyes, and excessive eye discharge; distinctive hair follicles; gastrointestinal disturbances; neurological symptoms including headache, dizziness, depression, nervousness, numbness of the extremities, and joint and muscle pain; liver enlargement; menstrual changes in women; and chronic bronchitis. Cancer, primarily liver, is also a possible result of exposure, but data is inconclusive.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Rinsing eyes with medical oil (olive, mineral) initially may remove PCB and halt irritation better than water rinsing alone. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. *Multiple soap and water washings are necessary.* Avoid the use of organic solvents to clean the skin. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** In most cases, accidental PCB ingestion will not be recognized until long after vomiting would be of any value. Never give anything by mouth to an unconscious or convulsing person. Vomiting of the pure substance may cause aspiration. Consult a physician. **Note to Physicians:** Monitor patients for increased hepatic enzymes, chloroacne, and eye, gastrointestinal, and neurologic symptoms listed above. Diagnostic tests include blood levels of PCBs and altered liver enzymes.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, provide adequate ventilation, and isolate hazard area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. For small spills, take up with sand or other noncombustible material and place into containers for later disposal. For larger spills, dike far ahead of spill to contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** PCBs have been shown to bio-concentrate significantly in aquatic organisms. **Ecotoxicity:** Bluegill, TLm: 0.278 ppm/96 hr. Mallard Duck, LD_{50}: 2000 ppm. **Environmental Degradation:** In general, the persistence of PCBs increases with an increase degree of chlorination. **Soil Absorption/Mobility:** PCBs are tightly absorbed in soil and generally do not leach significantly in most aqueous soil systems. However, in the presence of organic solvents, PCBs may leach rapidly through the soil. Volatilization of PCBs from soil may be slow, but over time may be significant. **Disposal:** Approved PCB disposal methods include: incineration with scrubbing, high-efficiency boilers, landfills, and EPA-approved alternative disposal methods. Each disposal method has various criteria. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1 lb (0.454 kg) [* per CWA, Sec. 311(b)(4) and 307(a)]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. Minimum respiratory protection should include a combination dust-fume-mist and organic vapor cartridge or canister or air-supplied, depending upon the situation. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Butyl rubber, neoprene, Teflon, and fluorocarbon rubber have break through times greater than 8 hrs. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Segregate contaminated clothing in such a manner so that there is no direct contact by laundry personnel. Implement quality assurance to ascertain the completeness of the cleaning procedures. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a closed, labelled, container in a ventilated area with appropriate air pollution control equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Inform employees of the adverse health effects associated with PCBs. Limit access to PCB work areas to authorized personnel. Consider preplacement and periodic medical examinations with emphasis on the skin, liver, lung, and reproductive system. Monitor PCB blood levels. Consider possible effects on the fetus. Keep medical records for the entire length of employment and for the following 30 yrs.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Polychlorinated biphenyls
DOT Hazard Class: 9
D No.: UN2315
DOT Packing Group: II
DOT Label: CLASS 9
Special Provisions (172.102): 9, N81

Packaging Authorizations
a) Exceptions: 173.155
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 100 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 34

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 163, 164, 168, 169, 174, 175, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy MPH, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 316
Benzene

Issued: 11/78 Revision: E, 8/90

Section 1. Material Identification

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Benzene (C_6H_6) Description: Derived by fractional distillation of coal tar, hydrodealkylation of toluene or pyrolysis of gasoline, catalytic reforming of petroleum, and transalkylation of toluene by disproportionation reaction. Used as a fuel; a chemical reagent; a solvent for a large number of materials such as paints, plastics, rubber, inks, oils, and fats; in manufacturing phenol, ethylbenzene (for styrene monomer), nitrobenzene (for aniline), dodecylbenzene (for detergents), cyclohexane (for nylon), chlorobenzene, diphenyl, benzene hexachloride, maleic anhydride, benzene-sulfonic acid, artificial leather, linoleum, oil cloth, varnishes, and lacquers; for printing and lithography; in dry cleaning; in adhesives and coatings; for extraction and rectification; as a degreasing agent; in the tire industry; and in shoe factories. Benzene has been banned as an ingredient in products intended for household use and is no longer used in pesticides.
Other Designations: CAS No. 0071-43-2, benzol, carbon oil, coal naphtha, cyclohexatriene, mineral naphtha, nitration benzene, phene, phenyl hydride, pyrobenzol.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

R	1
I	4
S	2*
K	4

*Skin absorption

NFPA

HMIS	
H	3
F	3
R	0
PPG†	

† Sec. 8

Cautions: Benzene is a confirmed *human carcinogen* by the IARC. *Chronic low-level exposure may cause cancer (leukemia) and bone marrow damage, with injury to blood-forming tissue.* It is also a dangerous fire hazard when exposed to heat or flame.

Section 2. Ingredients and Occupational Exposure Limits

Benzene, ca 100%*

1989 OSHA PELs
(29 CFR 1910.1000, Table Z-1-A)
8-hr TWA: 1 ppm, 3 mg/m³
15-min STEL: 5 ppm, 15 mg/m³

(29 CFR 1910.1000, Table Z-2)
8-hr TWA: 10 ppm
Acceptable Ceiling Concentration: 25 ppm
Acceptable Maximum Peak: 50 ppm (10 min)†

1989-90 ACGIH
TLV-TWA: 10 ppm, 32 mg/m³

1988 NIOSH RELs
TWA: 0.1 ppm, 0.3 mg/m³
Ceiling: 1 ppm, 3 mg/m³

1985-86 Toxicity Data‡
Man, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted
Man, inhalation, TC_{Lo}: 150 ppm inhaled intermittently over 1 yr in a number of discrete, separate doses affects the blood (other changes) and nutritional and gross metabolism (body temperature increase)
Rabbit, eye: 2 mg administered over 24 hr produces severe irritation

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* OSHA 29 CFR 1910.1000, Subpart Z, states that the final benzene standard in 29 CFR 1910.1028 applies to all occupational exposures to benzene except in some subsegments of industry where exposures are consistently under the action level (i.e., distribution and sale of fuels, sealed containers and pipelines, coke production, oil and gas drilling and production, natural gas processing, and the percentage exclusion for liquid mixtures); for the excepted subsegments, the benzene limits in Table Z-2 apply.
† Acceptable maximum peak above the acceptable ceiling concentration for an 8-hr shift.
‡ See NIOSH, *RTECS* (CY1400000), for additional irritative, mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 176 °F (80 °C)
Melting Point: 42 °F (5.5 °C)
Vapor Pressure: 100 mm Hg at 79 °F (26.1 °C)
Vapor Density (Air = 1): 2.7
Evaporation Rate (Ether = 1): 2.8
Molecular Weight: 78.11
Specific Gravity (15 °C/4 °C): 0.8787
Water Solubility: Slightly (0.180 g/100 g of H_2O at 25 °C)
%Volatile by Volume: 100
Viscosity: 0.6468 mPa at 20 °C

Appearance and Odor: A colorless liquid with a characteristic sweet, aromatic odor. The odor recognition threshold (100% of panel) is approximately 5 ppm (unfatigued) in air. Odor *is not* an adequate warning of hazard.

Section 4. Fire and Explosion Data

Flash Point: 12 °F (-11.1 °C), CC	**Autoignition Temperature:** 928 °F (498 °C)	**LEL:** 1.3% v/v	**UEL:** 7.1% v/v

Extinguishing Media: Use dry chemical, foam, or carbon dioxide to extinguish benzene fires. Water may be ineffective as an extinguishing agent since it can scatter and spread the fire. Use water spray to cool fire-exposed containers, flush spills away from exposures, disperse benzene vapor, and protect personnel attempting to stop an unignited benzene leak.
Unusual Fire or Explosion Hazards: Benzene is a Class 1B flammable liquid. A concentration exceeding 3250 ppm is considered a potential fire explosion hazard. Benzene vapor is heavier than air and can collect in low lying areas or travel to an ignition source and flash back. Explosive and flammable benzene vapor-air mixtures can easily form at room temperature. Eliminate all ignition sources where benzene is used, handled, or stored.
Special Fire-fighting Procedures: Isolate hazard area and deny entry. Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and full protective equipment. Structural firefighter's protective clothing provides limited protection. Stay out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways. Runoff to sewer can create pollution, fire, and explosion hazard.

Section 5. Reactivity Data

Stability/Polymerization: Benzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Benzene explodes on contact with diborane, permanganic acid, bromine pentafluoride, peroxodisulfuric acid, and peroxomonosulfuric acid. It ignites on contact with dioxygen difluoride, dioxygenyl tetrafluoroborate, iodine heptafluoride, and sodium peroxide + water. Benzene forms sensitive, explosive mixture with iodine pentafluoride, ozone, liquid oxygen, silver perchlorate, nitryl perchlorate, nitric acid, and arsenic pentafluoride + potassium methoxide (explodes above 30 °C). A vigorous or incandescent reaction occurs with bromine trifluoride, uranium hexafluoride, and hydrogen + Raney nickel [above 410 °F (210 °C)]. Benzene is incompatible with oxidizing materials.
Conditions to Avoid: Avoid heat and ignition sources.
Hazardous Products of Decomposition: Thermal oxidative decomposition of benzene can produce toxic gases and vapors such as carbon monoxide.

Section 6. Health Hazard Data

Carcinogenicity: The ACGIH, OSHA, and IARC list benzene as, respectively, a supected human carcinogen, a cancer hazard, and, based on sufficient human and animal evidence, a human carcinogen (Group 1).
Summary of Risks: Prolonged skin contact or excessive inhalation of benzene vapor may cause headache, weakness, appetite loss, and fatigue. The most important health hazards are cancer (leukemia) and bone marrow damage with injury to blood-forming tissue from chronic low-level exposure. Higher level exposures may irritate the respiratory tract and cause central nervous system (CNS) depression.
Medical Conditions Aggravated by Long-Term Exposure: Exposure may worsen ailments of the heart, lungs, liver, kidneys, blood, and CNS.
Target Organs: Blood, central nervous system, bone marrow, eyes, upper respiratory tract, and skin.
Primary Entry Routes: Inhalation, skin contact.
Acute Effects: Symptoms of acute overexposure include irritation of the eyes, nose, and respiratory tract, breathlessness, euphoria, nausea, drowsiness, headache, dizziness, and intoxication. Severe exposure may lead to convulsions and unconsciousness. Skin contact may cause a drying rash (dermatitis).
Chronic Effects: Long-term chronic exposure may result in many blood disorders ranging from aplastic anemia (an inability to form blood cells) to leukemia.

FIRST AID

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Immediately rinse with flooding amounts of water for at least 15 min. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air. Emergency personnel should protect against inhalation exposure. Provide CPR to support breathing or circulation as necessary. Keep awake and transport to a medical facility.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, *do not induce vomiting* since aspiration may be fatal. Call a physician immediately.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Evaluate chronic exposure with a CBC, peripheral smear, and reticulocyte count for signs of myelotoxicity. Follow up any early indicators of leukemia with a bone marrow biopsy. Urinary phenol conjugates may be used for biological monitoring of recent exposure. Acute management is primarily supportive for CNS depression.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a benzene spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel, eliminate all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against vapor inhalation, eye contact, and skin absorption. Absorb as much benzene as possible with an inert, noncombustible material. For large spills, dike far ahead of spill and contain liquid. Use nonsparking tools to place waste liquid or absorbent into closable containers for disposal. Keep waste out of confined spaces such as sewers, watersheds, and waterways because of explosion danger. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Waste No. U019
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 307 (a), 311 (b)(4), 112; and per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Tables Z-1-A and Z-2)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations at least below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.[103]
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in tightly closed containers in a cool, dry, well-ventilated area away from all heat and ignition sources and incompatible materials. *Caution! Benzene vapor may form explosive mixtures in air.* To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations in production and storage areas. When opening or closing benzene containers, use nonsparking tools. Keep fire extinguishers readily available.
Engineering Controls: Because OSHA specifically regulates benzene (29 CFR 1910.1028), educate workers about its potential hazards and dangers. Minimize all possible exposures to carcinogens. If possible, substitute less toxic solvents for benzene; use this material with extreme caution and only if absolutely essential. Avoid vapor inhalation and skin and eye contact. Use only with adequate ventilation and appropriate personal protective gear. Institute a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Designate regulated areas of benzene use (see legend in the box below) and label benzene containers with "DANGER, CONTAINS BENZENE, CANCER HAZARD."
Other Precautions: Provide preplacement and periodic medical examinations with emphasis on a history of blood disease or previous exposure.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Benzene (*benzol*)
DOT Hazard Class: Flammable liquid
ID No.: UN1114
DOT Label: Flammable liquid
DOT Packaging Exceptions: 173.118
DOT Packaging Requirements: 173.119

IMO Shipping Name: Benzene
IMO Hazard Class: 3.2
ID No.: UN1114
IMO Label: Flammable liquid
IMDG Packaging Group: II

DANGER
BENZENE
CANCER HAZARD
FLAMMABLE–NO SMOKING
AUTHORIZED PERSONNEL ONLY
RESPIRATOR REQUIRED

MSDS Collection **References:** 1, 2, 12, 26, 73, 84-94, 100, 101, 103, 109, 124, 126, 127, 132, 134, 136, 138, 139, 143
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** MJ Upfal, MD, MPH; **Edited by:** JR Stuart, MS

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Material Safety Data Sheet Collection

Coal Tar Creosote

MSDS No. 757

Date of Preparation: 7/91

Revision: A, 9/97

Section 1 - Chemical Product and Company Identification

50

Product/Chemical Name: Coal tar creosote

Chemical Formula: Not found; consists of many compounds and the composition depends on the coal used to make the tar and the design and operating conditions of the coke oven and still.

CAS Number: 8001-58-9

Synonyms: AWPA #1; brick oil; Caswell No. 225; coal tar oil; creosote; creosote oil; creosote P1; creosotum; cresylic creosote; heavy oil; liquid pitch oil; naphthalene oil; Preserv-o-sote; Sakresote; tar oil; wash oil

Derivation: By distillation of coal tar produced by high-temperature carbonization of bituminous coal; by mixing strained naphthalene oil, wash oil, and strained or light anthracene oil; as a by-product of conventional coal coking.

General Use: Used mainly as a wood preservative for railroad ties, poles, fence posts, marine pilings, and other lumber for outdoor use; as a water-proofing agent, fuel oil constituent, frothing agent for mineral separation, tap hole refractory cement, and lubricant for die molds. Used only in limited quantities as an animal and bird repellent, animal dip, and insecticide (ovicide).

Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Coal tar creosote consists of aromatic hydrocarbons, anthracene, naphthalene, and phenanthrene derivatives; some tar acids; and tar bases. Polycylic aromatic hydrocarbons make up at least 75%.* (198)

OSHA PEL†
8-hr TWA: 0.2 mg/m^3

ACGIH TLV†
TWA: 0.2 mg/m^3

NIOSH REL†
0.1 mg/m^3 (cyclohexane-extractable fraction)
Carcinogen

IDLH Level†
80 mg/m^3

DFG (Germany) MAK
None established

* Creosote contains several carcinogenic polycyclic aromatic hydrocarbons including benz[a]anthracene, benzo[a]pyrene, and dibenz[a,h]anthracene.

† Coal tar pitch volatiles, as benzene solubles (CAS No. 65996-93-20)

Section 3 - Hazards Identification

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Coal tar creosote is a colorless (pure) or yellow to black (industrial) liquid with an aromatic smoky smell. It is irritating to the eyes, skin and respiratory tract and can be corrosive, causing severe burns. Coal tar creosote is a probable human carcinogen. It is a combustible liquid that is a moderate fire hazard when exposed to an ignition source.

Wilson Risk Scale	
R	1
I	3
S	3
K	2

* Skin absorption

HMIS	
H	3†
F	2
R	0
PPE‡	

†Chronic effects
‡Sec. 8

Potential Health Effects

Primary Entry Routes: Inhalation, skin absorption, and skin and/or eye contact

Target Organs: Eyes, skin, bladder, kidneys, and respiratory system

Acute Effects *Note! Phenol and phenolic derivatives of various aromatic hydrocarbons (tar acids), present in low concentrations, are the constituents most likely to be responsible for acute toxicity.*

Inhalation: Inhalation of vapors causes moderate irritation to the nose, throat, and upper respiratory tract.

Eye: Contact with liquid causes conjunctivitis (inflammation of the eye's lining), keratitis (corneal inflammation), or corneal burns with scarring. May cause loss of vision.

Skin: Contact causes irritation, burning, itching, redness, pigment changes, dermatitis (a rash of redness and bumps), or burns. Photosensitization (worsening of rash with exposure to sunlight) may occur.

Ingestion: Causes salivation, nausea; vomiting; gastrointestinal tract irritation or bleeding; abdominal pain; rapid, thready pulse; vertigo; headaches; loss of pupillary reflexes; hypothermia; cyanosis; respiratory distress; shock and mild convulsions. Large doses may be fatal.

Carcinogenicity: IARC classifies coal tar creosote as Group 2A: probably carcinogenic to humans: limited human evidence, sufficient animal evidence. NTP classifies coal tar creosote as Group 2B: sufficient evidence of carcinogenicity from studies in experimental animals. OSHA does not specifically classify coal tar creosote as a carcinogen. NIOSH classifies coal tar pitch volatiles, as benzene solubles, as a carcinogen defined with no further categorization.

Medical Conditions Aggravated by Long-Term Exposure: Skin disorders.

Chronic Effects: Include dermatitis and, possibly, skin cancer or other forms of cancer. An increased risk of scrotal cancer for creosote-exposed brick makers was indicated in a worker mortality analysis. Epidemiological studies of coke oven workers reveal increased incidences of lung, bladder, prostate, pancreas, and intestinal cancer.

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air, monitor for respiratory distress, and support breathing as needed.
ye Contact: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician or ophthalmologist immediately.
Skin Contact: *Quickly* remove contaminated clothing. Prior to washing and if readily available, use undiluted polyethylene glycol 300 to 400. Wash affected area with soap and flooding amounts of water for at least 15 min. *Do not* rub or apply pressure to the affected skin, apply any oily substance or use hot water to rinse. For reddened or blistered skin, consult a physician.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Rinse the mouth several times with cold water. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water. *Do not induce vomiting!* Keep victim warm and at rest.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Creosote may be detected in urine.
Special Precautions/Procedures: An exposed person should examine their skin periodically for growths, changes in warts or moles, and sores that do not heal.

Section 5 - Fire-Fighting Measures

Flash Point: 165.2 °F (74 °C)
Flash Point Method: CC
Autoignition Temperature: 637 °F (336 °C)
LEL: None reported.
UEL: None reported.
Flammability Classification: OSHA IIIA combustible liquid
Extinguishing Media: For small fires, use dry chemical, carbon dioxide, water spray or regular foam. For large fires, use water spray, fog or regular foam.
Unusual Fire or Explosion Hazards: Coal tar creosote may present a vapor explosion hazard indoors, outdoors, and in sewers. Vapors may travel to an ignition source and flash back.
Hazardous Combustion Products: Include carbon oxides.
Fire-Fighting Instructions: If feasible and without undue risk, remove containers from fire hazard area. Otherwise use water pray to cool fire-exposed containers until well after they are extinguished. *Do not* release runoff from fire control methods to sewers or waterways.
Fire-Fighting Equipment: Because fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, wear full protective clothing. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Immediately leave area if you hear a rising sound from venting safety device or notice any fire-caused tank discoloration as a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Isolate area for 1/2 mile in all directions if fire involves tank, rail car or tank truck. Fully decontaminate or properly dispose of personal protective clothing.

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Notify safety personnel. Isolate hazard area, deny entry, and stay upwind of spills. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin and eye contact.
Small Spills: Take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal.
Large Spills
Containment: Consider initial downwind evacuation for at least 300 meters (1000 feet). For large spills, dike far ahead of liquid spill for later disposal. Water spray may reduce vapor. *Do not* release into sewers or waterways.
Cleanup: Use nonsparking tools.
Regulatory Requirements: Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Avoid vapor inhalation and skin and eye contact. Use ventilation sufficient to reduce airborne exposures to nonhazardous levels (Sec. 2). Wear protective gloves, goggles, and clothing to avoid contact. Wear respiratory protection when necessary (Sec. 8). Consult your industrial hygienist. Practice good personal hygiene procedures to avoid inadvertently ingesting this material. Keep away from ignition sources.
Storage Requirements: Store in a cool, dry, well-ventilated area away from heat and ignition sources. Store coal tar creosote as close to area of use as possible to minimize transporting distance. Avoid physical damage to containers.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: Enclose all operations and/or ventilate at the site of release to avoid vapor dispersion into the work area. To prevent static sparks, electrically ground and bond all containers and equipment.

Ventilation: Provide general or local exhaust ventilation systems equipped with high-efficiency particulate filters to maintain airborne concentrations below OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source. (103)

Administrative Controls: Preplacement and periodic medical examinations of exposed workers emphasizing respiratory, skin, liver, and kidney disorders, including comprehensive work and medical history, physical examination, CXR, PFTs, urinalysis, LFT, and sputum cytology as the attending physician considers appropriate. Educate workers about the health and safety hazards associated with coal tar creosote.

Respiratory Protection: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. (The following respirator recommendations are for coal tar pitch volatiles.) For concentrations above the NIOSH REL or at any detectable concentrations, wear a SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode; or any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode in combination with an auxiliary SCBA operated in pressure-demand or other positive-pressure mode. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Protective Clothing/Equipment: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent any skin contact. With breakthrough times of >8 hr, butyl rubber, Teflon™, and Viton™ are recommended materials. Frequent change of protective garments is an additional protective measure. Wear protective eyeglasses or chemical safety goggles and face shield, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of contact lenses.

Safety Stations: Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work area.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Oily liquid

Appearance and Odor: Colorless (pure) or yellow to black (industrial); aromatic smoky smell

Specific Gravity (H_2O=1, at 4 °C): 1.07 to 1.08 at 68 °F (20 °C)

Water Solubility: Slightly soluble

Other Solubilities: Soluble in alcohol; ether; glycerin; dimethyl sulfate; fixed or volatile oils; in solution of fixed alkali hydroxides.

Boiling Point Range: 381 to 752 °F (194 to 400 °C)

Octanol/Water Partition Coefficient: $\log K_{ow} = 1.0$

Heat of Combustion: -12,500 Btu/lb; -6,900 cal/g

Section 10 - Stability and Reactivity

Stability: Coal tar creosote is stable at room temperature in closed containers under normal storage and handling conditions.

Polymerization: Hazardous polymerization cannot occur.

Chemical Incompatibilities: Creosote oil mixed with chlorosulfonic acid in a closed container causes an increase in temperature and pressure.

Conditions to Avoid: Avoid excessive heat and contact with chlorosulfonic acid.

Hazardous Decomposition Products: Thermal oxidative decomposition of coal tar creosote can produce carbon oxides and thick, black, acrid smoke.

Section 11 - Toxicological Information

Toxicity Data:*

Genetic Effects:

S. typhimurium: 20 µg/plate (-S9) produced mutations.

Hamster, ovary cell: 10 mg/L induced sister chromatid exchange.

Reproductive Effects:

Mouse, oral: 2 g/kg administered on gestational days 5-9 produced maternal effects and fetotoxicity.

Acute Oral Effects:

Rat, oral, LD_{50}: 725 mg/kg

Mouse, oral, LD_{50}: 433 mg/kg

Tumorigenicity: Mouse, skin, 99 g/kg/33 weeks administered intermittently produced tumors on skin and appendages (carcinogenic by RTECS criteria).

* See NIOSH, *RTECS* (GF8615000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: TL_{50}, goldfish (*Carassius auratus*), 3.51 ppm/24 hr (60:40) mixture of creosote and coal tar; TL_{50}, rainbow trout *Salmo gairdneri*), 3.72 ppm/24 hr (60:40) mixture of creosote and coal tar; LD_{50}, bob white quail (*Colinus virginianus*), 1,260 ppm/8 days (60:40) mixture of creosote and coal tar.

Environmental Fate: Data not found.

Section 13 - Disposal Considerations

Disposal: Coal tar creosote is a good candidate for rotary kiln and fluidized bed incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Container Cleaning and Disposal: Handle empty containers carefully as hazardous residues may still remain.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Corrosive liquids, n.o.s.
Shipping Symbols: Not listed.
Hazard Class: 8
ID No.: UN1760
Packing Group: I, II, or III*
Label: CORROSIVE
Special Provisions: A7, B10, T42†; B2, T14 ‡; T7 §

Packaging Authorizations
a) Exceptions: None †; 173.154 ‡ §
b) Non-bulk Packaging: 173.201†; 173.202‡; 173.203§
c) Bulk Packaging: 173.243†; 173.242‡; 173.241§

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 0.5 L†; 1 L‡; 5 L§
b) Cargo Aircraft Only: 2.5 L†; 30 L‡; 60 L§

Vessel Stowage Requirements
a) Vessel Stowage: B†; B‡; A§
b) Other: 40†‡§

* See 49 CFR 173.137 to assign Packing Group. Data was not available for Genium to make this determination.
† Packing Group I
‡ Packing Group II
§ Packing Group III

Section 15 - Regulatory Information

EPA Regulations:
isted as a RCRA Hazardous Waste (40 CFR 261.33), Hazardous Material No. U051
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) listed specific per RCRA, Sec. 3001
CERCLA Final Reportable Quantity (RQ), 1 lb (0.454 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

OSHA Regulations:
Listed (as coal tar pitch volatiles) as an Air Contaminant (29 CFR 1910.1000, Table Z-1)
Listed as an OSHA Specifically Regulated Substance (29 CFR 1910.1002; interpretation of term)

Section 16 - Other Information

References: 73, 103, 124, 136, 139, 184, 196, 197, 198, 200, 209

W5-MAC

Prepared By .... J Sawyer, MS/MJ Wurth, BS
Industrial Hygiene Review .... DJ Wilson, CIH
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Material Safety Data Sheets Collection:

Sheet No. 409
Cresol (Mixed Isomers)

Issued: 12/78 Revision: B, 3/92

Section 1. Material Identification

Cresol, *mixed isomers* ($CH_3C_6H_4OH$) Description: Derived from coal tar or petroleum. Cresol is marketed by individual isomer and as pure or crude cresol. Pure cresol is a mixture of *ortho*, *meta*, and *para* isomers. Crude cresol (commercial cresol) is prepared by distilling "grey phenic acid" at 356 to 401 °F (180 to 205 °C) and is comprised of 20% *ortho*, 40% *meta*, and 30% *para* isomers, plus small amounts of phenol and xylenols. Each isomer can be prepared synthetically by diazotization of the specific corresponding toluidine. Used in manufacturing synthetic resins, explosives, photographic developers, petroleum, paint, disinfectants, and fumigants; as an ore flotation agent; and in the agriculture industry for herbicides and insecticides.
Other Designations: CAS No. 1319-77-3, Bacillol, cresylic acid, Tekresol, tricresol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Cresol is severely irritating to mucous membranes, eyes, and skin. Depending on the cresol concentration, extent of exposure, and amount of skin exposed, toxicity may be slight (irritation) or severe (permanent injury or death).

R 1
I 4
S 3*
K 2
* Skin absorption

NFPA
2
3 0
—

HMIS
H 3
F 2
R 0
PPG†
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Cresol (*mixed isomers*) National Formulary (NF) grade contains < 5% phenol

1990 OSHA PEL (Skin)
8-hr TWA: 5 ppm (22 mg/m^3)

1990 NIOSH REL
TWA: 5 ppm (22 mg/m^3)

1990 IDLH Level
250 ppm

1991-92 ACGIH TLV (Skin)
TWA: 5 ppm (22 mg/m^3)

1990 DFG (Germany) MAK
TWA: 5 ppm (22 mg/m^3) (H)*
Peak Exposure Limit: 10 ppm, 5 min, momentary value/8 per shift

1985-86 Toxicity Data†
Rat, oral, LD_{50}: 1454 mg/kg; toxic effects not yet reviewed
Mouse, inhalation, LC_{50}: 179 mg/m^3/2 hr; no toxic effects noted (*o*-)
Rabbit, eye: 103 mg produced severe irritation (*p*-)
Rabbit, skin: 517 mg applied for 24 hr produced severe irritation (*m*-)
Rabbit, skin, LD_{50}: 2000 mg/kg; toxic effects not yet reviewed

* Danger of cutaneous absorption.
† See NIOSH, *RTECS* (GO5950000), for additional toxicity data. For data on specific isomers, see *RTECS* (GO6125000, *meta*; GO6300000, *ortho*; and GO6475000, *para*).

Section 3. Physical Data

Boiling Point Range: 375.8 to 397.4 °F (191 to 203 °C)
Melting Point Range: 51.8 to 95 °F (11 to 35 °C)
Vapor Pressure: 0.25 (*ortho*), 0.15 (*meta*), 0.11 (*para*) mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 3.72
pH: Saturated solutions are neutral or slightly acidic to litmus
Viscosity: 4.49 to 7.0 cP at 104 °F (40 °C)
Molecular Weight: 108.13
Specific Gravity: 1.030 to 1.038 at 77 °F (25 °C)
Water Solubility: Soluble, 1%
Other Solubilities: Soluble in alcohol, ether, dilute alkalies, glycol and vegetable oils
Refraction Index: 1. 5353 at 75.2 °F (24 °C)
Odor Threshold: Low, 0.012 mg/m^3; high, 22 mg/m^3

Appearance and Odor: Colorless, yellow, or pinkish liquid turning brown on exposure to air or light with a phenolic odor and pungent taste.

Section 4. Fire and Explosion Data

Flash Point: 178 °F (81.11 °C, *ortho*), 187 °F (86.11 °C, *meta* and *para*), CC	**Autoignition Temperature:** 1110 °F (559 °C, *ortho*), 1038 °F (558 °C, *meta* and *para*)	**LEL:** 1.4% (*ortho*), 1.1% (*meta* and *para*) at 302 °F (150 °C)	**UEL:** None reported

Extinguishing Media: While cresol does not ignite easily, it burns. For small fires, use dry chemical, carbon dioxide (CO_2), water spray, or regular foam. For large fires, use water spray, fog, or regular foam. Do not scatter material with more water than is necessary to put out fire.
Unusual Fire or Explosion Hazards: Container may explode in heat of fire.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is ineffective for fires involving cresol. Use clothing the manufacturer recommends specifically for use with cresol. If possible without risk, remove container from fire area. Fight fire from maximum distance. Stay away from ends of tanks. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Cresol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Cresol reacts with oxidizing materials and causes a temperature and pressure increase with chlorosulfonic acid, nitric acid, and oleum.
Conditions to Avoid: Ignition sources and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of cresol can produce carbon dioxide (CO_2) and toxic cresol fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(142) and OSHA(164) do not list cresol as a carcinogen. **Summary of Risks:** Cresol is corrosive to eyes, skin, and mucous membranes. Degree of toxicity depends on the cresol concentration involved, amount of surface area exposed, and duration of exposure. Ingestion is corrosive to the digestive tract's mucous membranes and can pose serious problems if not treated promptly. Because cresol has a low vapor pressure, it is not volatile enough under normal conditions to present an inhalation hazard. If heated, vapor inhalation is likely. Severe chemical burns and dermatitis are the main hazards in industry. Note that cresol's *ortho* and *para* isomers (if used individually) are in crystal form and thus are a dust inhalation hazard. By all routes of exposure, cresol produces toxic symptoms similar to phenol's. **Medical Conditions Aggravated by Long-Term Exposure:** Skin diseases. **Target Organs:** Eyes, skin, central nervous system (CNS), liver and kidney. **Primary Entry Routes:** Skin and eye contact/absorption. **Acute Effects:** Cresol is absorbed through skin, open wounds, and the mucous membranes of the respiratory and digestive tracts. The rate at which skin absorbs cresol depends more on the size of exposure area than on the concentration of material applied. Cresol is corrosive to the skin causing smarting; tingling; redness; swelling; burns that may be very painful and become white and wrinkled with softening that may become gangrenous; blisters; possible shock as a result

Continue on next page

Section 6. Health Hazard Data, *continued*

of pain; and, in severe cases of absorption, coma and death. Contact with eyes may cause stinging, and burning, watering of eyes, redness and swelling of lids, corneal opaqueness causing blurred vision and possible loss of sight. In rare cases, a pigment disorder called ochronosis occurs characterized by darkening of skin, conjunctiva, and cartilage of the nose and ears. Ingestion leads to burning of lips, mouth, and throat, pain in swallowing, ulceration of the mucous membranes of the mouth, color change of the tongue (white), thirst, throat swelling, cramps, nausea and vomiting (sometimes of coffee grounds-like material due to digestive hemorrhage). In severe cases symptoms might progress to shock, convulsions, coma, and death. If vapor inhalation occurs, symptoms include irritation of mucous membranes of nose, eyes, and mouth, watering of eyes, sneezing, coughing, difficulty breathing, headache, nausea, muscle weakness, and possible pulmonary edema. In most cases of exposure, if death occurs, it is usually caused by respiratory failure. **Chronic Effects:** Repeated exposure to cresol may cause digestive disturbances, liver, kidney, spleen and pancreatic damage, and skin eruptions or dermatitis. Some people can become allergic or hypersensitive to cresol.

FIRST AID: *Emergency personnel should protect against contamination.*

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing to prevent burns. Rinse with flooding amounts of water for at least 15 min. If clothing is stuck to skin after flushing with water, *do not* remove! Thoroughly wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting with 2 tablespoons of Ipecac (adult dose). After patient vomits, give activated charcoal in 8 oz. of water to drink. **After first aid, get appropriate in-plant, paramedic, or community medical support.**

Note to Physicians: Since effects may be delayed, keep victim under observation. Irrigate eyes and wash skin with a mixture of polyethylene glycol 300 and industrial methylated spirits (PEG 300/IMS, 2:1 by volume). Recommended treatment for ingestion is repeated gastric lavage with large quantities of olive oil.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area (with fixed or portable fan systems for cross-ventilation), deny entry, and stay upwind. Shut off all ignition sources. Spilled liquid can be neutralized with crushed limestone or soda ash. Take up small spills with earth, sand, vermiculite or other absorbent, noncombustible material and place into suitable containers. For large spills, dike far ahead of liquid for later disposal or reclamation. For water spills, you may need to trap cresol at the bottom with sandbag barriers, apply activated charcoal, and then remove trapped material with dredges or lifts. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Degradation: When released into the atmosphere, cresol degrades by reacting with photochemically produced hydroxyl radicals during the day (half-life = 8 to 10 hr), and with nitrate radicals at night (half-life = 2 to 5 min). Cresol biodegrades in eutrophic (nutrient-rich) waters.

Ecotoxicity Values: Blue gill, TL_m, 24 mg/L/96 hr (fresh water); shrimp, TL_m, 10 to 100 ppm/48 hr (saltwater).

Soil Absorption/Mobility: Cresol is mobile in soil but biodegradation is probable. Cresols probably leach due to water solubility.

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U052*

Listed as a CERCLA Hazardous Substance† (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [† per RCRA, Sec. 3001 and CWA, Sec. 311(b)(4)]

isted (*o-cresol only*) as a SARA Extremely Hazardous Substance (40 CFR 355)

Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

* When a spent solvent and classified as a hazardous waste from nonspecific sources, cresol has Hazardous Waste No. F004.

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles or faceshields to protect against droplets or spray, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. At 50 to 500 ppm use a full face gas mask. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.

Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. Rubber is suggested as a material suitable for protection against cresol.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in properly labelled (with trade name) iron or steel containers in cool, dry, well-ventilated location. Protect from light and keep away from incompatibles (Sec. 5). Outside or detached storage is preferred. To prevent static sparks, electrically ground and bond all equipment used in cresol manufacture, use, and storage.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level.

Administrative Controls: Consider preplacement and periodic examinations of exposed workers that emphasize skin, kidney, liver, and respiratory system.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Cresol
DOT Hazard Class: Corrosive material
ID No.: UN2076
DOT Label: Corrosive
DOT Packaging Exceptions: 173.244
DOT Packaging Requirements: 173.245

IMO Shipping Name: Cresols (*o-*, *m-*, *p-*)
IMO Hazard Class: 6.1
ID No.: UN2076
IMO Label: Poison
IMDG Packaging Group: II

***MSDS Collection* References:** 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 140, 153, 159, 162, 163, 164

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Material Safety Data Sheets Collection:

Sheet No. 703
1,2-Dichloroethylene

Issued: 4/90

Section 1. Material Identification

31

1,2-Dichloroethylene Description: An industrial solvent composed of 60% cis- and 40% trans-isomers. Both isomers, cis and trans, are made by partial chlorination of acetylene. Used as a general solvent for organic materials, lacquers, dye extraction, thermoplastics, organic synthesis, and perfumes. The trans-isomer is more widely used in industry than either the cis-isomer or the mixture. Toxicity also varies between the two isomers.
Other Designations: CAS No. 0540-59-0; $C_2H_2Cl_2$; acetylene dichloride; *cis*-1,2-dichloroethylene; *sym*-dichloroethylene; *trans*-1,2-dichloroethylene, dioform.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*(73) for a suppliers list.

R 1
I 2
S 2
K 1

NFPA

HMIS
H 2
F 3
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

1,2-Dichloroethylene, ca 100%

OSHA PEL
8-hr TWA: 790 mg/m³, 200 ppm

ACGIH TLV, 1989-90
TLV-TWA: 790 mg/m³, 200 ppm

NIOSH REL, 1987
790 mg/m³, 200 ppm

Toxicity Data*
Rat, oral, LD_{50}: 770 mg/kg; toxic effects not yet reviewed
Frog, inhalation, TC_{Lo}: 117 mg/m³ inhaled for 1 hr affects the peripheral nerve and sensation (flaccid paralysis without anesthesia); behavior (excitement); lungs, thorax, or respiration (respiratory depression)

* See NIOSH, *RTECS* (KV9360000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 119 °F/48 °C
Melting Point: -56 to -115 °F/-49 to -82 °C/
Vapor Pressure: 180 to 264 torr at 68 °F/20 °C
Vapor Density (Air = 1): 3.4

Molecular Weight: 96.95 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.27 at 77 °F/25 °C
Water Solubility: Insoluble

Appearance and Odor: A colorless, low-boiling liquid with a pleasant odor.

Section 4. Fire and Explosion Data

Flash Point: 37 °F/2.8 °C, CC	**Autoignition Temperature:** 860 °F/460 °C	**LEL:** 5.6% v/v	**UEL:** 12.8% v/v

Extinguishing Media: Use dry chemical, CO_2, halon, water spray, or standard foam. Water may be ineffective unless used to blanket the fire.
Unusual Fire or Explosion Hazards: This material's vapors are a dangerous fire hazard and moderate explosion hazard when exposed to any heat or ignition source or oxidizer.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit. Vapors may travel to heat or ignition sources and flash back. Stay upwind and out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: This material is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: This material is incompatible with alkalies, nitrogen tetraoxide, difluoromethylene, strong oxidizers, and dihypofluorite. When in contact with copper or copper alloys or by reaction with potassium hydroxide, explosive chloroacetylene may be released.
Conditions to Avoid: Addition of hot liquid to cold 1,2-dichloroethylene may cause sudden emission of vapor that could flash back to an ignition source.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,2-dichloroethylene can produce highly toxic fumes of chlorine (Cl^-).

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Material Safety Data Sheets Collection:

Sheet No. 300
Acetone

Issued: 11/77 Revision: F, 9/92

Section 1. Material Identification

39

Acetone (CH_3COCH_3) Description: Derived by the dehydrogenation or oxidation of isopropyl alcohol with a metallic catalyst, the oxidation of cumene, the vapor phase oxidation of butane; and as a by-product of synthetic glycerol production. Used as a solvent for paint, varnish, lacquer, fat, oil, wax, resin, rubber, plastic, and rubber cement; to clean and dry parts of precision equipment; in the manufacture of chemicals (methyl isobutyl ketone, methyl isobutyl carbinol, methyl methacrylate, bisphenol-A, acetic acid (ketene process), mesityl oxide, diacetone alcohol, chloroform, iodoform, bromoform), explosives, aeroplane dopes, rayon, photographic films, isoprene; acetylene gas storage cylinders; in purifying paraffin; in nail polish remover; in the extraction of various principles from animal and plant substances; in hardening and dehydrating tissues; in cellulose acetate (especially as spinning solvent); as a solvent for potassium iodide and permanganate; as a delusterant for cellulose acetate fibers; in the specification testing of vulcanized rubber products.

Other Designations: CAS No. 67-64-1, AI3-01238, Chevron acetone, dimethylformaldehyde, dimethylketal, dimethyl ketone, β-ketopropane, methyl ketone, propanone, 2-propanone, pyroacetic acid, pyroacetic ether.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Acetone vapor is a dangerous fire and explosion hazard. High vapor concentrations may produce narcosis (unconsciousness). Prolonged or repeated skin contact causes dryness, irritation, and mild dermatitis.

R 1
I 1
S 1*
K 3
* Slight skin absorption

NFPA
3
1 0
–

HMIS
H 1
F 3
R 0
PPE*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Acetone, 99.5% plus 0.5% water

1991 OSHA PELs *
8-hr TWA: 750 ppm (1800 mg/m^3)
15-min STEL: 1000 ppm (2400 mg/m^3)

1990 IDLH Level
20,000 ppm

1990 NIOSH REL
TWA: 250 ppm (590 mg/m^3)

1992-93 ACGIH TLVs
TWA: 750 ppm (1780 mg/m^3)
STEL: 1000 ppm (2380 mg/m^3)

1990 DFG (Germany) MAK
1000 ppm (2400 mg/m^3)
Category IV: Substances eliciting very weak effects (MAK >500 mL/m^3)
Peak: 2000 ppm, 60 min, momentary value†, 3 peaks/shift

1985-86 Toxicity Data ‡
Human, eye: 500 ppm
Human, inhalation, TC_{Lo}: 500 ppm produced olfaction effects, conjunctival irritation, and other changes involving the lungs, thorax, or respiration.
Rat, oral, LD_{50}: 5800 mg/kg altered sleep time and produced tremors.
Mammal, inhalation, TC_{Lo}: 31500 μg/m^3/24 hr administered to pregnant female from the 1st to 13th day of gestation produced effects on fertility (post-implantation mortality).

* In the cellulose acetate fiber industry, enforcement of the OSHA TWA for "doffers" was stayed on 9/5/89 until 9/1/90; the OSHA STEL *does not* apply to that industry.
† Momentary value is a level which the concentration should never exceed.
‡ See NIOSH, *RTECS* (AL3150000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 133.2 °F (56.2 °C) at 760 mm Hg
Freezing Point: -139.6 °F (-95.35 °C)
Vapor Pressure: 180 mm Hg at 68 °F (20 °C), 400 mm Hg at 103.1 °F (39.5 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3, 0.075 lb/ft^3): 1.48 kg/m^3, .093 lb/ft^3
Refractive Index: 1.3588 at 20 °C
Appearance and Odor: Colorless, highly volatile liquid; sweetish odor.
Molecular Weight: 58.08
Specific Gravity: 0.7899 at 20 °C/4 °C
Water Solubility: Soluble
Other Solubilities: Alcohol, benzene, dimethyl formamide, chloroform, ether, and most oils.
Odor Threshold: 47.5 mg/m^3 (low), 1613.9 mg/m^3 (high)*

* Odor thresholds recorded as a range from the lowest to the highest concentration.

Section 4. Fire and Explosion Data

Flash Point: 0 °F (-18 °C), CC	**Autoignition Temperature:** 869 °F (465 °C)	**LEL:** 2.6% v/v	**UEL:** 12.8% v/v

Extinguishing Media: *Do not* extinguish fire unless flow can be stopped. For small fires, use dry chemical, carbon dioxide (CO_2), water spray or alcohol-resistant foam. For large fires, use water spray, fog, or alcohol-resistant foam. Use water in flooding quantities as fog because solid streams may be ineffective. **Unusual Fire or Explosion Hazards:** Acetone is a dangerous fire and explosion hazard; it is a Class IB flammable liquid. Vapors may travel to a source of ignition and flash back, fire-exposed containers may explode, and a vapor explosion hazard may exist indoors, outdoors, or in sewers. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. If feasible, remove all fire-exposed containers. Otherwise, apply cooling water to sides of containers until well after fire is extinguished. If the fire becomes uncontrollable or container is exposed to direct flame, consider evacuation of a one-third mile radius. In case of rising sound from venting safety device or any discoloration of tank during fire, withdraw immediately. For massive cargo fires, use unmanned hose holder or monitor nozzles. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Acetone is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Acetone may form explosive mixtures with hydrogen peroxide, acetic acid, nitric acid, nitric acid + sulfuric acid, chromic anhydride, chromyl chloride, nitrosyl chloride, hexachloromelamine, nitrosyl perchlorate, nitryl perchlorate, permonosulfuric acid, thiodiglycol + hydrogen peroxide. Acetone reacts vigorously with oxidizing materials and ignites on contact with activated carbon, chromium trioxide, dioxygen difluoride + carbon dioxide, and potassium-*tert*-butoxide. Other incompatibles include air, bromoform, bromine, chloroform + alkalies, trichloromelamine, and sulfur dichloride. **Conditions to Avoid:** Keep acetone away from plastic eyeglass frames, jewelry, pens, pencils, and rayon garments. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of acetone can produce CO_2 and carbon monoxide (CO).

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list acetone as a carcinogen. **Summary of Risks:** Acetone has been placed among solvents of comparatively low acute and chronic toxicities. In industry, the most common effects reported are headache from prolonged vapor inhalation and skin irritation resulting from its defatting action. Exposures to less than 1000 ppm acetone vapor produces only slight eye, nose, and throat irritation. Acetone does not have sufficient warning properties to prevent repeated exposures. It is narcotic at high concentrations, i.e., above 2000 ppm. Concentrations above 12000 ppm cause loss of consciousness.

Continue on next page

Section 6. Health Hazard Data,*continued*

Medical Conditions Aggravated by Long-Term Exposure: None reported. **Target Organs:** Respiratory and central nervous systems, skin. **Primary Entry Routes:** Inhalation, skin and eye contact, ingestion. Liquid acetone is slowly absorbed through the skin. **Acute Effects:** Human ystemic effects by inhalation include eye, nose and throat irritation; nausea and vomiting; changes in EEG (electroencephalogram) and carbohydrate metabolism; muscle weakness; drunken behavior; mental confusion and visual disturbance. In extreme cases, breathing high concentrations may produce coma. Human systemic effects by ingestion include gastrointestinal irritation, kidney damage (often indicated by albumin and red and white blood cells in the urine), liver damage (indicated by high levels of urobilin and early appearance of bilirubin), coma, metabolic changes, and systemic effects described for inhalation. Direct eye contact by liquid acetone may produce painful burning and stinging; watering of eyes; conjuctival inflammation; and corneal injury. Skin contact produces a cold feeling, dryness, and mild irritation.

Chronic Effects: Cases of chronic poisoning resulting from prolonged exposure to low concentrations of acetone are rare. Workers exposed to 1000 ppm, 3 hrs per day for 7-15 yrs, complained of dizziness, asthenia (lack or loss of strength), and chronic inflammation of the airways, stomach, and duodenum. Prolonged or repeated skin contact with liquid acetone may defat the skin and cause eczematoid dermatitis.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing because it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air, monitor for respiratory distress, and administer 100% humidified supplemental oxygen as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. **After first aid, get appropriate in-plant, paramedic, or community medical support.**

Note to Physicians: In symptomatic patients, monitor serum and urine acetone, fluid intake, blood glucose, and arterial pH. Because of the prolonged elimination half-life of acetone, the symptomatic patient may need medical supervision for many hours (up to 30 hrs). Patients may develop hyperglycemia and ketosis mimicking acute diabetic coma. The hyperglycemia may persist for several days following acute exposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and provide adequate ventilation. Cleanup personnel should protect against inhalation and skin or eye contact. If feasible and without risk, stop leak. Use water spray to reduce vapor, but it may not prevent ignition in closed spaces. For small spills, take up with sand or other noncombustible absorbent material and using nonsparking tools, place into containers for later disposal. For large spills, dike far ahead of liquid spill for later disposal. Do not release to sewers or waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Toxicity:** LC_{50} *Salmo gairdneri* (rainbow trout): 5540 mg/L/96 hr at 54 °F (12 °C). LC_{50} (oral) Ring-necked pheasant: >40,000 ppm. **Environmental Degradation:** Acetone biodegrades when released into the environment. The biological oxygen demand for 5 days (BOD5) is 46-55%. **Soil Absorption/Mobility:** Acetone volatilizes, leaches, and biodegrades if released on soil. **Disposal:** Acetone is a good candidate for fluidized bed, rotary kiln incineration, or catalytic oxidation. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): Hazardous Waste No. U002 (Ignitability), (40 CFR 261.31): F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per Clean Water Act, Sec. 311(b)(4)]
ARA Extremely Hazardous Substance (40 CFR 355): Not listed
isted as a SARA Toxic Chemical (40 CFR 372:65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For concentrations < 1000 ppm, wear any chemical cartridge respirator with organic vapor cartridge(s) and wear eye protection to avoid irritation or damage. For concentrations <6250 ppm, wear any supplied-air respirator operated in a continuous-flow mode. For concentrations < 12,500 ppm, wear any air-purifying, full-facepiece respirator (gas mask) with a chin-style, front- or back-mounted organic vapor canister. For concentrations < 20,000 ppm, wear any supplied-air respirator that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polyethylene/ethylene vinyl alcohol, Teflon, or butyl rubber with breakthrough times > 8 hr is recommended for PPE . **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in closed containers in a cool, dry well-ventilated area away from heat, sparks, flames, and other incompatibles. Keep large stocks away from inhabited buildings. Use non-sparking tools to open containers. Keep dry chemical or CO_2 extinguishers on hand in case of fire. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all containers and equipment during fluid transfer. For bulk storage rooms, install electrical equipment, Class I, Group D. **Administrative Controls:** Consider preplacement and periodic medical examinations with emphasis on the skin and respiratory tract. Also consider liver and kidney function tests and urinalysis.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Acetone	**Packaging Authorizations**	**Quantity Limitations**	**Vessel Storage Requirements**
DOT Hazard Class: 3	**a) Exceptions:** 173.150	**a) Passenger, Aircraft, or Railcar:** 5L	**Vessel Stowage:** B
No.: UN1090	**b) Non-bulk Packaging:** 173.202	**b) Cargo Aircraft Only:** 60L	**Other:** --
DOT Packaging Group: II	**c) Bulk Packaging:** 173.242		
DOT Label: Flammable Liquid			
Special Provisions (172.102): T8			

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 176, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MPH, MD

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Material Safety Data Sheets Collection:

Sheet No. 337

n-Butyl Alcohol

Issued: 10/78 Revision: D, 1/93

Section 1. Material Identification

40

R 1
I 2
S 2*
K 3

*Skin absorption

NFPA
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HMIS
H 1
F 3
R 0
PPE†
† Sec. 8

n-Butyl Alcohol ($C_2H_5CH_2CH_2OH$) Description: Naturally occurring in Brazilian peppermint oil. Derived by several processes including reduction of butyraldehyde with sodium borohydride, from ethylene oxide and triethylaluminum, oxidation of tributyl borane, carbohydrate fermentation, condensation of acetaldehyde to crotonaldehyde with subsequent hydrogenation, or by passing ethyl alcohol over magnesium oxide/copper oxide at 617 °F (325 °C) and 128 atm. Used as a solvent for fats, oils, waxes, resins, shellac, varnish, gums, vegetable oils, alkaloids, and dyes; in manufacture of lacquers, rayon, detergents, other butyl compounds, and pharmaceuticals (extractant for antibiotics, vitamins, and hormones); in microscopy preparing paraffin imbedding materials; as a dehydrating agent; in medicine for control of post-operative otolaryngeal pain and for an anti-hemorrhagic effect in advanced cancer patients; in veterinary medicine as a bactericide.
Other Designations: CAS No. 71-36-3, *n*-butanol, 1-butanol, butyl hydroxide, butyric alcohol, CCS 203, Henostyp, 1-hydroxybutane, methylolpropane, propylcarbinol, propyl methanol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: *n*-Butyl alcohol is irritating to the eyes and skin and can cause dermatitis. Central nervous system depression may occur at high concentrations. It is a highly flammable liquid.

Section 2. Ingredients and Occupational Exposure Limits

n-Butyl alcohol, ca 99.9%. May contain 0.1% water by wt.

1992 OSHA PEL
Transitional Limit:
TWA, 100 ppm (300 mg/m^3)
Final Rule Limit:
Ceiling, 50 ppm (150 mg/m^3), *skin*

1990 IDLH Level
8000 ppm

1990 NIOSH REL
Ceiling: 50 ppm (150 mg/m^3), *skin*

1992-93 ACGIH TLV
Ceiling: 50 ppm (152 mg/m^3), *skin*

1990 DFG (Germany) MAK
TWA: 100 ppm (300 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 200 ppm, 30 min average value, 4/shift

1992 Toxicity Data*
Human, eye, 50 ppm caused irritation.
Human, inhalation, TC_{Lo}: 25 ppm caused conjunctival and respiratory irritation.
Rat, oral, LD_{50}: 790 mg/kg; toxic effects not yet reviewed
Rabbit, skin, LD_{50}: 3400 mg/kg; no toxic effect noted

* See NIOSH, *RTECS* (EO1400000), for additional irritation, mutation, and toxicity data.

Section 3. Physical Data

Boiling Point: 243 °F (117 °C)
Freezing Point: -130 °F (-90 °C)
Vapor Pressure: 6.5 mm Hg at 77 °F (25 °C)
Ionization Potential: 10.04 eV
Relative Evaporation Rate (BuAc = 1): 0.46
Refraction Index: 1.3993 at 68 °F (20 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): 1.216 kg/m^3
Liquid Surface Tension: 69.3 dyne/cm
Molecular Weight: 74.12
Specific Gravity: 0.8109 at 68 °F (20 °C)
Water Solubility: Soluble, 9.1 mL/100 mL water
Other Solubilities: Soluble (10%) in acetone, benzene, ethanol, and ether.
log Octanol Water Partition Coefficient: 0.88
Viscosity: 36.1 cP at -50.6 ° F (-50.9 °C), 5.18 cP at 32 °F (0 °C), 2.94 cP at 68 °F (20 °C), 0.54 cP at 212 °F (100 °C).
Critical Temperature and Pressure: 289.8 °C and 43.6 atm

Appearance and Odor: Colorless liquid with a harsh fuel oil and banana smell. The odor threshold is 0.12 to 11 ppm.

Section 4. Fire and Explosion Data

Flash Point: 84 °F (28.9 °C) CC, 98 °F (37 °C) OC	**Autoignition Temperature:** 650 °F (343 °C)	**LEL:** 1.4% v/v	**UEL:** 11.2% v/v

Extinguishing Media: A Class I C Flammable Liquid. For small fires, use dry chemical, carbon dioxide, water spray, or 'alcohol-resistant' foam. For large fires, use water spray, fog, or 'alcohol-resistant' foam. **Unusual Fire or Explosion Hazards:** Burning Rate = 3.2 mm/min. Vapors may travel to an ignition source and flash back. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Cool container sides with water until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice tank discoloration due to fire because a BLEVE may be imminent. Do not release runoff from fire control methods to sewers or waterways; dike for proper disposal.

Section 5. Reactivity Data

Stability/Polymerization: *n*-Butyl alcohol is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include aluminum, chromium trioxide, organic peroxides, and strong oxidizers. Attacks some forms of plastic, rubber, coatings. **Conditions to Avoid:** Exposure to heat, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of *n*-butyl alcohol can produce carbon monoxide and acrid smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(183) NTP,(169) and OSHA(183) do not list *n*-butyl alcohol as a carcinogen. **Summary of Risks:** *n*-Butyl alcohol is potentially more toxic (seen in animal studies) than its lower homologues but its airborne hazards are substantially reduced due to a low vapor pressure. The estimated human lethal oral dose is 3 to 7 ounces. Vapor inhalation is irritating to the eyes and respiratory tract. Skin contact is irritating and may lead to dermatitis. *n*-Butyl alcohol can be absorbed through the skin; direct hand contact for 1 hr resulted in a body burden 4x that from inhalation of 50 ppm/1 hr. The average odor threshold is ~ 15 ppm but because of rapid olfactory fatigue it rises to 10,000 ppm after adaptation.

Continue on next page

Section 6. Health Hazard Data, *continued*

Two studies suggest unprotected noise exposure concurrent with exposure to butyl alcohol (~ 80 ppm) increased hearing loss beyond that occurring from noise exposure alone. Animal studies show lowered white blood cell counts, lymphocytosis, lung hemorrhage, albuminuria lbumin in urine), early degenerative liver changes, and cortical/tubular degeneration of the kidneys. **Medical Conditions Aggravated by Long-erm Exposure:** Dermatitis. **Target Organs:** Eyes, ears, skin, respiratory tract. **Primary Entry Routes:** Inhalation, eye contact, skin contact/absorption. **Acute Effects:** Skin contact produces drying and cracking due to its defatting action. Vapor inhalation is irritating to respiratory tract and eyes. Conjuctival edema (swelling), headache, dizziness, and drowsiness may also occur. **Chronic Effects:** Repeated exposure to 50 to 200 ppm leads to blurred vision, burning, and sensitivity to light. Symptoms become more severe toward week's end and decrease over the weekend. Hearing loss and vestibular damage resulting in vertigo may occur from current exposure to *n*-butyl alcohol and noise pollution.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water. If pain, photophobia, or lacrimation persists after 15 min. of flushing, consult an ophthalmologist. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting. **Note to Physicians:** Treatment is symptomatic and supportive.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spill for later disposal or reclamation. Prevent entry into sewers, drains, and waterways. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** *Pseudomas putida* (bacteria), 650 mg/L inhibited cell multiplication; fathead minnow, LC_{50} = 1940 mg/L/1 hr; aquatic plant toxicity = 8500 ppm. **Environmental Degradation:** In air, *n*-butyl alcohol will react with photochemically produced hydroxyl radicals with an estimated half-life of 2.3 days. In a sunlit urban atmosphere the half-life is reduced to 5 hr. In water, some butyl alcohol will biodegrade and the rest will volatilize with estimated half-lives of 2.4 hr, 3.9 hr, and 125.9 days in streams, rivers, and lakes, respectively. The ability to volatilize depends on temperature, turbulence, wind speed, current velocity, and water depth. If released to soil, *n*-butyl alcohol may volatilize, biodegrade, or leach into groundwater. **Soil Absorption/Mobility:** A soil absorption coefficient (Koc) of 71.6 indicates moderate to high mobility. **Disposal:** A good candidate *for* liquid injection incineration, with a temperature range of 650 to 1600 °C and a residence time of 0.1 to 2 sec; *for* rotary kiln incineration at 820 to 1600 °C for a few seconds, and *for* fluidized bed incineration at 450 to 980 °C for a few seconds. Land disposal is limited because sub-surface dilution does not adequately keep groundwater concentrations below regulated levels. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): U031

SARA Extremely Hazardous Substance (40 CFR 355): Not listed

Listed as a SARA Toxic Chemical (40 CFR 372.65)

isted as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per RCRA, Sec. 3001]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

ection 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any powdered air purifying respirator with organic vapor cartridges. For < 1250 ppm, use any supplied-air respirator (SAR) operated in continuous-flow mode. For < 2500 ppm, use any air-purifying, full face respirator (gas mask) with a chin style, front or back mounted organic vapor canister, or any SAR or SCBA with a full facepiece. For < 8000 ppm, use any SAR with a full facepiece and operated in pressure-demand or positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Teflon and chlorosulphonated ethylene rubber with a breakthrough time (BT) of > 8 hr; and butyl rubber, polyethylene, neoprene, and nitrile rubber with a BT of > 4 hr are suitable materials for protective gear. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage/Handling Requirements: Prevent physical damage to containers. Store in a cool, dry, dark, well-ventilated area away from heat, ignition sources, and incompatibles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use electrical equipment of Class I, Group D. Use non-sparking tools during maintenance operations and electrically ground and bond equipment. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on the eyes, skin and respiratory tract.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Butanols
DOT Hazard Class: 3
ID No.: UN1120
T Packing Group: III
/T Label: Flammable Liquid
Special Provisions (172.102): B1, T1

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: —

***MSDS Collection* References:** 23, 54, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 153, 159, 167, 168, 169, 171, 176, 183

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 397
***n*-Hexane**

Issued: 10/78 Revision: D, 9/92

Section 1. Material Identification 39

***n*-Hexane ($CH_3(CH_2)_4CH_3$) Description:** Derived by fractional distillation from petroleum (molecular sieve process). Used as a solvent for glues, cements, adhesives, fats, and oils; a lab reagent; liquid in low temperature thermometers (instead of mercury); thinner, cleaning agent; polymerization reaction medium; an alcohol denaturant; in retreading tires for determining the refraction index of minerals.

Other Designations: CAS No. 110-54-3, dipropyl, Gettysolve-B, hexyl hydride, NCI-C60571, Skellysolve-B.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA

HMIS
H 2†
F 3
R 0
PPE-Sec. 8
† Chronic effects

Cautions: *n*-Hexane is highly flammable. It is irritating to the eyes, skin, and mucous membranes. Vapor inhalation produces central nervous system (CNS) depression, becoming anesthetic at high concentrations. Chronic exposure may result in polyneuropathy.

Section 2. Ingredients and Occupational Exposure Limits

n-Hexane; commercial hexane is a mixture of *n*-hexane and isomers of methyl pentane and heptane. 1 to 6% benzene may also be present.

1991 OSHA PEL
8-hr TWA: 50 ppm (180 mg/m^3)

1990 IDLH Level
5000 ppm

1990 NIOSH REL
TWA: 50 ppm (180 mg/m^3)

1992-93 ACGIH TLV
TWA: 50 ppm (176 mg/m^3)

1990 DFG (Germany) MAK
TWA: 50 ppm (180 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 5000 ppm/10 min caused hallucinations and distorted perceptions.
Rat, oral, LD_{50}: 28,710 mg/kg; no toxic effect noted
Rat, inhalation, TC_{Lo}: 1000 ppm/6 hr from the 8th to 16th day of pregnancy produced effects on newborn growth.
Rabbit, eye: 10 mg caused mild irritation.

* See NIOSH, *RTECS* (MN9275000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 156 °F (69 °C)
Freezing Point: -139 °F (-95 °C)
Vapor Pressure: 150 mm Hg at 77 °F (25 °C)
Refraction Index: 1.37486 at 68 °F (20 °C)
Critical Temperature: 453.2 °F (234 °C)
Critical Pressure: 29.7 atm
Liquid Surface Tension: 18.4 dyne/cm
Odor Threshold: 65 ppm
Molecular Weight: 86.17
Density: 0.66 at 20/4 °C
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.1049 lb/ft^3 or 1.678 kg/m^3
Water Solubility: Slightly, 0.014 mg/ml at 68 °F (20 °C)
Other Solubilities: Alcohol, acetone, chloroform, ether, and most non-polar solvents.
Ionization Potential: 10.18 eV
Viscosity: 0.334 cP at 35 °F (2 °C), 0.306 cP at 80 °F (27 °C), 0.276 cP at 145 °F (62.5 °C)
Appearance and Odor: A colorless, volatile liquid with a gasoline-like odor.

Section 4. Fire and Explosion Data

Flash Point: -7.6 °F (-22 °C)	**Autoignition Temperature:** 437 °F (225 °C)	**LEL:** 1.2% v/v	**UEL:** 7.5% v/v

Extinguishing Media: *n*-Hexane is a Class 1B Flammable Liquid. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. *n*-Hexane poses a vapor explosion hazard indoors, outdoors, and in sewers. Burning rate = 7.3 mm/min. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing appar-atus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection. If possible without risk, move container from fire area. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire. Discoloration may indicate danger of BLEVE (boiling liquid expanding vapor explosion). Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: *n*-Hexane is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Incompatible with strong oxidizers and may explode at 82.4 °F (28 °C) when mixed with dinitrogen tetraoxide. **Conditions to Avoid:** Contact with heat and incompatibles.

Hazardous Products of Decomposition: Thermal oxidative decomposition of *n*-hexane can produce acrid smoke and irritating vapors.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list *n*-hexane as a carcinogen. Although there is no data on human carcinogenicity specifically caused by n-hexane, there is an increase in association between Leukemia risk in the rubber industry and exposure to a variety of substances including hexane. **Summary of Risks:** Vapors are irritating to the skin, eyes, and respiratory tract. Inhalation produces varying degrees of CNS depression depending on concentration. High concentrations may lead to asphyxia (oxygen displacement). Chronic exposure (usually at least 60 to 240 ppm) results in neurotoxicity characterized by sensory loss, pain, and neurogenic atrophy of skeletal muscle. Peripheral neuropathy is mostly of the 'stocking & glove' type. *n*-Hexane is ultimately converted to 2,5-hexanedione during metabolism and is considered to be the metabolite responsible for toxicity. Evidence exists that *n*-hexane accumulates in fatty tissue which would explain its affinity for the blood, liver, and brain where lipids are prevalent. After exposure has ceased, the half-life is 64 hrs. Metabolism is inhibited by co-exposure to toluene, methylethyl ketone, or methyl *n*-butyl ketone. *n*-Hexane is absorbed through the skin in both liquid and vapor form. Therefore, dermal vapor absorption raises biological levels above those reached during inhalation of or below the TLV concentration. This is why it is imperative that protective clothing be used so that the TLV levels are sufficient to prevent over-exposure. **Medical Conditions Aggravated by Long-Term Exposure:** Skin, CNS, PNS, and respiratory diseases. **Target Organs:** Eyes, skin, respiratory system, central and peripheral nervous system. **Primary Entry Routes:** Inhalation, skin contact/absorption, eyes, ingestion. **Acute Effects:** Vapor inhalation produced marked vertigo and hallucinations at 5000 ppm/10 min; drowsiness, fatigue, appetite loss, and paresthesia in the distal extremities at 1000 to 2500/12 hrs; muscle weakness, cold pulsation in extremeties, blurred vision, headache, anorexia and onset of polyneuropathy at 500 to 2500 ppm (time not given).

Continue on next page

Section 6. Health Hazard Data

Skin contact causes immediate irritation with redness, painful burning and possible blisters. Eye contact produces irritation, watering, and burning. Ingestion poses a serious aspiration hazard. If aspiration into the lungs occurs, asphyxiation from oxygen displacement may lead to brain damage and cardiac arrest. Cardiac sensitization to epinephrine (the body's adrenalin) may cause rhythm disturbances with potentially fatal consequences. **Chronic Effects:** Polyneuropathy occurs from repeated exposure to levels typically in the 400 to 600 ppm range; there is a case of polyneuropathy after exposure to 54 to 200 ppm/1 year. Initial symptoms include muscle weakness, motor loss, sensation disturbances (numbness and pain without stimulus), and distal symmetric leg pain after 2 to 6 months exposure. Clinical studies indicate muscle atrophy (wasting away), foot drop, decreased muscle tone and strength, and paresthesias of the arms and legs. Vision problems including changes in color vision, retinal pigmentation, and in perifoveal capillaries were found in workers exposed to 420 to 1280 ppm for > 5 years. Progression of neuropathy may continue for several months after exposure has ceased, followed by slow recovery taking on the average of 9 to 10 months and rarely, up to 2 years. Residual spinal cord damage was noted in most severely injured victims.

FIRST AID ***Emergency personnel should protect against exposure***

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and administer supplemental oxygen as needed. Intubation may be necessary in severe cases (aspiration of liquid). **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of severe aspiration hazard. If spontaneous vomiting occurs, position head to avoid aspiration of vomitus.

Note to Physicians: BEI = 2,5-hexanedione in urine, sample at end of shift at workweeks end, 5 mg/g creatine. Also measure *n*-hexane in expired air. Analgesics may be necessary for pain management, there is no specific antidote. Monitor arterial blood gases in cases of severe aspiration.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers. Dike far ahead of large spill for later disposal or reclamation. For water spills, use oil skimming equipment to lift spill. Absorbent foams can be applied to slick. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Degradation:** If released on soil, *n*-hexane will readily volatilize from moist surfaces although some may absorb to soil. In water, *n*-hexane will volatilize rapidly although some will absorb to sediment. The log bioconcentration factor (log BCF) estimated at 2.24 to 2.89 suggests bioconcentration is not an important factor in aquatic systems. The estimated Koc of 1250 to 4100 indicates that *n*-hexane absorbs to carbon/organic matter. Volatilization half-life from a model river is 2.7 hr at 77 °F (25 °C), 1 meter deep flowing at 1m/sec with a 3 m/sec wind speed. Volatilization from a model pond (which considers effect of absorption) is estimated at 6.8 days. In the atmosphere, it is expected to exist entirely in the vapor phase. It does not absorb UV light in the environmentally significant range (> 290 nm). It reacts with photochemically produced hydroxyl radicals. Estimated lifetime under photochemical smog conditions is 5.9 hr (SE England). **Disposal:** Spray into an incinerator (may burn quicker by addition of another flammable solvent). Evaporation in a suitable hood may be used for smaller amounts. Landfill is *not* recommended. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed
Listed as a RCRA Hazardous Waste (40 CFR 261.21): D001, *Characteristic of ignitability*
Listed as 'Unlisted hazardous Waste, *Characteristic of ignitability*' a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 500 ppm, use a supplied-air respirator (SAR) or SCBA. For < 1250 ppm, use a SAR operated in continuous-flow mode. For 2500 ppm, use a SAR with a tight-fitting facepiece operated in continuous-flow mode or a SCBA with a full facepiece. For < 5000 ppm, use a SAR operated pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres*. If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of nitrile, Viton, polyvinyl chloride, or chlorinated polyethylene to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from heat, ignition sources, and incompatibles (Sec. 5).
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Purge all vessels previously containing *n*-hexane with steam before entering for the purpose of repair (cutting, welding). Refer to OSHA's Confined Space Standard (29 CFR 1910.119). **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the central and peripheral nervous systems, skin, eyes, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Hexanes
DOT Hazard Class: 3
ID No.: UN1208
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T8

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
a) Vessel Stowage: E
b) Other:

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 139, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171, 174

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 30A
Hydrochloric Acid

Issued: 10/77 Revision: C, 9/92 Erratum: 5/93

Section 1. Material Identification

41

Hydrochloric Acid (HCl) Description: An aqueous solution of hydrogen chloride. Derived by dissolving hydrogen chloride gas in water at various concentrations. Hydrochloric acid is also formed as a byproduct from oxychlorination and/or oxyhydrochlorination of organic materials. Used in metal pickling and cleaning (boiler and heat exchange equipment scale removal), ore reduction, processing (corn syrup, hydrolyzing starch), dye and dye intermediate production, electroplating, leather tanning, in fertilizer, artificial silk, and paint pigment production, refining soaps and edible fats and oils, petroleum extraction, toilet bowl cleaners; as an alcohol denaturant, a chemical intermediate and solvent in organic synthesis, and in the photographic, textile, and rubber industries.

Other Designations: CAS No. 7647-01-0, Caswell No. 486, chlorohydric acid, Muriatic acid, spirits of salt.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Hydrochloric acid is highly corrosive and causes serious skin and eye burns as well as acute and chronic respiratory problems.

R 1
I 4
S 4
K 0

NFPA
0
3 0
-

HMIS
H 2*
F 0
R 0
PPE†
* Chronic effects
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Hydrochloric acid; ~38% (commercial), 20% ("azeotrope"). Trace impurities include ammonia, arsenic, iron, sulfate, free Cl-, and heavy metals.

1991 OSHA PEL
Ceiling: 5 ppm (7 mg/m^3)

1990 IDLH Level
100 ppm

1990 NIOSH REL
Ceiling: 5 ppm (7 mg/m^3)

1992-93 ACGIH TLV
Ceiling: 5 ppm (7.5 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 5 ppm (7 mg/m^3)
Category 1: local irritants
Peak Exposure Limit: 10 ppm, 5 min momentary value/8 per shift

1985-86 Toxicity Data*
Human, inhalation, LC_{Lo}: 1300 ppm/30 min; toxic effects not yet reviewed
Rabbit, oral, LD_{50}: 900 mg/kg; toxic effects not yet reviewed
Rat, inhalation, TC_{Lo}: 450 mg/m^3/1 hr (1 day prior to pregnancy) produced fetotoxicity (except death) & specific developmental abnormalities (homeostasis).
Rabbit, eye: 100 mg rinse caused mild irritation.

*See NIOSH, *RTECS* (MW4025000), for additional irritation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: -120.64 °F (-84.8 °C)*
Vapor Pressure: 4 atm at 64 °F (17.8 °C)
Vapor Density (Air = 1): 1.257
Surface Tension: 23 at 244.68 (118.16 °C)
Molecular Weight: 36.46
Odor Threshold: 0.1 to 5 ppm
Ionization Potential: 12.74 eV
Freezing Point: 1.1 °F (-17.14 °C) for 10.81%, -51.16 °F (-46.2 °C) for 31.24%
Density: 1.194 at -14.8 °F (-26 °C)
Water Solubility: Soluble, 823 g/L at 32 °F (0 °C); 561 g/L at 140 °F (60 °C).
Other Solubilities: Soluble in alcohol, benzene, and ether; insoluble in hydrocarbons.
pH: 1N (0.1), 0.1N (1.1), 0.01N (2.02), 0.001N (3.02), 0.0001N (4.01)
Refraction Index (1N solution): 1.34168 at 64.4 °F (18 °C/D)

Appearance and Odor: Colorless liquid that fumes in air and has a strong pungent odor. Can be slightly yellow from traces of iron, chlorine, or organic matter. Forms a constant boiling azeotrope at 20 % HCl, 108.58 °C and 760 mm Hg.

* Decomposes at 3239.6 °F (1782 °C).

Section 4. Fire and Explosion Data

Flash Point: Noncombustible	**Autoignition Temperature:** None reported	**LEL:** None reported*	**UEL:** None reported*

Extinguishing Media: Use extinguishing agents suitable for surrounding fire.
Unusual Fire or Explosion Hazards: *Extreme heat or contact with many metals liberates hydrogen gas which has explosion limits of 4 to 75%.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing is *ineffective* for fires involving hydrochloric acid. Stay away from ends of tanks. Cool tanks with water spray until well after fire is out. *Do not* release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Hydrochloric acid has high thermal stability (decomposes at 3239.6 °F/1782 °C). Hazardous polymerization does not occur unless exposed to aldehydes or epoxides.
Chemical Incompatibilities: Polymerizes on contact with aldehydes or epoxides; attacks most metals (except mercury, silver, gold, platinum, tantalum, and some alloys), some plastics, rubber, and coatings; reacts explosively with alcohols + hydrogen cyanide, potassium permanganate, tetraselenium tetranitride; ignites on contact with fluorine, hexalithium disilicide, metal acetylides or carbides (cesium acetylide, rubidium acetylide); and is incompatible with acetic anhydride, 2-amino ethanol, ammonium hydroxide, calcium phosphide, chlorosulfonic acid, 1,1-difluoroethylene, ethylene diamine, ethylene imine, oleum, perchloric acid, ß-propiolacetone, propylene oxide, sodium hydroxide, silver perchlorate + carbon tetrachloride, sulfuric acid, uranium phosphide, acetate, calcium carbide, magnesium bromide, mercuric sulfate, and chlorine + dinitroaniline.
Conditions to Avoid: Avoid contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of HCl produces toxic chloride fumes and explosive hydrogen gas.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list HCl as a carcinogen.
Summary of Risks: HCl is a highly corrosive liquid and depending on concentration and duration of exposure, symptoms range from irritation to ulcerations and permanent injury. **Target Organs:** Eyes, skin, respiratory tract, and liver (in animals). **Primary Entry Routes:** Inhalation, skin and eye contact. **Medical Conditions Aggravated by Long-Term Exposure:** Respiratory disorders.

Continue on next page

Section 6. Health Hazard Data, *continued*

Acute Effects: Inhalation of vapors or mists is corrosive to the respiratory tract and can cause tracheal and bronchial epithelium necrosis (tissue death), cough, choking, ulceration. Liquid aspiration can cause pulmonary edema, lung collapse, emphysema and damage to the pulmonary blood vessels. Skin contact with HCl solutions causes burns and ulcerations. Permanent eye damage may result from splashes. Ingestion is unlikely but if it occurs, symptoms include gray tongue color, corrosion of mucous membranes, esophagus, and stomach, nausea, vomiting, intense thirst, diarrhea, difficulty swallowing, circulatory collapse and possible death. **Chronic Effects:** Repeated or prolonged exposure can cause dermatitis, conjunctivitis, gastritis, photosensitization, tooth erosion, and repeated exposure to mists from heated-metal pickling solutions can cause nose and gum bleeds, ulceration of oral or nasal mucosa, and "renders facial skin so tender that shaving is painful."(133)

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Treat skin with a 5% triethanolamine solution. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting!

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Consider a chest x-ray in acute overexposure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Neutralize spills with crushed limestone, soda ash, lime, or sodium bicarbonate. After neutralizing, take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for disposal; flush large spills to containment area and reclaim (if possible) or await disposal. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** In soil, HCl will infiltrate moving faster in the presence of moisture. It may dissolve some soil matter, particularly those of a carbonate base will be neutralized to some degree and will be transported to groundwater. **Ecotoxicity Values:** Chronic plant toxicity = 100 ppm; injurious to irrigatable crops at 350 mg/L; trout, LC_{100}, 10 mg/L/24 hr shrimp, LC_{50}, 100 to 330 ppm/starfish, LC_{50}, 100 to 330 mg/L/48 hr; shore crab, LC_{50}, 240 mg/L/48 hr. **Disposal:** Neutralize to between 5.5 & 8.5 before disposal. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.23, *0.01N solution or higher*): No. D002, Characteristic of corrosivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per CWA, Sec. 311 (b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 50 ppm, use a cartridge respirator with acid gas cartridges, or any supplied-air respirator (SAR) or SCBA. For < 100 ppm, use any chemical cartridge respirator with a full facepiece and cartridge that protects against HCl inhalation, or any SAR or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polycarbonate, butyl rubber, polyvinyl chloride, and chlorinated polyethylene are recommended materials for PPE. Polyvinyl alcohol is not recommended. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area on a cement floor away from direct sunlight and heat sources. Use decanting pumps or pouring frames to minimize spillage during loading and unloading operations.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. HCl should be manufactured in closed systems. Pay close attention to leak detection. Aqueous scrubbers are used to control hydrogen chloride emissions from vent stacks and other sources. Workers shouldn't enter tanks previously containing HCl until they have been cleaned.

Administrative Controls: Consider preplacement and periodic medical exams of exposed workers with emphasis on the eyes, skin, and respiratory tract. Pulmonary function tests (FEV, FVC) are useful in determining lung disorders. Conduct difficult operations in fume hoods.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Hydrochloric acid, solution
DOT Hazard Class: 8
ID No.: UN1789
DOT Label: Corrosive
DOT Packing Group: II
Special provisions (172.102): A3, A6, B2, B15, N41, T9, T27

Packaging Authorizations
a) Exceptions: 173.154
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity limitations
a) Passenger, Aircraft, or Railcar: 1 L
b) Cargo Aircraft Only: 30 L

Vessel Stowage Requirements
a) Vessel Stowage: C
b) Other: 8

***MSDS Collection* References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 180

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Material Safety Data Sheet Collection

Methanol **MSDS No. 354**

Date of Preparation: 11/77 Revision: E, 3/98

Section 1 - Chemical Product and Company Identification

Product/Chemical Name: Methanol **Chemical Formula:** CH_4O or CH_3OH **CAS Number:** 67-56-1

Synonyms: carbinol; Coat-B1400; Colonial Spirits; Columbian Spirit; EPA pesticide chemical code 053801; methyl alcohol; methyl hydrate; methyl hydroxide; monohydroxymethane; pyroligneous spirit; pyroxylic spirit; pyroxylic spirits; Surflo-B17; wood alcohol; wood naphtha; wood spirit

Derivation: Prepared by wood pyrolysis; non-catalytic oxidation of hydrocarbons; as a by-product in the fisher-tropsch synthesis; or by reduction of carbon monoxide.

General Use: Used as an industrial solvent; starting material for organic synthesis; antifreeze for windshield washer fluid; in fuel antifreezes; gasoline octane booster; fuel for stoves; extractant for oils; denaturing ethanol; softening agent; food additive; in paint, varnish removers, and embalming fluids; in the manufacture of photographic film, celluloid, textile soap, wood stains, coated fabrics, shatterproof glass, paper coating, waterproofing formulations, artificial leather, dyes.

Vendors: Consult the latest *Chemical Week Buyers' Guide.* (73)

Section 2 - Composition / Information on Ingredients

Methanol, ca 100% vol
Trace Impurities (Grade A): Acetone and aldehydes < 30 ppm, acetic acid < 30 ppm

OSHA PELs
8- hr TWA: 200 ppm (260 mg/m^3)
Vacated 1989 Final Rule Limits:
TWA: 200 ppm (260 mg/m^3)
STEL: 250 ppm (325 mg/m^3)

ACGIH TLVs*
TWA: 200 ppm (262 mg/m^3), *Skin*
STEL: 250 ppm (328 mg/m^3)

NIOSH REL
10- hr TWA: 200 ppm (260 mg/m^3), *Skin*
STEL: 250 ppm (325 mg/m^3)

IDLH Level
6000 ppm

DFG (Germany) MAK
TWA: 200 ppm (260 mg/m^3), *Skin*
Category II, 1: Substances with systemic effects; onset of effect ≤ 2 hr; half life < 2 hr
Embryo/Fetus Risk of Damage Classification C†

Peak Exposure Limit:
400 ppm (520 mg/m^3), 30 min, average value, 4/shift

*There are also ACGIH Biological Exposure Indices (BEIs™).
†There is no reason to fear risk of damage to developing embryo or fetus when MAK or BAT values are observed.

Section 3 - Hazards Identification

ANSI Signal Word: Warning!

☆☆☆☆☆ Emergency Overview ☆☆☆☆☆

Methanol is a colorless liquid with a slight alcohol odor when pure, or disagreeably pungent odor when crude. It is irritating to the eyes, skin, and respiratory tract. Exposure may result in headache, visual disturbance, blindness, and respiratory failure. Reproductive effects have been reported in animal testing. This flammable liquid is a moderate explosion hazard. When heated to decomposition, methanol emits carbon oxides (CO_x), formaldehyde, acrid smoke, and irritating fumes.

Potential Health Effects

Primary Entry Routes: Inhalation, ingestion, skin and/or eye contact/absorption

Target Organs: Eyes, skin, central nervous system (CNS), gastrointestinal (GI) tract, respiratory system

Acute Effects

Inhalation: Irritation, breathing difficulty, headache, drowsiness, vertigo, light-headedness, nausea, vomiting, acidosis (decreased blood alkalinity), visual disturbance, and at high concentrations, CNS damage, convulsions, circulatory collapse, respiratory failure, coma and blindness can result from inhalation of methanol vapor. Concentration ≥ 200 ppm may cause headache; 50,000 ppm can cause death within 1-2 hrs. **Eye:** Contact with liquid may result in irritation, inflamed lids, light sensitization, and superficial lesions. **Skin:** Contact may cause irritation, dermatitis, swelling, scaling, and systemic effects listed under inhalation. **Ingestion:** GI irritation and systemic effects (see Inhalation). Symptoms may be delayed 18-48 hours. Fatal dose: 2-8 ounces.

Carcinogenicity: IARC, NTP, and OSHA do not list methanol as a carcinogen. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Chronic Effects:** Exposure to methanol vapors has caused conjunctivitis, headache, giddiness, insomnia, GI disturbance, impaired vision. CNS damage is also likely. Methanol is slowly eliminated from the body; exposure is considered cumulative over the short term.

Wilson Risk Scale

R	1
I	3
S	2*
K	3

*Skin absorption

HMIS

H	2*
F	3
R	0

PPE†

*Chronic effects
†Sec. 8

Section 4 - First Aid Measures

Inhalation: Remove exposed person to fresh air and support breathing as needed. **Eye Contact:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water for at least 15 minutes. Consult a physician or ophthalmologist if pain or irritation develops. **Skin Contact:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have the *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. ***After first aid, get appropriate in-plant, paramedic, or community medical support.***
Note to Physicians: Follow emesis with rehydration, correction of acidosis, and folate to enhance formate oxidation. Consider IV administration of ethanol (if blood methanol >20 mg/dL) to show metabolic oxidation of methanol. Assay formic acid in urine, blood pH and plasma bicarbonate.

Section 5 - Fire-Fighting Measures

Flash Point: 54 °F (12 °C) **Flash Point Method:** CC **Burning Rate:** 1.7 mm/min
Autoignition Temperature: 867 °F (464 °C) **LEL:** 6.0% v/v **UEL:** 36% v/v
Flammability Classification: OSHA Class IB Flammable Liquid.

Extinguishing Media: Use dry chemical, carbon dioxide, water spray, fog or alcohol-resistant foam. A water spray may be used to cool fire-exposed containers, and flush spills away from ignition sources.
Unusual Fire or Explosion Hazards: Can form explosive mixtures in the air. The heavier-than-air vapors of methanol may travel along low-lying surfaces to distant sources of ignition and flash back to the material source. Containers may explode in heat of fire. **Hazardous Combustion Products:** Heating methanol to decomposition can produce carbon oxides (CO_x), formaldehyde, acrid smoke, and irritating fumes. **Fire-Fighting Instructions:** *Do not* scatter material with any more water than needed to extinguish fire. *Do not* release runoff from fire control methods to sewers or waterways. **Fire-Fighting Equipment:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode.

NFPA

Section 6 - Accidental Release Measures

Spill /Leak Procedures: Isolate spill area for at least 330-660 feet (100-200 m) in all directions. Fully encapsulating, vapor protective clothing should be worn for spills and leaks with no fire. Eliminate all ignition sources (no smoking, flares, sparks or flames in immediate area). Ground all equipment used when handling this product. *Do not* touch or walk through spilled material. Stop leak if you can do it without risk. Prevent entry into waterways, sewers, basements or confined areas. A vapor suppressing foam may be used to reduce vapors. **Small Spills:** Absorb with earth, sand or other non-combustible material and transfer to containers for later disposal. Use clean non-sparking tools to collect absorbed material. **Large Spills, Containment:** Dike far ahead of liquid spill for later disposal. *Do not* release into sewers or waterways. **Cleanup:** Ground all equipment. Use non-sparking tools. **Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.120).

Section 7 - Handling and Storage

Handling Precautions: Avoid vapor inhalation, and skin and eye contact. Use only with ventilation sufficient to reduce airborne concentrations to non-hazardous levels (see Sec. 2). Wear protective gloves, goggles, and clothing (see Sec. 8). Keep away from heat and ignition sources. Ground and bond all containers during transfers to prevent static sparks. Use non-sparking tools to open and close containers. **Storage Requirements:** Store in tightly closed container in cool, well-ventilated area, away from heat, ignition sources and incompatibles (see Sec. 10). Equip drums with self-closing valves, pressure vacuum bungs, and flame arrestors. **Regulatory Requirements:** Follow applicable OSHA regulations (29 CFR 1910.106) for Class 1B Flammable Liquids.

Section 8 - Exposure Controls / Personal Protection

Engineering Controls: To prevent static sparks, electrically ground and bond all containers and equipment used in shipping, receiving, or transferring operations. **Ventilation:** Provide general or local exhaust ventilation systems to maintain airborne concentrations as low as possible. Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source. **Administrative Controls:** Enclose operations and/or provide local explosion-proof exhaust ventilation at the site of chemical release. Where possible, transfer methanol from drums or other storage containers to process containers. Minimize sources of ignition in surrounding areas. **Respiratory Protection:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations ≤ 2000 ppm, use a supplied air respirator; ≤ 5000 ppm, supplied air (SA) respirator in continuous flow mode; ≤ 6000 ppm, SA respirator with tight-fitting face mask operated in continuous flow mode, or SCBA with full facepiece, or SA respirator with full facepiece; > IDLH/unknown/emergency, SCBA with full facepiece operated in pressure-demand or other positive-pressure mode, or SA respirator with full facepiece operated in pressure-demand or other positive-pressure mode in combination with auxiliary SCBA operated in pressure-demand or other positive-pressure mode. For escape, use an appropriate escape-type SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Protective Clothing/Equipment:** Wear chemically protective gloves, boots, aprons, and gauntlets of butyl rubber, Teflon™, Viton™, Saranex™, 4H™, Responder™, Trellchem HPS™, or Tychem 10000™ (Breakthrough Time (BT) >8 hr) to prevent skin contact. Natural rubber, neoprene, nitrile rubber, polyethylene, polyvinyl alcohol and CPF 3™ may degrade after contact and are not recommended. Wear splash-proof chemical safety goggles, and face shield, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Contact lenses are not eye protective devices. Appropriate eye protection must be worn instead of, or in conjunction with contact lenses. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, washing facilities available in work area. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9 - Physical and Chemical Properties

Physical State: Liquid
Appearance and Odor: Colorless; slight alcohol odor when pure, disagreeably pungent odor when crude
Odor Threshold Range: 13.1150 to 26840 mg/m^3
Vapor Pressure: 127 mm Hg at 77 °F (25 °C)
Vapor Density (Air=1): 1.11
Saturated Vapor Density (air=1.2 kg/m^3, 0.075 lb./ft^3): 1.221 kg/m^3
Formula Weight: 32.04
Density: 0.796 g/mL at 59 °F (15 °C)
Specific Gravity (H_2O=1, at 4 °C): 0.81 at 0 °C/4 °C
Bulk Density: 6.59 lbs/gal at 68 F (20 °C)
pH: Slightly acidic
Water Solubility: Miscible
Other Solubilities: Ethanol, acetone, benzene, chloroform, DMSO, ether, ketones, most organic solvents.
Boiling Point: 148 °F (64.7 °C) at 760 mm Hg
Freezing Point: -144.04 °F (-97.8 °C)
Viscosity: 0.614 mPa sec
Refractive Index: 1.3292 at 68 °F (20 °C)/D
Surface Tension: 22.61 dynes/cm
Ionization Potential (eV): 10.84
Henry's Law Constant (H): 4.55 x10^{-6} atm-m^3/mole at 77 °F (25 °C)
Octanol/Water Partition Coefficient: log K_{ow} = -0.77
Soil Sorption Coefficient (log K_{oc}): 0.44

Section 10 - Stability and Reactivity

Stability: Methanol is stable at room temperature in closed containers under normal storage and handling conditions. **Polymerization:** Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include beryllium dihydride, metals (potassium, magnesium), oxidants (barium perchlorate, bromine, chlorine, hydrogen peroxide, sodium hypochlorite, phosphorus trioxide), potassium tertbutoxide, carbon tetrachloride and metals, chloroform and heat, diethyl zinc, alkyl aluminum salts, acetyl bromide, chloroform and sodium hydroxide, cyanuric chloride, nitric acid, chromic anhydride, lead perchlorate. **Conditions to Avoid:** Vapor inhalation, oxidizers. **Hazardous Decomposition Products:** Thermal oxidative decomposition of methanol can produce carbon oxides (CO_x), formaldehyde, acrid smoke, and irritating fumes.

Section 11- Toxicological Information

Toxicity Data:*

Reproductive Effects:

Rat (female), oral: 7500 mg/kg, administered during gestational days 17-19 produced effects on newborn - behavioral.
Rat (female), oral: 35295 mg/kg administered during gestational days 1-15 produced effects on the fertility index; pre-implantation mortality; and post-implantation mortality.
Rat (female), inhalation: 20000 ppm/7 hr, administered during gestational days 1-22 produced specific developmental abnormalities - musculoskeletal system; cardiovascular (circulatory) system; urogenital system.
Rat (male), oral: 200 ppm/20 hr, 78 weeks prior to mating produced paternal effects - testes, epididymis, sperm duct.

Multiple Dose Toxicity Data:

Rat, oral: 12 g/kg/8 weeks intermittently produced toxic effects: behavioral - ataxia; behavioral - alteration of operant conditioning.
Rat, inhalation: 50 mg/m^3/12 hr/13 weeks intermittently produced degenerative changes to brain and coverings; muscle contraction or spasticity.
Rat, inhalation: 2610 ppm/6 hr/4 weeks intermittently produced toxic effects: endocrine - changes in spleen weight.

Eye Effects:

Rabbit, standard Draize test: 100 mg/24 hr resulted in moderate irritation.

Section 11- Toxicological Information, continued

Toxicity Data:*

Skin Effects:
Rabbit, standard Draize test: 20 mg/24 hr resulted in moderate irritation.

Acute Oral Effects:
Human, oral, LD_{Lo}: 428 mg/kg produced toxic effects: behavioral - headache; lungs, thorax, or respiration - other changes.
Human, oral, LD_{Lo}: 143 mg/kg produced optic nerve neuropathy, dyspnea, nausea or vomiting.
Rat, oral, LD_{50}: 5628 mg/kg

Acute Dermal Effects:
Monkey, skin, LD_{Lo}: 393 mg/kg
Rabbit, skin, LD_{50}: 15800 mg/kg

Acute Inhalation Effects:
Human, inhalation, TC_{Lo}: 300 ppm produced visual field changes, headache; lungs, thorax, or respiration - other changes.
Rat, inhalation, LC_{50}: 64000 ppm/4 hr

Mutagenicity:
Human, lymphocyte: 300 mmol/L resulted in DNA inhibition.
Rat, oral: 10 µmol/kg resulted in DNA damage.

* See NIOSH, *RTECS* (PC1400000), for additional toxicity data.

Section 12 - Ecological Information

Ecotoxicity: Trout, LC_{50}: 8,000 mg/L/48 hr; *Pimephales promelas* (fathead minnow) LC_{50}: 29.4 g/L/96 hr.

Environmental Fate: Bioconcentration (BCF, estimated at 0.2) is not expected to be significant. Physical removal from air can occur via rainfall. Relatively rapid evaporation from dry surfaces is likely to occur.

Environmental Degradation: If released to the atmosphere, it degrades via reaction with photochemically produced hydroxyl radicals with an approximate half-life of 17.8 days. If released to water or soil, biodegradation is expected to occur.

Soil Adsorption/Mobility: A low Koc indicates little sorption and high mobility in the soil column.

Section 13 - Disposal Considerations

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

Section 14 - Transport Information

DOT Transportation Data (49 CFR 172.101):

Shipping Name: Methanol
Shipping Symbols: D
Hazard Class: 3
ID No.: UN1230
Packing Group: II
Label: FLAMMABLE LIQUID
Special Provisions (172.102): T*

Packaging Authorizations
a) **Exceptions:** 173.150
b) **Non-bulk Packaging:** 173.202
c) **Bulk Packaging:** 173.242

Quantity Limitations
a) **Passenger, Aircraft, or Railcar:** 1 L
b) **Cargo Aircraft Only:** 60 L

Vessel Stowage Requirements
a) **Vessel Stowage:** B
b) **Other:** 40

Section 15 - Regulatory Information

EPA Regulations:
Listed and Classified as a RCRA Hazardous Waste (40 CFR 261.33): Characteristic of Ignitability
RCRA Hazardous Waste Number: U154
Listed as a CERCLA Hazardous Substance (40 CFR 302.4) specific per (3) CAA, Sec. 112; (4) RCRA, Sec. 3001
CERCLA Final Reportable Quantity (RQ), 5000 lb (2268 kg)
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA EHS (Extremely Hazardous Substance) (40 CFR 355): Not listed

OSHA Regulations:
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1, Z-1-A)

Section 16 - Other Information

References: 1, 73, 99, 103, 124, 136, 149, 176, 190, 209, 216, 217, 218, 222, 223, 224, 227, 228, 230
Prepared By .... HM Spliethoff, MS
Industrial Hygiene Review .... PA Roy, MPH, CIH
Medical Review .... T Thoburn, MD, MPH

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Material Safety Data Sheets Collection:

Sheet No. 7
Nitric Acid

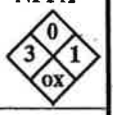
Issued: 10/88 Revision: D, 9/92

Section 1. Material Identification

39

Nitric Acid (HNO_3) Description: A solution of nitrogen dioxide in water commercially available in many concentrations. Derived by oxidation of ammonia by catalytic process (heated platinum catalyst); or by direct synthesis, combining atmospheric nitrogen and oxygen in an electric arc (an expensive process, thus largely abandoned). HNO_3 is usually found in conjunction with nitrogen dioxide, which is considered more hazardous. Used in fertilizer production (ammonium nitrate), in photoengraving, steel etching, explosives (TNT, nitroglycerin, trinitrophenol); manufacture of metallic nitrates, sulfuric acid, aqua regia and oxalic acid, jewelry, various dyes and dyestuffs, pharmaceuticals; as a laboratory reagent, in metallurgy (*mainly* as a pickling agent) and the printing industy.
Other Designations: CAS No. 7697-37-2, aqua fortis, aqua regia, azotic acid, engravers nitrate, hydrogen nitrate, red fuming nitric acid (RFNA), white fuming nitric acid (WFNA).
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for suppliers list.

Cautions: Nitric acid is a corrosive, strong oxidizer that causes irritation or severe burns to the skin, eyes, and respiratory tract. Exposures to high levels of the concentrated acid can be fatal. Increases the flammability of combustibles. Use extreme caution when handling HNO_3.

R	2	HMIS			**NFPA**
I	4	H	3*	*Fuming* nitric acid	
S	4	F	0		
K	0	R	1		
		PPE**			
R	2	HMIS			
I	4	H	3*	*> 40%* nitric acid	
S	4	F	0		
K	0	R	1		
		PPE**			
R	2	HMIS			
I	3	H	3*	*≤ 40%* nitric acid	
S	3	F	0		
K	0	R	0		
		PPE**			

* Chronic effects ** See Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Nitric acid, various %. Commercially available in nearly all concentrations; most common are 56 and 68%. RFNA (85%), WFNA (97.5%).

1991 OSHA PELs
8-hr TWA: 2 ppm (5 mg/m^3)
15-min STEL: 4 ppm (10 mg/m^3)

1990 IDLH Level
100 ppm

1990 NIOSH REL
8-hr TWA: 2 ppm (5 mg/m^3)
15-min STEL: 4 ppm (10 mg/m^3)

1992-93 ACGIH TLVs
TWA: 2 ppm (5.2 mg/m^3)
STEL: 4 ppm (10 mg/m^3)

1990 DFG (Germany) MAK
2 ppm (5 mg/m^3)
Category I: local irritants
Peak Exposure Limit: 2 ppm
5 min momentary value, 8 per shift

1985-86 Toxicity Data*
Man, unreported route, LD_{Lo}: 110 mg/kg; toxic effects not yet reviewed
Rat, oral, TD_{Lo}: 5275 g/kg administered from 1 to 21 days of pregnancy caused post-implantation mortality and specific developmental abnormalities of the musculoskeletal system.
Rat, inhalation, LC_{50}: 67 ppm (NO_2)/4 hr; toxic effects not yet reviewed

* See NIOSH, *RTECS* [QU5775000 (nitric acid), QU5900000 (RFNA), QU6000000 (WFNA)] , for additional reproductive and toxicity data.

Section 3. Physical Data

Boiling Point: 186.8 °F (86 °C)
Melting Point: -43.6 °F (-42 °C)
Vapor Pressure: 67% HNO_3 = 6.8 mm Hg at 68 °F (20 °C); 95 to 98% = 113 at 100.4 °F (38 °C)
Saturated Vapor Density (Air = 1.2 kg/m³): 1.212 kg/m^3 or 0.0757 lb/ft^3 (67 % HNO_3)
pH: 1

Molecular Weight: 63.02
Density: 1.50269 at 77/39.2 °F (25/4 °C)
Water Solubility: Soluble (releases heat)
Ionization Potential: 11.95 eV

Appearance and Odor: Transparent, clear to yellow, fuming liquid with an acrid, suffocating odor which darkens to a brownish color on aging and exposure to light. "Fuming" nitric acid is red-brown in color.

Section 4. Fire and Explosion Data

Flash Point: Noncombustible	**Autoignition Temperature:** Noncombustible	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fires (< 40% HNO_3), use dry chemical, carbon dioxide (CO_2), water spray, or regular foam. For large fires, use water spray, fog, or regular foam. For small fires (> 40% HNO_3), use water spray, dry chemical, or soda ash. For large fires, flood area with water (*do not* get inside HNO_3 containers). Apply water from as far a distance as possible.
Unusual Fire or Explosion Hazards: HNO_3 is noncombustible but is an oxidizer which increases fire involving combustibles and can initiate an explosion. It releases flammable hydrogen gas in contact with many metals.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing is not effective for fires involving nitric acid. Acid-resistant clothing is needed. Apply cooling water to sides of containers until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. *Do not* release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Nitric acid decomposes in air and in contact with light and organic matter. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Nitric acid reacts explosively with combustibles, organics or readily oxidizable materials such as wood, turpentine, metal powder and hydrogen sulfide, carbides, cyanides, and alkalies; causes spattering with strong bases; is corrosive to paper, cloth and most metals (except aluminum, gold, platinum, thorium, and tantalum. Will also attack some forms of plastics, rubber, and coatings. There are at least 150 chemicals and chemical combinations which are incompatible with nitric acid. HNO_3 reacts with water to produce heat and toxic corrosive fumes. Refer to *Genium* references 126 and 159 for further detail. **Conditions to Avoid:** Avoid exposure to moisture, heat, and incompatibles.
Hazardous Decomposition Products: Thermal oxidative decomposition of HNO_3 produces nitrogen peroxide and toxic, irritating nitrogen oxides.

Section 6. Health Hazards Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list nitric acid as a carcinogen.
Summary of Risks: Nitric acid is very corrosive to the skin, eyes, digestive and respiratory tract or any tissue it comes in contact with. 58 to 68% (nitric acid) vapors are moderately irritating and can't be tolerated at high concentrations. 95% (nitric acid) vapors cause severe irritation at very low levels and the liquid causes 2nd and 3rd degree burns on short contact with skin or eyes. Vapor inhalation may cause pulmonary edema (fluid in lungs) leading to death. HNO_3 vapor or mist can slowly corrode teeth when chronically exposed. **Medical Conditions Aggravated by Long-Term Exposure:** Chronic respiratory diseases. **Target Organs:** Eyes, skin, respiratory tract, teeth.

Continue on next page

Section 6. Health Hazard Data, continued

Primary Entry Routes: Inhalation, ingestion, skin and eye contact. **Acute Effects:** Inhalation symptoms may take several hours and include throat and nose irritation, cough, chest pain, difficulty breathing, salivation, giddiness, nausea, muscular weakness, ulceration of nasal mucous membranes, pulmonary edema, and chemical pneumonia. Skin contact is moderately irritating to severely corrosive depending on % of nitric acid. Burns may penetrate deeply causing ulcers. Skin may be stained yellowish brown. Dilute solutions cause irritation and tend to harden the epithelium (outer skin layer) without destroying it. HNO_3 liquid causes yellow discoloration of the eyes and severe burns which may result in permanent damage, i.e., sight loss. Ingestion produces immediate pain and digestive tract burns followed by throat swelling, convulsions, risk of stomach perforation (causing a rigid abdomen) and possible coma. **Chronic Effects:** Repeated inhalation of low concentrations may cause chronic bronchitis, tooth erosion, and/or appetite loss. Repeated exposure to $NO_{(x)}$ such as produced by thermal decomposition of HNO_3 is implicated in chronic lung diseases.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing (*do not force removal if stuck to skin*). Rinse with flooding amounts of water for at least 15 min. Apply a 5% triethanolamine solution to affected area. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute followed by lime milk or milk of magnesia. Do not induce vomiting. *Do not* give sodium bicarbonate or attempt to neutralize the acid.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Observe for several hours since symptoms such as pulmonary edema may be delayed.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel should wear fully-encapsulating vapor-protective clothing. Use water spray to cool and disperse vapor. Keep combustibles away from spilled material. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in dry containers for disposal. For large spill, flush with water to containment area and neutralize with agricultural (slaked) lime, sodium bicarbonate, crushed limestone, soda ash, or lime. Report any release in excess of 1000 lb. Control runoff and dike for disposal. Follow applicable OSHA regulations (29 CFR 1910.120).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a SARA Toxic Chemical (40 CFR 372.65)

Listed as a SARA Extremely Hazardous Substance (40 CFR 355), TPQ: 1000 lb

Listed as a RCRA Hazardous Waste (40 CFR 261.22): No. D001, Characteristic of corrosivity

Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311(b)(4)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Listed as a Process Safety Hazardous Chemical (29 CFR 1910.119), TQ: 500 lb

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact ns use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For < 50 ppm, use any supplied-air respirator operated in a continuous-flow mode. For < 100 ppm, use any supplied-air respirator or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear acid-proof gloves, boots, aprons, and gauntlets to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in aluminum, stainless steel, or glass containers on a cement floor in a cool, dry, well-ventilated area away from incompatibles (Sec. 5). Dike around storage tanks with large kirbs or stills to retain the acid in event of leakage. Keep neutralization agents on hand and install a fire hydrant in storage area. (See NFPA Code 43A). **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the eyes, skin, respiratory tract and teeth. Pulmonary function tests (FEV< FVC) are helpful. Educate workers about the hazardous properties of nitric acid.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: *, †, ‡, §, ¥, ψ, ϕ
DOT Hazard Class: 8

ID No.: UN1826 (*†), UN1796 (‡§), UN2031 (¥ψ), UN2032 (ϕ)
DOT Packing Group: I (†§¥ϕ), II (*‡ψ)

DOT Packaging Label: Corrosive (*‡¥ψ), Corrosive, Oxidizer (†§), Corrosive, Oxidizer, Poison (ϕ)
Special Provisions (172.102): B2, T12, T27 (*); T12, T27 (†); B2, T12, T27 (‡); T12, T27 (§); B12, B53, T9, T27 (¥); B2, B12, B53, T9, T27(ψ); 2, B9, B32, B74, T38, T43, T45(ϕ)

* Nitrating acid mixtures spent, < 50% HNO_3
† Nitrating acid mixtures spent, > 50% HNO_3
‡ Nitrating acid mixtures, < 50% HNO_3
§ Nitrating acid mixtures, > 50% HNO_3
¥ Nitric acid other than red fuming, > 70% HNO_3
ψ Nitric acid other than red fuming, < 70% HNO_3
ϕ Nitric acid, red fuming.

Packaging Authorizations
a) **Exceptions:** None
b) **Non-bulk Packaging:** 173.158 (*†‡§¥ψ), 173.227 (ϕ)
c) **Bulk Packaging:** 173.242 (*‡ψ), 173.243 (†§¥), 173.244(ϕ)

Quantity limitations
a) **Passenger Aircraft or Railcar:** Forbidden
b) **Cargo Aircraft Only:** 30L (*‡ψ), 2.5L (†§¥), Forbidden (ϕ)

Vessel Stowage Requirements
a) **Vessel stowage:** D
b) **Other:** 40(*); 40, 66, 89 (†); 40 (‡); 40, 66, 89 (§); 110, 111 (¥); 110, 111 (ψ); 40, 66, 74, 89, 90, 95 (ϕ)

MSDS Collection References: 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 136, 139, 140, 148, 149, 153, 159, 162, 163, 164, 167, 168, 171, 174, 175

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 3
Sodium Hydroxide

Issued: 10/77 Revision: C, 11/91

Section 1. Material Identification

36

Sodium Hydroxide (NaOH) Description: Derived by electrolysis of sodium chloride brines, by reacting calcium chloride with sodium carbonate, or by electrolytic production using the diaphragm cell. Sodium hydroxide often contains as impurities minimal amounts of sodium chloride, sodium carbonate, sodium sulfate, sodium chlorate, iron, or nickel. Used to hydrolyze fats and form soaps; in making plastics to dissolve casein; in treating cellulose to make rayon and cellophane; in explosives, dyestuffs, electrolytic extraction of zinc, reclaiming rubber, tin plating, oxide coating, etching and electroplating, laundering and bleaching, pulp and paper manufacture; in vegetable oil refining; in peeling of fruits and vegetables in the food industry; and in veterinary medicine as a disinfectant.

Other Designations: CAS No. 1310-73-2; Aetznatron; caustic soda; Collo-Grillrein; Collo-Tapette; Feurs Rohp; Lewis-Red Devil Lye; soda, hydrate; soda lye; sodium hydrate.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Sodium hydroxide is moderately toxic by ingestion and inhalation and can be seriously corrosive to eyes, skin, and mucous membranes.

R	0
I	2
S	4
K	0

NFPA

HMIS

H	3
F	0
R	1
PPG*	

* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Sodium hydroxide, ca 100%

1990 OSHA PEL
Ceiling: 2 mg/m³

1990 IDLH Level
250 mg/m³ (solution mists)

1991-92 ACGIH TLV
Ceiling: 2 mg/m³

1990 DFG (Germany) MAK
2 mg/m³

1990 NIOSH REL
Ceiling: 2 mg/m³

1985-86 Toxicity Data*
Rabbit, oral, LD_{Lo}: 500 mg/kg; no toxic effect noted
Rabbit, skin: 500 mg applied over 24 hr causes severe irritation
Mouse, intraperitoneal, LD_{50}: 40 mg/kg; toxic effects not yet reviewed

* See NIOSH, *RTECS* (WB4900000), for additional irritation, mutation, and toxicity data.

Section 3. Physical Data

Boiling Point: 2534 °F (1390 °C)
Melting Point: 605 °F (318.4 °C)
Vapor Pressure: 1 mm Hg at 1362 °F (739 °C)
pH (0.5% solution): 13
Molecular Weight: 40.01

Specific Gravity: 2.13 at 77 °F (25 °C)
Water Solubility: 1 g/0.9 ml water, 1 g/0.3 ml boiling water
Other Solubilities: 1 g/7.2 ml alcohol, 1 g/4.2 ml methanol, soluble in glycerol; insoluble in acetone and ether

Appearance and Odor: Odorless, hydroscopic (readily absorbs water) white flakes, cake, lumps, chips, pellets, or sticks.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Although noncombustible as a solid, when in contact with moisture or water sodium hydroxide can generate enough heat to ignite surrounding combustibles. If possible without risk, remove containers from area. Use extinguishing agents suitable for surrounding fire. For small fire, use dry chemical, carbon dioxide (CO_2), or regular foam. Avoid water spray since water reacts with sodium hydroxide to generate substantial heat. If you must use water, be sure it is as cold as possible. For large fires, use fog or regular foam.

Unusual Fire or Explosion Hazards: Sodium hydroxide may melt and flow when heated.

Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, wear fully protective clothing. Structural firefighters' protective clothing provides limited protection. Apply cooling water to fire-exposed sides of container until fire is well out. *Do not* splatter or splash this material. Stay away from ends of tanks. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Sodium hydroxide is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Violent polymerization can occur when in contact with acrolein or acrylonitrile. Since sodium hydroxide readily absorbs water and carbon dioxide from air, keep containers tightly closed.

Chemical Incompatibilities: Sodium hydroxide generates large amounts of heat when in contact with water and may steam and splatter. It reacts with mineral acids to form corresponding salts; reacts with weak-acid gases like hydrogen sulfide, sulfur dioxide, and carbon dioxide; ignites when in contact with cinnamaldehyde or zinc; and has exploded when exposed to a mixture of chloroform and methane. Sodium hydroxide can be very corrosive to metals such as aluminum, tin, and zinc as well as to alloys such as steel, and may cause formation of flammable hydrogen gas. An increase in temperature and pressure occurs in closed containers when sodium hydroxide is mixed with: acetic anhydride, glacial acetic acid, chlorohydrin, chlorosulfonic acid, ethylene cyanohydrin, glyoxal, oleum, 36% hydrochloric acid, 48.7% hydrofluoric acid, 70% nitric acid, or 96% sulfuric acid.

Conditions to Avoid: Avoid generation of sodium hydroxide dusts, and contact with water, metals, and the chemicals listed above.

Hazardous Products of Decomposition: Thermal oxidative decomposition of sodium hydroxide can produce toxic sodium oxide (Na_2O) and sodium peroxide (Na_2O_2) fumes.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list sodium hydroxide as a carcinogen (see Chronic Effects).

Summary of Risks: Sodium hydroxide is toxic by inhalation of dusts or mists, ingestion, or direct skin or eye contact. Damage is immediate and without prompt medical attention can become permanent. This strong, corrosive alkali dissolves any living tissue it contacts.

Medical Conditions Aggravated by Long-Term Exposure: None reported.

Target Organs: Eyes, digestive tract, respiratory system, and skin.

Primary Entry Routes: Ingestion, inhalation, and skin and eye contact.

Continue on next page

Section 6. Health Hazard Data, *continued*

Acute Effects: Ingestion causes immediate burning of mouth, esophagus, and stomach; painful swallowing; excessive salivation; edematous (excess fluid in surrounding tissue) lips, chin, tongue, and pharynx covered with exudate (fluid oozed from swollen tissue); esophageal edema (swelling from fluid buildup in esophagus walls that can prevent all swallowing within hours); possibly edematous, gelatinous, and necrotic (localized tissue death) mucous membranes; vomiting (sometimes coffee grounds-like material due to digestive hemorrhage); and rapid, faint pulse; and cold, clammy skin. Death results commonly from shock, asphyxia (oxygen loss due to interrupted breathing), or pneumonia by the second or third day after ingestion. Dust inhalation can cause many small burns, temporary hair loss (in nasal passages since sodium hydroxide breaks down keratin), and possibly pulmonary edema (fluid in lungs). Skin contact causes slippery, soapy feeling that is not usually painful for 3 min after contact—even though skin damage begins immediately. It causes burns, keratin (hair and nails) destruction, and intracellular edema (excess fluid in skin cells), with damage progressing to severe burns, tissue corrosion, deep ulcerations, and permanent scarring if not immediately washed off. The cornea begins to corrode on contact. Disintegration and sloughing of conjunctival and corneal epithelium may progress to temporary or permanent corneal opacification (cloudiness, becoming impervious to light) or symblepharon (adhesion of lid to eyeball).
Chronic Effects: Dermatitis may result from repeated exposure to dilute solutions. Cases of squamous cell carcinoma (malignant tumors of epithelial origin) of the esophagus are reported 12 to 42 years after sodium hydroxide ingestion, although it is unclear whether the cancer results from scar formation caused by tissue destruction or directly from the chemical's possible carcinogenicity.
FIRST AID: Emergency personnel should protect against contamination.
Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of cold water until transported to an emergency medical facility. *Do not* allow victim to keep eyes tightly shut. *Warning!* Although splashed directly in only one eye, sodium hydroxide may affect the other eye's sight if prompt medical attention is not received. Consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. *Be aware* that this substance can become very hot when in contact with water. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious and alert* person drink 1 to 2 glasses of water, followed by vinegar or fruit juice to neutralize the poison. *Do not induce vomiting!*
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Perform endoscopy in all suspected cases of sodium hydroxide ingestion. Perform blood analysis to determine if dehydration, acidosis, or other electrolyte imbalances have occurred.

Section 7. Spill, Leak and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate hazard area, deny entry, and stay upwind of spills. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Use water spray to disperse vapors, but do not spray directly on spills. For small dry spills, avoid excess dust generation by carefully scooping or vacuuming (with appropriate filter) into a suitable container (above 60 °C sodium hydroxide corrodes steel) for later disposal. For large dry spills, cover with plastic sheet or other impermeable layer and contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: Sodium hydroxide is not mobile in solid form, although it absorbs moisture very easily. Once liquid, sodium hydroxide leaches rapidly into soil, possibly contaminating water sources.
Environmental Degradation: Ecotoxicity values: TLm, mosquito fish, 125 ppm/96 hr (fresh water); TLm, bluegill, 99 mg/48 hr (tap water).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.22): Characteristic of corrosivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable
Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 311 (b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Select the respirator based on its suitability to provide adequate worker protection for the given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent any skin contact.
Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in dry, well-ventilated area away from water, acids, metals, flammable liquids, and organic halogens. Keep containers tightly closed since sodium hydroxide can decompose to sodium carbonate and carbon dioxide upon exposure to air. Since corrosion occurs easily above 140 °F (60 °C), do not store or transport sodium hydroxide in aluminum or steel containers at temperatures near this level. Store containers in rooms equipped with trapped floor drains, curbs, or gutters.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control hazardous contaminants and to maintain concentrations at the lowest practical level.
Other Precautions: Consider preplacement and periodic medical examinations of exposed workers that emphasize eyes, skin, and respiratory tract. Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Inform employees of the possible hazards in using sodium hydroxide.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Sodium hydroxide; dry, solid, flake, bead *or* granular
DOT Hazard Class: Corrosive material
ID No.: UN1823
DOT Label: Corrosive
DOT Packaging Exceptions: 173.244
DOT Packaging Requirements: 173.245b

IMO Shipping Name: Sodium hydroxide, solid
IMO Hazard Class: 8
ID No.: UN1823
IMO Label: Corrosive
IMDG Packaging Group: II

MSDS Collection References: 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 143, 146, 148, 149, 153, 159, 161, 163
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** ER O'Connor, MS

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Material Safety Data Sheets Collection:

Sheet No. 3A
Sodium Hydroxide, 50% Liquid

Issued: 10/77 Revision: B, 11/91

Section 1. Material Identification

36

Sodium Hydroxide, 50% Liquid (NaOH), Description: Derived by electrolysis of sodium chloride brines, by reacting calcium chloride with sodium carbonate, or by electrolytic production using the diaphragm cell. Sodium hydroxide often contains minimal amounts of sodium chloride, sodium carbonate, sodium sulfate, sodium chlorate, iron, or nickel. Used in making plastics to dissolve casein; in treating cellulose in making rayon and cellophane; in explosives, dyestuffs, electrolytic extraction of zinc, reclaiming rubber, tin plating, oxide coating, etching and electroplating, laundering and bleaching, pulp and paper manufacture; in vegetable oil refining; in peeling fruits and vegetables in the food industry; to hydrolyze fats and form soaps; and in veterinary medicine as a disinfectant.

R 0
I 2
S 4
K 0

NFPA

Other Designations: CAS No. 1310-73-2; Aetznatron; Collo-Grillrein; Collo-Tapette; Feurs Rohp; Lewis-Red Devil Lye; soda lye; soda, lye solution; sodium hydrate solution; sodium hydroxide solution; white caustic solution.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Sodium hydroxide is moderately toxic by ingestion and inhalation and can be seriously corrosive to eyes, skin, and mucous membranes.

HMIS
H 3
F 0
R 1
PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Sodium hydroxide, ca 50% water solution

1990 OSHA PEL
Ceiling: 2 mg/m³

1991-92 ACGIH TLV
Ceiling: 2 mg/m³

1990 DFG (Germany) MAK
2 mg/m³

1990 IDLH Level
250 ppm

1990 NIOSH REL
Ceiling: 2 mg/m³

1985-86 Toxicity Data*
Monkey, eye: 1% solution applied over 24 hr produced severe irritation
Rabbit, eye: 1% solution applied to the eye caused severe irritation
Grasshopper, parenteral: 20 µl produced cytogenic mutations

* See NIOSH, *RTECS* (WB4905000), for additional irritation, mutation and toxicity data.

Section 3. Physical Data

Boiling Point: 284 °F (140 °C)
Freezing Point: 53.6 °F (12 °C)
Viscosity: 50 cP at 68 °F (20 °C)
pH (0.5 % solution): 13

Molecular Weight: 40.01
Specific Gravity: 1.53 at 77 °F (25 °C)
Water Solubility: Completely soluble in water
Other Solubilities: Soluble in alcohol, methanol and glycerol; insoluble in acetone and ether

Appearance and Odor: An odorless, clear liquid.

Section 4. Fire and Explosion Data

Flash Point: None reported	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Although noncombustible, when in contact with moisture or water sodium hydroxide, 50% liquid, can generate enough heat to ignite surrounding combustibles. If possible without risk, remove containers from area. Use extinguishing agents suitable for surrounding fire. For small fire, use dry chemical, carbon dioxide (CO_2), or regular foam. Avoid using water spray since water reacts with sodium hydroxide to generate substantial heat. If you must use water, be sure it is as cold as possible. For large fires, use fog or regular foam.
Unusual Fire or Explosion Hazards: Sodium hydroxide solution can become very hot when in contact with water.
Special Fire-fighting Procedures: Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Also, wear fully protective clothing. Structural firefighters' protective clothing provides limited protection. Apply cooling water to sides of fire-exposed containers until fire is well out. *Do not* splatter or splash this material. Stay away from ends of tanks. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Sodium hydroxide solution is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Violent polymerization can occur when in contact with acrolein or acrylonitrile. Since sodium hydroxide readily absorbs water and carbon dioxide from air, keep containers tightly closed.
Chemical Incompatibilities: Since it generates large amounts of heat when in contact with water, sodium hydroxide may steam and splatter. It reacts with mineral acids to form corresponding salts, and with weak-acid gases like hydrogen sulfide, sulfur dioxide and carbon dioxide. Sodium hydroxide can be very corrosive to metals such as aluminum, tin, and zinc, as well as alloys such as steel, and may cause formation of flammable hydrogen gas. An increase in temperature and pressure occurs in closed containers when sodium hydroxide is mixed with acetic anhydride, glacial acetic acid, chlorohydrin, chlorosulfonic acid, ethylene cyanohydrin, glyoxal, oleum, 36% hydrochloric acid, 48.7% hydrofluoric acid, 70% nitric acid, or 96% sulfuric acid.
Conditions to Avoid: Avoid generation of sodium hydroxide mists, and contact with water, metals, and the chemicals listed above.
Hazardous Products of Decomposition: Thermal oxidative decomposition of sodium hydroxide can produce toxic sodium oxide (Na_2O) and peroxide (Na_2O_2) fumes.

Section 6. Health Hazard Data

Carcinogenicity: In 1990 reports, the IARC, NTP, and OSHA do not list sodium hydroxide as a carcinogen (see Chronic Effects).
Summary of Risks: Sodium hydroxide solution is toxic by mist inhalation, ingestion, or direct skin or eye contact. Damage is immediate and without prompt medical attention can become permanent. This strong, corrosive alkaline solution dissolves any living tissue it contacts.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Eyes, digestive tract, respiratory system, and skin.
Primary Entry Routes: Ingestion, inhalation, and skin and eye contact.
Acute Effects: Ingestion causes immediate burning of mouth, esophagus, and stomach; painful swallowing; excessive salivation; edematous (excess fluid in surrounding tissue) lips, chin, tongue, and pharynx covered with exudate (fluid oozed from swollen tissue); esophageal edema (swelling from fluid buildup in esophagus walls that can prevent swallowing within hours); edematous, gelatinous, and necrotic (localized tissue

Continue on next page

Section 6. Health Hazard Data, *continued*

death) mucous membranes; vomiting (sometimes coffee grounds-like material due to digestive hemorrhage); rapid, faint pulse; and cold, clammy skin. Death commonly occurs due to shock, asphyxia (oxygen loss due to interrupted breathing), or pneumonia by the second or third day after ingestion. Mist inhalation can cause many burns, temporary hair loss (in nasal passages since sodium hydroxide breaks down keratin), and possibly pulmonary edema (fluid in lungs). Skin contact causes slippery, soapy feeling that is usually not painful for 3 min after contact—even though skin damage begins immediately. It causes burns, keratin (hair and nails) destruction, and intracellular edema (excess fluid in skin cells), with damage progressing to severe burns, tissue corrosion, deep ulcerations, and permanent scarring if not washed off immediately. The cornea begins to corrode on contact. Disintegration and sloughing of conjunctival and corneal epithelium may progress to temporary or permanent corneal opacification (cloudiness, becoming impervious to light) or symblepharon (adhesion of lid to eyeball).

Chronic Effects: Dermatitis may result after repeated exposure to dilute solutions. Cases of squamous cell carcinoma (malignant tumors of epithelial origin) of the esophagus are reported 12 to 42 years after ingestion, although it is unclear whether the cancer resulted from scar formation caused by tissue destruction or directly from the chemical's possible carcinogenicity.

FIRST AID: Emergency personnel should protect against contamination.

Eyes: Gently lift the eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to keep his eyes tightly shut. *Warning!* Although splashed in only one eye, sodium hydroxide may affect the other eye's sight if prompt medical attention is not received. Consult a physician immediately.

Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of cold water for at least 15 min. *Be aware* that this substance can become very hot when in contact with water. For reddened or blistered skin, consult a physician. Wash affected area with soap and water.

Inhalation: Remove exposed person to fresh air and support breathing as needed.

Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have that *conscious and alert* person drink 1 to 2 glasses of water followed by vinegar or fruit juice to neutralize the poison. *Do not* induce vomiting.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: Perform endoscopy in all suspected cases of sodium hydroxide ingestion. Perform blood analysis to determine if dehydration, acidosis, or other electrolyte imbalances have occurred.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate hazard area, deny entry, and stay upwind of spills. Cleanup personnel should protect against vapor inhalation and skin or eye contact. Use water spray to disperse vapors but do not spray directly on spills. Absorb small liquid spills with fly ash or cement powder. Neutralize spill with vinegar or dilute acid. Perlite and Cellosolve WP 3H (hydroxyethyl cellulose) are recommended for vapor suppression and containment of 50% sodium hydroxide solutions. Place material in suitable container (sodium hydroxide corrodes steel at temperatures above 60 °C) for later disposal. For large wet spills, dike flow using soil, sand bags, foamed polyurethane, or foamed concrete to contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120).

Environmental Transport: In solid form, sodium hydroxide is not mobile, although it very easily absorbs moisture. Once liquid, sodium hydroxide rapidly leaches into the soil, possibly contaminating water sources.

Environmental Degradation: Ecotoxicity values (as 100% NaOH): TLm, mosquito fish, 125 ppm/96 hr (fresh water); TLm, bluegill, 99 mg/48 hr (tap water).

Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.22): Characteristic of corrosivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 1000 lb (454 kg) [* per Clean Water Act, Sec. 311 (b)(4)]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations

Sodium hydroxide is listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Since contact lens use in industry is controversial, establish your own policy.

Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Select the respirator based on its suitability to provide adequate worker protection for the given working conditions, level of ariborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.*

Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent any skin contact.

Ventilation: Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL and IDLH values (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)

Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.

Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.

Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Avoid physical damage to containers. Store in dry, well-ventilated area away from water, acids, metals, flammable liquids and organic halogens. Keep containers tightly closed since sodium hydroxide can decompose to sodium carbonate and carbon dioxide upon exposure to air. Since corrosion occurs easily above 140 °F (60 °C), do not store or transport in aluminum or steel containers when temperatures are near this level. Store containers in rooms equipped with trapped floor drains, curbs, or gutters.

Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control hazardous airborne contaminants and to maintain concentrations at the lowest practical level.

Other Precautions: Institute preplacement and periodic medical exams of exposed workers emphasizing the eyes, skin and respiratory tract. Consider a respiratory protection program that includes regular training, maintenance, inspection, and evaluation. Educate employees to the possible hazards in using sodium hydroxide.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Sodium hydroxide, liquid *or* solution
DOT Hazard Class: Corrosive material
ID No.: UN1824
DOT Label: Corrosive
DOT Packaging Exceptions: 173.244
DOT Packaging Requirements: 173.249

IMO Shipping Name: Sodium hydroxide, solution
IMO Hazard Class: 8
ID No.: UN1824
IMO Label: Corrosive
IMDG Packaging Group: II

MSDS Collection References: 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 143, 146, 148, 149, 153, 159, 161, 163

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 9
Sulfuric Acid, Concentrated

Issued: 10/77 Revision: D, 9/92

Section 1. Material Identification

Sulfuric Acid Concentrated (H_2SO_4) Description: Prepared by the "Cat-Ox" process; by the contact process (vanadium pentoxide catalyst) with sulfur, pyrite (FeS_2), hydrogen sulfide, or sulfur-containing smelter gases; and from gypsum (calcium sulfate). Sulfuric acid is by far the most widely used industrial chemical. Its uses include: in the manufacture of fertilizers, chemicals, nitrate explosives, parchment paper, glue, dyes and pigments; as an etchant, a lab reagent, an electrolyte in lead/acid batteries, a dehydrating agent in the manufacture of ethers and esters, and an alkylation catalyst; in the purification of petroleum, the refining of mineral and vegetable oils, the leather industry, the carbonization of wool fabrics, the recuperation of fatty acids from soapworks waste water, the production of rayon and film, the extraction of uranium from pitchblende, and pickling of metal; in electroplating baths, gas drying and nonferrous metallurgy; and to obtain glucose by the hydrolysis of cellulose.

Other Designations: CAS No. 7664-93-9, battery acid, BOV, Caswell No 815, dipping acid, electrolyte acid, hydrogen sulfate, matting acid, oil of vitriol, sulphuric acid, vitriol brown oil.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Handle concentrated sulfuric acid with extreme caution because it is corrosive to all body tissues. Vapor inhalation can cause severe lung damage. Skin or eye contact can produce severe burns; blindness may result.

R	1
I	3
S	4
K	0

NFPA

HMIS	
H	3*
F	0
R	2
PPE†	

* Chronic effects
† Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Sulfuric acid concentrated, 93-98% sulfuric acid; remainder is water. Impurities include nonvolatiles, 0.02-0.03 ppm; SO_2, 40-80 ppm; iron, 50-100 ppm; nitrate, 5-20 ppm.

1991 OSHA PEL
8-hr TWA: 1 mg/m^3

1990 IDLH Level
80 mg/m^3

1990 NIOSH REL
TWA: 1 mg/m^3

1992-93 ACGIH TLVs
TWA: 1 mg/m^3
STEL: 3 mg/m^3

1990 DFG (Germany) MAK
TWA: 1 mg/m^3
Category: Local irritants
Peak: 2 mg/m^3, 5 min, momentary value †, 8 peaks per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 3 mg/m^3 for 24 weeks; toxic effects not yet reviewed.
Man, unreported route, LD_{Lo}: 135 mg/kg; toxic effects not yet reviewed.
Rat, oral, LD_{50}: 2140 mg/kg; toxic effects not yet reviewed.
Rabbit, eye: 100 mg rinse produced severe irritation.

* See NIOSH, *RTECS* (WS5600000), for additional toxicity data.
† The momentary value is a level which the concentration should never exceed.

Section 3. Physical Data

Boiling Point: 554 °F (290 °C); decomposes at 644 °F (340 °C) into sulfur trioxide and water.
Melting Point (100%): 50.65 °F (10.36 °C)
Vapor Pressure: <0.001 mm Hg at 20 °C
Saturated Vapor Density (air = 1.2 kg/m^3): 1.2 kg/m^3, 0.075 lbs/ft^3
pH: 1 N sol = 0.3, 0.1 N sol = 1.2, 0.01 N sol = 2.1
Molecular Weight: 98.08
Density/Specific Gravity (96-98%): 1.841
Water Solubility: Soluble; reacts!*
Other Solubilities: Ethyl alcohol
Odor Threshold: 0.150 ppm

Appearance and Odor: Colorless (pure) to dark brown (impure), odorless, dense, oily liquid. Pure compound is a solid below 51 °F (11 °C).

* Sulfuric acid reacts violently with water with the evolution of heat. *Always add the acid to water or other diluent, not the water to acid!*

Section 4. Fire and Explosion Data

Flash Point: Not combustible	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: Use extinguishing media appropriate to surrounding fire. Only use water if absolutely necessary and use with great caution. Water applied directly to sulfuric acid results in violent heat liberation and splattering of the material. Use water spray only to keep fire-exposed containers cool. **Unusual Fire or Explosion Hazards:** Sulfuric acid, a strong dehydrating agent, reacts with organic materials and produces enough heat ignition, chars wood, and may cause ignition of finely divided materials on contact. Reaction with metals may produce highly flammable, hydrogen gas. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing is *not* effective. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Sulfuric acid is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include acetic acid; acetone cyanohydrin; (acetone + nitric acid); (acetone + potassium dichromate); acetonitrile; acrolein; acrylonitrile; acrylonitrile + water; (alcohol + hydrogen peroxide); allyl alcohol; allyl chloride; ammonium hydroxide; 2-amino ethanol; ammonium; triperchromate; aniline; (bromates + metals); bromine pentafluoride; *n*-butyraldehyde; carbides; cesium acetylene carbide; chlorates; (chlorates + metals); chlorine trifluoride; chlorosulfonic acid; cuprous nitride; diisobutylene; (dimethylbenzylcarbinol + hydrogen peroxide); epichlorohydrin; ethylene cyanohydrin; ethylene diamine; ethylene glycol; ethylene imine; fulminates; hydrochloric acid; hydrogen; iodine heptafluoride; (indene + nitric acid); iron; isoprene; lithium silicide; mercuric nitride; mesityl oxide; powdered metals; (nitric acid + glycerides); *p*-nitrotoluene; pentasilver trihydroxydiaminophosphate; perchlorates; perchloric acid; (permanganates + benzene); (1-phenyl-2-methylpropryl alcohol + hydrogen peroxide); phosphorus; phosphorus isocyanate; picrates; potassium *tert*-butoxide; potassium chlorate; (potassium permanganate + potassium chloride); (potassium permanganate + water); beta-propiolactone; propylene oxide; pyridine; rubidium acetylene carbide; silver permanganate; sodium; sodium carbonate; sodium chlorate; sodium hydroxide; steel; styrene monomer; (toluene + nitric acid); vinyl acetate; and water. **Conditions to Avoid:** Water, combustibles, heat, ignition sources, and other incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of sulfuric acid can produce sulfur oxides.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list sulfuric acid as a carcinogen. However, a number of studies have associated exposures to sulfuric acid or to acid mists in general with laryngeal cancer. In 50 confirmed cases there was an approximately four-fold increased risk among highly exposed individuals relative to matched controls. It is not known if sulfuric acid can act as a direct carcinogen, as a promoter, or in combination with other substances. (167) **Summary of Risks:** Concentrated sulfuric acid is a severe respiratory tract, skin, and eye irritant.

Continue on next page

Section 6. Health Hazard Data, *continued*

Exposure can result in severe burns, tissue damage, scarring, functional inhibition, and blindness if splashed in the eye. Although ingestion is unlikely, it may cause severe injury and death. **Medical Conditions Aggravated by Long-Term Exposure:** Chronic respiratory, gastrointestinal, nervous, skin or eye diseases. **Target Organs:** Respiratory system, eyes, skin, and teeth. **Primary Entry Routes:** Inhalation, skin and eye contact. **Acute Effects:** Vapor or mist inhalation causes coughing, sneezing, nose irritation and nose bleeds, reflex bronchospasm, shortness of breath, pulmonary edema (fluid in lungs), emphysema, and permanent changes in pulmonary function. Ingestion causes corrosion of the mucous membranes of mouth, throat, and esophagus; and epigastric pain with nausea and vomiting of mucoid and "coffee ground" material. Skin contact produces severe burns; initially the zone of contact is bleached and turns brown prior to the formation of a clearly defined ulcer. These wounds are slow in healing and may cause extensive scarring that results in functional inhibition. If burns are extensive, the outcome may prove fatal. Circulatory collapse with clammy skin, weak and rapid pulse, shallow respirations, and scanty urine may follow ingestion or skin contact. Circulatory shock is often the immediate cause of death. Eye contact produces deep corneal ulceration, kerato-conjunctivitis, palpebral lesions, and possible blindness. **Chronic Effects:** Chronic effects may include dental erosion, conjunctivitis, tracheobronchitis, emphysema, stomatitis (inflammation of the mouth mucous membranes), gastritis (inflammation of stomach mucous membranes), and dermatitis. **FIRST AID Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Use a 2% sodium bicarbonate solution to further neutralize any H_2SO_4 on the skin. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water or milk to dilute. *Do not* induce vomiting! Do not attempt to neutralize the acid with sodium bicarbonate. **Note to Physicians:** Monitor arterial blood gases, chest x-ray, and pulmonary function tests if respiratory tract irritation or respiratory depression is evident. Treat dermal irritation or burns with standard topical therapy.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill, evacuate all unnecessary personnel, remove all ignition sources, and provide adequate ventilation. Cleanup personnel should wear fully-encapsulating, vapor-protective clothing to protect against inhalation and skin or eye contact. Keep water and combustibles away from release. Stop or control leak if this can be done without undue risk. Neutralize small spills with sodium bicarbonate or a mixture of soda ash/slaked lime (50/50) and place into sealed containers for disposal. If a neutralizing agent is not available, absorb spilled sulfuric acid with vermiculite, dry sand, or earth. *Never* use organic material (e.g., sawdust) to absorb spill. For large spills, dike far ahead to contain for later disposal. Follow applicable OSHA regulations (29 CFR 1910.120). Report any release in excess of 1000 lbs. **Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Neutralize waste water pH between 5.5 and 8.5. Follow applicable Federal, state, and local regulations.

Aquatic Toxicity: LC_{50} (saltwater, prawns): 42.5 ppm for 48 hrs; lethal (freshwater, bluegill): 24.5 ppm/24 hr.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): Characteristic of corrosivity
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311(b)(4)]
Listed as a SARA Extremely Hazardous Substance (40 CFR 355), TPQ: 1000 lbs.
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations < 25 mg/m^3 use any powered, air-purifying respirator with acid gas cartridge(s) in combination with a high-efficiency particulate filter. For concentrations < 50 mg/m^3, use any chemical cartridge respirator with a full facepiece and acid gas cartridge(s) in combination with a high-efficiency particulate filter. For concentrations < 80 mg/m^3, use any supplied air-respirator with a full facepiece and operated in pressure-demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. H_2SO_4 has a minor to moderate effect on neoprene or rubber.(131) **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in clearly labelled, steel containers in a cool [below 50 °F (10 °C)], dry, well-ventilated location on an acid-resistant cement floor and away from direct sunlight, combustibles, and other reactive materials. Separate from carbides, chlorates, fulminates, nitrates, picrates, and powdered metals. Protect storage containers against damage and water. Use non-sparking tools near sulfuric acid carboys, drums, tank cars, or metal storage tanks because of the possible production of hydrogen during storage. Use hand pumps for the decanting and emptying of carboys. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Total enclosures of processes and the mechanization of handling procedures are the most effective measures to prevent contact with sulfuric acid. Protect electrical installations against the corrosive action of acid vapors. **Administrative Controls:** Consider preplacement and periodic physical examinations with emphasis on the respiratory tract (including pulmonary function tests), skin, eyes, and teeth.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Sulfuric acid
DOT Hazard Class: 8
ID No.: UN1830
DOT Packaging Group: II
DOT Label: Corrosive
Special Provisions (172.102): A3, A7, B2, B83, B84, N34, T9, T27

Packaging Authorizations
a) **Exceptions:** 173.154
b) **Non-bulk Packaging:** 173.202
c) **Bulk Packaging:** 173.242

Quantity Limitations
a) **Passenger, Aircraft, or Railcar:** 1L
b) **Cargo Aircraft Only:** 30L

Vessel Stowage Requirements
a) **Vessel Stowage:** C
b) **Other:** 14

MSDS Collection **References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 131, 132, 139, 140, 148, 149, 153, 159, 163, 164, 167, 171, 174, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MPH

MATERIAL SAFETY DATA SHEET

DATE PREPARED: August 5, 1987 **DATE REVISED:**

SECTION I PRODUCT AND MANUFACTURER

15-177-25

PRODUCT NAME: YSI 3682 Zobell Solution

CHEMICAL NAME AND SYNONYMS: None

MANUFACTURED BY: Yellow Springs Instrument Company, Inc.
1725 Brannum Lane, P.O. Box 279
Yellow Springs, Ohio 45387
Telephone (513) 767-7241 Telex 20-5437

SECTION II INGREDIENTS

Hazardous Ingredients	Percent	Occupational Exposure Limits TLV	PEL
none			

Non-Hazardous Ingredients

Potassium Chloride	75
Potassium Ferrocyanide Trihydrate	14
Potassium Ferricyanide	11

SECTION III PHYSICAL DATA

Lemon Yellow Powder with Red Flecks

SECTION IV FIRE AND EXPLOSION HAZARD DATA

Wear self contained breathing apparatus and protective clothing to prevent contact with skin and eyes. Extinguishing media: H_2O spray; CO_2; dry chemical powder; alcohol foam. Dangerous when heated to decomposition. Emits toxic fumes of cyanide under these conditions.

SECTION V HEALTH HAZARD DATA

IRRITANT: May be harmful by inhalation, ingestion, skin absorption.

FIRST AID: In case of contact, flush eyes with copious amounts of water for at least 15 minutes. Wash skin with soap and water. Get medical attention. If inhaled remove to fresh air. If breathing has stopped, give artificial respiration; if breathing is difficult, give oxygen. Get medical attention. If ingested, induce vomiting if victim is conscious. Get medical attention.

SECTION VI REACTIVITY DATA

Will react with acids or acid fumes to form toxic gases. Avoid contact with strong oxidizing agents and chromium trioxide, chromium anhydride, sodium nitrate, and other metal cyanides. May be explosive when mixed with ammonia.

SECTION VII SPILL OR LEAK PROCEDURES

Wear personal protective equipment to prevent inhalation or contact. Sweep up, place in container and hold for waste disposal. Avoid raising dust. Wash spill site with water.

Dispose in accordance with local, state, and federal regulations.

SECTION VIII SPECIAL INFORMATION

Use with ventilation adequate to prevent inhalation of dust. Avoid contact with eyes, skin, and clothing. Wash thoroughly after handling.

SECTION IX SPECIAL PRECAUTIONS

Store in cool dry place. Avoid contact with acids, and oxidizing agents. Keep tightly closed.

NOTE:
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Material Safety Data Sheets Collection:

Sheet No. 385
Ethylbenzene

Issued: 8/78 Revision: B, 9/92

Section 1. Material Identification

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Ethylbenzene ($C_6H_5C_2H_5$) Description: Derived by heating benzene and ethylene in presence of aluminum chloride with subsequent distillation, by fractionation directly from the mixed xylene stream in petroleum refining, or dehydrogenation of naphthenes. Used as a solvent, an antiknock agent in gasoline; and as an intermediate in production of synthetic rubber, styrene, cellulose acetate, diethylbenzene, acetophenone, ethyl anthraquinone, propyl oxide, and α-methylbenzol alcohol.

Other Designations: CAS No. 100-41-4, ethylbenzol, EB, phenylethane, NCI-C56393.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

R 1
I 3
S 2*
K 4
* Skin absorption

NFPA

HMIS
H 2†
F 3
R 0
PPE - Sec. 8
† Chronic effects

Cautions: Ethylbenzene is a skin and mucous membrane irritant considered the most irritating of the benzene series. Inhalation causes acute and chronic central nervous system (CNS) effects. It is highly flammable and forms explosive mixtures with air.

Section 2. Ingredients and Occupational Exposure Limits

Ethylbenzene, ca >99.0%. Impurities include ~ 0.1% *meta & para* xylene, ~ 0.1% cumene, and ~ 0.1% toluene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 125 ppm (545 mg/m^3)
Action Level: 50 ppm (217 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH REL
TWA: 100 ppm (435 mg/m^3)
STEL: 125 ppm (545 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 125 ppm (545 mg/m^3)

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category 1: local irritants
Peak Exposure Limit: 200 ppm, 5 min momentary value, max of 8/shift
Danger of cutaneous absorption

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 100 ppm/8 hr caused eye effects, sleep, and respiratory changes.
Human, lymphocyte: 1 mmol/L induced sister chromatid exchange.
Rat, oral, LD_{50}: 3500 mg/kg; toxic effects not yet reviewed
Rat (female), inhalation, TC_{Lo}: 1000 ppm/7 hr/day, 5 days/wk, for 3 wk prior to mating and daily for 19 days of gestation produced pups with high incidence of extra ribs.[179]

* See NIOSH, *RTECS* (DA0700000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 277 °F (136 °C)
Melting Point: -139 °F (-95 °C)
Surface Tension: 31.5 dyne/cm
Ionization Potential: 8.76 eV
Viscosity: 0.64 cP at 77 °F (25 °C)
Refraction Index: 1.4959 at 68 °F (20 °C)
Relative Evaporation Rate (ether = 1): 0.0106
Bulk Density: 7.21 lb/Gal at 77 °F (25 °C)
Critical Temperature: 651 °F (343.9 °C)
Critical Pressure: 35.6 atm
Molecular Weight: 106.16
Density: 0.863 at 77 °F (25 °C)
Water Solubility: Slightly, 14 mg/100 mL at 59 °F (15 °C)
Other Solubilities: Miscible in alcohol, ether; soluble in carbon tetrachloride, benzene, sulfur dioxide, and many organic solvents; insoluble in ammonia
Odor Threshold: 2.3 ppm
Vapor Pressure: 7.1 mm Hg at 68 °F (20 °C); 10 mmHg at 78.62 °F (25.9 °C); 100 mm Hg 165.38 °F (74.1 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0768 lb/ft^3 or 1.2298 kg/m^3

Appearance and Odor: Colorless, flammable liquid with a pungent odor.

Section 4. Fire and Explosion Data

Flash Point: 64 °F (18 °C) CC	**Autoignition Temperature:** 810 °F (432 °C)	**LEL:** 1.0% v/v	**UEL:** 6.7% v/v

Extinguishing Media: Class 1B Flammable liquid. For small fires, use dry chemical, carbon dioxide, or 'alcohol-resistant' foam. For large fires, use fog or 'alcohol-resistant' foam. Use water only if other agents are unavailable; EB floats on water and may travel to an ignition source and spread fire. **Unusual Fire or Explosion Hazards:** Burning rate = 5.8 mm/min. Vapors may travel to an ignition source and flash back. Container may explode in heat of fire. EB poses a vapor explosion hazard indoors, outdoors, and in sewers. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Cool container sides with water until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from area and let fire burn. Withdraw immediately if you hear rising sound from venting safety device or notice any tank discoloration due to fire. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Ethylbenzene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: Reacts vigorously with oxidizers.
Conditions to Avoid: Exposure to heat and oxidizers.
Hazardous Products of Decomposition: Thermal oxidative decomposition of EB can produce acrid smoke and irritating fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,[164] NTP,[169] and OSHA[164] do not list EB as a carcinogen. **Summary of Risks:** Occupational exposure to EB alone is rare since it is usually present together with other solvents. EB is irritating to the eyes, skin, and respiratory tract. Vapor inhalation produces varying degrees of CNS effects depending on concentration. The liquid is absorbed through the skin but vapors are not. 56 to 64% of inhaled ethylbenzene is retained and metabolized. Urinary metabolites following exposure to 23 to 85 ppm for 8 hr are mandelic acid (64%), phenylglyoxylic acid (25%), and methylphenylcarbinol/1-phenyl ethanol (5%). Concurrent exposure to xylene and ethylbenzene causes slower excretion of EB metabolites. Based on the rat LD_{50}, one manufacturer gives 3 to 4 oz. as the lethal dose for a 100 lb person.

Continue on next page

Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Skin and CNS diseases and impaired pulmonary function (especially obstructive airway disease). **Target Organs:** Eyes, respiratory system, skin, CNS, blood. **Primary Entry Routes:** Inhalation, skin and eye contact. **Acute Effects:** Vapor inhalation of 200 ppm caused transient eye irritation; 1000 ppm caused eye irritation with profuse watering (tolerance developed rapidly); 2000 ppm caused severe and immediate eye irritation and watering, nasal irritation, chest constriction, and vertigo; 5000 ppm was intolerable and caused eye and nose irritation. Inhalation of high concentrations may cause narcosis, cramps, and death due to respiratory paralysis. Skin exposed to pure ethylbenzene for 10 to 15 min absorbed 22 to 33 mg/cm^2/hr. Immersion of hand in solutions of 112 & 156 mg/L for 1 hr absorbed 118 & 215.7 μg/cm^2/hr, respectively. **Chronic Effects:** Repeated skin contact may cause dryness, scaling, and fissuring. Workers chronically exposed to > 100 ppm complained of fatigue, sleepiness, headache, and mild irritation of the eyes and respiratory tract. Repeated vapor inhalation may result in blood disorders, particularly leukopenia (abnormally low level of white blood cells) and lymphocytosis.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting! Aspiration of even a small amount of EB in vomitus can cause severe damage since its low viscosity and surface tension will cause it to spread over a large area of the lung tissue.

After first aid, get appropriate in-plant, paramedic, or community medical support.

Note to Physicians: BEI = mandelic acid in urine (1.5 g/g of creatinine), sample at end of shift at workweeks end. Since this test is not specific, test for EB in expired air for confirmation.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel. Isolate and ventilate area, deny entry and stay upwind. Shut off all ignition sources. Cleanup personnel should protect against vapor inhalation and skin/eye contact. Take up small spills with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container. Dike far ahead of large spill for later reclamation or disposal. Report any release >1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, EB partially evaporates into the atmosphere, with a half-life of hrs to wks, and some leaches into groundwater, especially in soil with low organic carbon content. Biodegradation occurs with a half-life of 2 days. Some EB may absorb to sediment or bioconcentrate in fish. Evidence points to slow biodegradation in groundwater. In air, it reacts with photochemically produced hydroxyl radicals with a half-life of hrs to 2 days. Additional amounts may be removed by rain. **Ecotoxicity Values:** Shrimp (*Mysidopsis bahia*), LC_{50} = 87.6 mg/L/96 hr; sheepshead minnow (*Cyprinodon variegatus*) LC_{50} = 275 mg/L/96 hr; fathead minnow (*Pimephales promelas*) LC_{50} = 42.3 mg/L/96 hr in hard water & 48.5 mg/L/96 hr in softwater. **Disposal:** A candidate for rotary kiln incineration at 1508 to 2912°F (820 to 1600°C), liquid injection incineration at 1202 to 2912°F (650 to 1600°C), and fluidized bed incineration at 842 to 1796°F (450 to 980°C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.21): No. D001
Listed as a SARA Toxic Chemical (40 CFR 372.65)
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per CWA, Sec. 311 (b)(4) & CWA, Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use a powered air-purifying respirator with an appropriate organic vapor cartridge, a supplied-air respirator (SAR), SCBA, or chemical cartridge respirator with appropriate organic vapor cartridge. For < 2000 ppm, use a SAR or SCBA with a full facepiece. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of Viton or polyvinylchloride to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from ignition sources and oxidizers. Outside or detatched storage is preferred. If inside, store in a standard flammable liquids cabinet. Containers should have flame-arrester or pressure-vacuum venting. To prevent static sparks, electrically ground and bond all equipment used with ethylbenzene. Install Class 1, Group D electrical equipment. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain levels as low as possible. Purge and ventilate reaction vessels before workers are allowed to enter for maintenance or cleanup. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, skin, blood, and respiratory system.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Ethylbenzene
DOT Hazard Class: 3
ID No.: UN1175
DOT Packing Group: II
DOT Label: Flammable liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 173.150
b) Non-bulk Packaging: 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger Aircraft or Railcar: 5L
b) Cargo Aircraft Only: 60 L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: —

***MSDS Collection* References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 153, 159, 162, 163, 164, 167, 168, 171, 176, 179

Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 309
Fluorotrichloromethane

Issued: 11/77 Revision: D, 9/92

Section 1. Material Identification

39

R	1
I	1
S	2
K	0

Genium

HMIS	
H	2
F	0
R	0
PPE*	

* Sec. 8

Fluorotrichloromethane (CCl_3F) Description: Derived from hydrogen fluoride and carbon tetrachloride in the presence of fluorinating agents such as antimony *tri*- and *penta*-fluoride. Used as a solvent, a degreasing agent, a chemical intermediate, a blowing agent; in fire extinguishers, electric insulation, and the production of polymeric resins. Formerly used in aerosol propellants (banned in the US in 1978).

Other Designations: CAS No. 75-69-4, Algofrene Type 1, Arcton 11, Electro-CF 11, Eskimon 11, FC-11, fluorocarbon No. 11, Freon 11, Freon MF, Frigen 11, Genetron 11, Halocarbon 11, Isceon 131, Isotron 11, Ledon 11, monofluorotrichloromethane, NCI-C04637, trichloromonofluoromethane, Ucon refrigerant 11.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: FC-11 may be narcotic in high concentrations. Contact with tissue may cause frostbite. *Do not* release FC-11 to the environment because FC-11 depletes the ozone.

Section 2. Ingredients and Occupational Exposure Limits

Fluorotrichloromethane, ca 100%

1991 OSHA PEL
Ceiling: 1000 ppm (5600 mg/m^3)

1990 IDLH Level
10,000 ppm

1990 NIOSH REL
Ceiling: 1000 ppm (5600 mg/m^3)

1992-93 ACGIH TLV
Ceiling: 1000 ppm (5620 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 1000 ppm (5600 mg/m^3)
Category IV: Substances eliciting very weak effects
Peak Exposure Limit: 2000, 60 min, momentary value (level which the concentration should never exceed), 4 peaks/shift

1985-86 Toxicity Data*
Human, inhalation, TD_{Lo}: 50000 ppm/30 min caused conjunctiva irritation, fibrosing alveolitis, and other changes of the liver.
Rat, inhalation, LC_{Lo}: 10 pph/20 min caused general anesthesia.

* See NIOSH, *RTECS* (PB6125000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 74.7 °F (23.7 °C)
Freezing Point: -168 °F (-111 °C)
Vapor Pressure: 796 mm Hg at 77 °F (25 °C)
Vapor Density (Air = 1): 5.04 at 77 °F (25 °C)
Relative Evaporation Rate (BuAc = 1): 63
Refractive Index: 1.3865 at 18.5 °C/D
Viscosity: 0.439 cP at 70 °F (21 °C)
Octanol/Water Partition Coefficient: Log K_{ow}=2.53
Molecular Weight: 137.38
Specific Gravity: 1.494 at 63.0 °F (17.2 °C)
Water Solubility: 1 g/L at 25 °C
Other Solubilities: Alcohol, ether, and other organic solvents
Critical Temperature: 388 °F (198 °C)
Critical Pressure: 43.2 atm (635 lbs/sq in, absolute)

Appearance and Odor: Clear, colorless gas with a faint ethereal odor; liquid at temperatures below 74.7 °F (23.7 °C).

Section 4. Fire and Explosion Data

Flash Point: Nonflammable	**Autoignition Temperature:** None reported	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fires, use dry chemical or carbon dioxide (CO_2). For large fires, use water spray, fog, or foam.
Unusual Fire or Explosion Hazards: Fire may produce highly toxic decomposition products (Sec. 5). Containers may explode in the heat of fire. FC-11 is 4 to 5 times heavier than air and may accumulate in low lying areas creating a potential health hazard.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. If feasible and without risk, move containers from fire area. Otherwise, cool fire-exposed containers until well after the fire is out. Stay away from the ends of tanks. In case of tank discoloration due to fire or rising sound from venting safety device, *withdraw immediately*. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: FC-11 is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: FC-11 reacts violently with aluminum, barium, or lithium. It attacks some forms of plastic, rubber, and coatings. Other incompatibilities include sodium, potassium, calcium, zinc, and magnesium.
Conditions to Avoid: Contact with incompatibles and heat and ignition sources
Hazardous Products of Decomposition: Thermal oxidative decomposition of FC-11 can produce toxic fluoride, chloride, hydrogen chloride, hydrogen fluoride, carbonyl fluoride, phosgene, and CO_2 fumes.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list fluorotrichloromethane as a carcinogen.
Summary of Risks: At extremely high concentrations, fluorotrichloromethane causes narcosis (unconsciousness) and death from respiratory depression or cardiac sensitization. Sudden death has been reported following intentional sniffing of aerosols containing FC-11. Dizziness is an early warning that a dangerous concentration is being reached. At low concentrations, FC-11 may cause eye, nose, and throat irritation. The decomposition products (Sec. 5) of FC-11 are highly toxic. A 10 to 90% mixture of FC-11 and FC-12 caused more severe respiratory problems in humans than FC-11 or FC-12 singly. Contact with tissues may cause frostbite.
Medical Conditions Aggravated by Long-Term Exposure: Cardiovascular disease.
Target Organs: Cardiovascular, pulmonary and central nervous systems, skin.

Continue on next page

Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation.
Acute Effects: Inhalation produces dizziness, light-headedness, drowsiness, disorientation, conjunctival irritation, bronchospasm, and possible pper respiratory tract irritation, cardiac arrythmias (irregular heartbeats) and liver changes. Peripheral neuropathy has also been reported. FC-11 nay cause freezing and frostbite if splashed on the skin or in the eyes. Ingestion may cause necrosis and stomach perforations.
Chronic Effects: Although there are few cases of chronic illness reported, long term exposure may damage the eyes, lungs and liver. Human exposures to 1000 ppm, 8 hr/day, 5 days/week for a total of 18 exposures produced no untoward subjective effects and there were no changes in the pulmonary function tests or electrocardiogram. Prolonged or repeated skin contact may cause defatting of the skin, dryness, redness and contact dermatitis.

FIRST AID

Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of luke-warm water for at least 15 min. If irritation or pain persist, consult a physician immediately.
Skin: *Quickly* remove contaminated clothing. Rinse with flooding amounts of luke-warm water for at least 15 min. Place affected area in a water bath with a temperature of 104 to 108 °F (40 to 42 °C) for 20 to 30 min. Do not use dry heat. Continue rewarming until a flush returns to the affected area. For reddened or blistered skin, consult a physician.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center. Unless the poison control center advises otherwise, if large amounts are ingested, have that *conscious and alert* person drink 1 to 2 glasses of water and induce vomiting.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Note to Physicians: Treatment is symptomatic and supportive. Keep patient calm and minimize physical exertion to avoid adrenalin surge. Monitor arterial blood gases, EKG, and vital signs. *Do not* use adrenalin because of the possibility of inducing cardiac arrythmias. Dilantin improves artrio-ventricular conduction and may be useful in the management of ventricular arrythmias.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel of spill, evacuate all unnecessary personnel, remove all heat and ignition sources, and ventilate area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If feasible and without risk, stop flow of gas. Avoid releasing FC-11 to the environment because of its potential ozone destruction. For liquid spills, cover with absorbent and place in a container for disposal. If possible return to vendor or licensed disposal company. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Degradation: Having a half-life of 52-207 yrs, FC-11 is very stable in the troposphere. Photodissociation of FC-11 in the stratosphere produces significant amounts of chlorine atoms and leads to ozone destruction.
Environmental Transport: Bioconcentration in fish is unlikely.
Soil Absorption/Mobility: If released on soil, FC-11 evaporates into the atmosphere and passes through the soil into the groundwater where it is likely to persist for a long time.
Disposal: FC-11 is a good candidate for rotary kiln and fluidized bed incineration with an acid scrubber to remove halo acids. FC-11 may also be removed from waste water by air stripping. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U121, F002 (spent solvent, 40 CFR 261.31)
isted as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 5000 lb (2270 kg) [* per RCRA, Sec. 3001]
ARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or splash-proof chemical goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For concentrations <10,000 ppm, wear any supplied-air respirator or any self-contained breathing apparatus. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear any SCBA that has a full facepiece and is operated in a pressure-demand or other positive-pressure mode. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent prolonged or repeated skin contact. Polycarbonate, Viton, or polyvinyl chloride are recommended for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in a cool, dry, well-ventilated area away from heat and ignition sources and incompatibles (Sec. 5). Protect containers against physical damage.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Space heaters should have an independent air supply because concentrations well below the TLV level can cause damage to the heater and generate toxic gases.
Administrative Controls: Consider preplacement and periodic medical exams with emphasis on the cardiovascular, respiratory, and central nervous systems.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Refrigerant gases, n.o.s.
DOT Hazard Class: 2.2
) No.: UN1078
OT Packing Group: --
DOT Label: Nonflammable Gas
Special Provisions (172.102): --

Packaging Authorizations
a) Exceptions: 173. 306
b) Non-bulk Packaging: 173.304
c) Bulk Packaging: 173.314, .315

Quantity Limitations
a) Passenger Aircraft or Railcar: 75 kg
b) Cargo Aircraft Only: 150 kg
Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: - -

MSDS Collection **References:** 26, 73, 100, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 159, 163, 164, 167, 168, 176, 178, 180
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** AC Darlington, MD

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Material Safety Data Sheets Collection:

Sheet No. 313
Perchloroethylene
Issued: 11/78 Revision: E, 9/92

Section 1. Material Identification

Perchloroethylene (C_2Cl_4) Description: By chlorination of hydrocarbons and pyrolysis of the carbon tetrachloride that is formed, or by catalytic oxidation of 1,1,2,2-tetrachloroethane. Used in dry cleaning and textile processing, metal degreasing, insulating fluid and cooling gas in electrical transformers, production of adhesives, aerosols, paints, and coatings; as a chemical intermediate, a solvent for various applications, extractant for pharmaceuticals, a pesticide intermediate, and an antihelminthic (parasitic worm removal) agent in veterinary medicine.
Other Designations: CAS No. 127-18-4, Ankilostin, carbon dichloride, Didakene, ethylene tetrachloride, Perchlor, Perclene, Perk, Tetracap, tetrachloroethylene.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*[73] for a suppliers list.

Cautions: Perchloroethylene is a central nervous system depressant, causes liver and kidney damage (from acute or chronic exposures), and is considered an IARC Class 2B carcinogen (animal sufficient evidence, human inadequate data).

R 1
I 3
S 2*
K 0
* Skin absorption

NFPA
0
2 0
-

HMIS
H 2†
F 0
R 0
PPE‡
† Chronic effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Perchloroethylene, < 99%. Impurities include a small amount of amine or phenolic stabilizers.

1991 OSHA PEL
8-hr TWA: 25 ppm (170 mg/m^3)

1990 IDLH Level
500 ppm

1990 NIOSH REL
NIOSH-X Carcinogen
Limit of Quantitation: 0.4 ppm

1992-93 ACGIH TLVs
TWA: 50 ppm (339 mg/m^3)
STEL: 200 ppm (1357 mg/m^3)

1990 DFG (Germany) MAK
TWA: 50 ppm (345 mg/m^3)
Category II: substances with systemic effects
Half-life: < 2 hr
Peak Exposure Limit: 100 ppm, 30 min average value, 4/shift

1985-86 Toxicity Data*
Man, inhalation, TC_{Lo}: 280 ppm/2 hr caused conjunctival irritation and anesthesia.
Human, lung: 100 mg/L caused unscheduled DNA synthesis.
Rat, oral, LD_{50}: 3005 mg/kg; caused somnolence, tremor, and ataxia.
Rat, inhalation, TC_{Lo}: 200 ppm/6 hr given intermittently over 2 years produced leukemia and testicular tumors.
Rabbit, eye: 162 mg caused mild irritation.
Rabbit, skin: 810 mg/24 hr caused severe irritation.

* See NIOSH, *RTECS* (KX3850000), for additional irritation, mutation, reproductive, tumorigenic, & toxicity data.

Section 3. Physical Data

Boiling Point: 250 °F (121.2 °C)
Freezing Point: -8 °F (-23.35 °C)
Vapor Pressure: 13 mm Hg at 68 °F (20 °C)
Surface Tension: 31.74 dyne/cm at 68 °F (20 °C)
Viscosity: 0.84 cP at 77 °F (25 °C)
Refraction Index: 1.50534 at 68 °F (20 °C)
Molecular Weight: 165.82
Density: 1.6311 at 59 °F (15/4 °C)
Water Solubility: 0.02% at 77 °F (25 °C)
Other Solubilities: Miscible with alcohol, ether, benzene, chloroform, and oils.
Odor Threshold: 47 to 71 ppm (poor warning properties since olfactory fatigue is probable)
Evaporation Rate: 0.15 gal/ft^2/day at 77 °F (25 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.081 lb/ft^3 or 1.296 kg/m^3
Appearance and Odor: Colorless liquid with an ether-like odor.

Section 4. Fire and Explosion Data

Flash Point: Nonflammable	**Autoignition Temperature:** Nonflammable	**LEL:** None reported	**UEL:** None reported

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2). For large fires, use water spray, fog, or regular foam.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and collect in low-lying areas.
Special Fire-fighting Procedures: Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Perchloroethylene is stable up to 932 °F (500 °C) in the absence of catalysts, moisture, and oxygen but deteriorates rapidly in warm, moist climates. It is slowly decomposed by light. Amine or phenolic stabilizers are usually added. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Slowly (faster in presence of water) corrodes aluminum, iron, and zinc. It is incompatible with chemically active metals (i.e., barium, beryllium, and lithium (explodes with lithium shavings), strong oxidizers, sodium hydroxide, caustic soda, potash, and nitric acid. Perchloroethylene forms an explosive mixture with dinitrogen tetraoxide and reacts with activated charcoal at 392 °F (200 °C) to yield hexachloroethane and hexachlorobenzene. **Conditions to Avoid:** Contact with moisture and incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition of perchloroethylene can produce carbon dioxide and toxic chlorine, hydrogen chloride, and phosgene gas (also produced by contact with UV light).

Section 6. Health Hazard Data

Carcinogenicity: Perchloroethylene is listed as a carcinogen by The IARC (Group 2B, animal sufficient evidence, human inadequate data),(164) NTP (Class 2, reasonably anticipated as a carcinogen, with limited human evidence and sufficient animal evidence),(169) NIOSH (Class-X, carcinogen defined with no further explanation),(164) and DFG (MAK-B, justifiably suspected of having carcinogenic potential)(164). There is some controversy regarding human carcinogenicity because even though there is an increased number of cancers of the skin, colon, lung, urogenital tract, and lympho-sarcomas; the dry cleaning workers studied were also exposed to other chemicals. **Summary of Risks:** Perchloroethylene is stored in the fatty tissue and slowly metabolized with the loss of chlorine. The half-life of its urinary metabolite (trichloroacetic acid) is 144 hours. Perchloroethylene exerts the majority of its toxicity on the central nervous system causing symptoms ranging from light-headedness and slight 'inebriation' to unconsciousness. Liver damage is possible after severe acute or minor long-term exposure. It has a synergistic effect with toluene.

Continue on next page

Section 6. Health Hazard Data, *continued*

Medical Conditions Aggravated by Long-Term Exposure: Nervous, liver, kidney, or skin disorders. **Target Organs:** Liver, kidney, eyes, upper respiratory tract, skin, and central nervous system. **Primary Entry Routes:** Inhalation and skin and eye contact. **Acute Effects:** Exposure to high levels can cause liver damage which may take several weeks to develop. Vapor exposure can cause slight smarting of the eyes and throat (in high concentrations). In human studies, exposure to 2000 ppm/5 min caused mild CNS depression; 600 ppm/10 min caused numbness around the mouth, dizziness, and incoordination; 100 ppm/7 hr caused mild eye, nose, and throat irritation, flushing of the face and neck, headache, somnolence, and slurred speech. Skin contact may produce dermatitis because of perchloroethylene's defatting action (more common after repeated exposure). Direct eye contact causes tearing and burning but no permanent damage. Ingestion is rare but can cause irritation of the lips, mouth and gastrointestinal tract, irregular heartbeat, nausea & vomiting, diarrhea (possibly blood stained), drowsiness, unconsciousness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Prolonged exposure can cause impaired memory, extremity (hands, feet) weakness, peripheral neuropathies, impaired vision, muscle cramps, liver damage (fatty degeneration, necrosis, yellow jaundice, and dark urine) and kidney damage (oliguric uremia, conjestion and granular swelling).

FIRST AID ***Rescuers must not enter areas with potentially high perchloroethylene levels without a self-contained breathing apparatus.***
Eyes: *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. *Never administer adrenalin!* **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Be sure victim's head is positioned to avoid aspiration of vomitus into the lungs. **Note to Physicians:** Monitor level of consciousness, EEG (abnormalaties may indicate chronic toxicity), blood enzyme levels (for 2 to 3 wk after exposure), EKG, adequacy of respirations & oxygenation, and liver and kidney function. *BEIs:* C_2Cl_4 in expired air (10 ppm), sample prior to last shift of work week; C_2Cl_4 in blood (1 mg/L), sample prior to last shift of work week; trichloroacetic acid in urine (7 mg/L), sample at end of workweek.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off ignition sources (although noncombustible, it forms toxic vapors from thermal decomposition). For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable containers for later disposal. For large spills, dike far ahead of spill and await reclamation or disposal. Report any release in excess of 1 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** If released to soil, perchloroethylene evaporates and some leaches to groundwater. It may absorb slightly to soils with heavy organic matter. Biodegradation may be important in anaerobic soils. In water, it is subject to rapid volatilization with an estimated half-life from <1 day to several weeks. In air, it exists mainly in the vapor-phase and is subject to photooxidation with a half-life of 30 minutes to 2 months. **Ecotoxicity Values:** Guppy (*Poecilia reticulata*), LC_{50} = 18 ppm/7 days; fathead minnow (*Pimephales promelas*), LC_{50} = 18.4 mg/L/96 hr, flow through bioassay. **Disposal:** Consider recovery by distillation. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) or fluidized bed incineration at 842 to 1796 °F (450 to 980 °C). Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U210
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per CWA Sec. 307 (a)]
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear a faceshield (8 inch minimum) per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For any detectable concentration, use a supplied-air respirator or SCBA with a full facepiece operated in pressure demand or other positive-pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made of butyl rubber, Neoprene, or Viton to prevent skin contact. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PEL (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from sunlight, and incompatibles. Do not store sludge from vapor degreasers in tightly-sealed containers and keep outside until disposal is arranged. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Check stabilizer levels frequently and ventilation equipment (air velocity, static pressure, air valve) at least every 3 months. Install an air dryer in ventlines to storage tanks to prevent moisture from rusting and weakening the tank and contaminating or discoloring its contents. Purge all tanks before entering for repairs or cleanup. Build a dike around storage tanks capable of containing all the liquid. Ground tanks to prevent static electricity. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers that emphasize liver, kidney, and nervous system function, and the skin. Alcoholism may be a predisposing factor.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Tetrachloroethylene
DOT Hazard Class: 6.1
D No.: UN1897
OT Packing Group: III
DOT Label: Keep away from food
Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60 L
b) Cargo Aircraft Only: 220 L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 311
Methyl Chloroform

Issued: 11/75 Revision: F, 3/92 Errata: 6/92

Section 1. Material Identification

38

Methyl Chloroform ($C_2H_3Cl_3$) Description: Derived by catalytic addition of hydrogen chloride to 1,1-dichloroethylene or by re-fluxing chlorine monoxide with carbon tetrachloride and chloroethane. Available in technical and solvent grades which differ only in the amount of stabilizer added to prevent metal parts corrosion. Used as a solvent for oils, waxes, tars, cleaning precision instruments, and pesticides; as a component of inks and drain cleaners; in degreasing metals, and textile processing. In recent years, methyl chloroform has found widespread use as a substitute for carbon tetrachloride.

R 1
I 2
S 2*
K 1

Genium

HMIS
H 2
F 1
R 1
PPG*
* Sec. 8

Other Designations: CAS No. 71-55-6, α-trichloroethane; Inhibisol; 1,1,1-trichloroethane; Strobane.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Methyl chloroform is a skin, eye, and respiratory tract irritant and can become narcotic with an anesthetic effect at high concentrations.

* Data on skin absorption via methyl chloroform is conflicting.(133) Some studies show definite absorption where others don't.

Section 2. Ingredients and Occupational Exposure Limits

Methyl chloroform, ca 92 to 97%*

1990 OSHA PELs
8-hr TWA: 350 ppm (1900 mg/m^3)
15-min STEL: 450 ppm (2450 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
15-min Ceiling: 350 ppm (1900 mg/m^3)

1991-92 ACGIH TLVs
TWA: 350 ppm (1910 mg/m^3)
STEL: 450 ppm (2460 mg/m^3)

1990 DFG (Germany) MAKs
TWA: 200 ppm (1080 mg/m^3)
Half-life: 2 hr to shift length
Peak Exposure Limit: 1000 ppm/30 min (average value)/2 per shift

1985-86 Toxicity Data†
Human, oral, TD_{Lo}: 670 mg/kg produced diarrhea, nausea, and vomiting
Human, inhalation, LC_{Lo}: 27 g/m^3/10 min; toxic effects not yet reviewed
Man, eye: 450 ppm/8 hr produced irritation
Rat, inhalation, TC_{Lo}: 2100 ppm/24 hr for 14 days prior to mating and from 1 to 20 days of pregnancy produced specific developmental abnormalities of the musculoskelatal system

* Methyl chloroform usually contains inhibitors (3 to 8%) to prevent corrosion of aluminum and some other metals. Typical inhibitors are nitromethane, butylene oxide, secondary butyl alcohols, ketones, and glycol diesters.
† See NIOSH, *RTECS* (KJ2975000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 165 °F (75 °C)
Freezing Point: -22 °F (-30 °C)
Vapor Pressure: 100 mm Hg at 68 °F (20 °C)
Vapor Density (air = 1): 4.55
Corrosivity: Readily corrodes aluminum and its alloys
Refraction Index: 1.43765 at 69.8 °F (21 °C)
Viscosity: 0.858 cP at 68 °F (20 °C)
Molecular Weight: 133.42
Density: 1.3376 at 68/39.8 °F (20/4 °C)
Water Solubility: Insoluble
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, carbon tetrachloride, and carbon disulfide
% in Saturated Air: 16.7% at 77 °F (25 °C)
Relative Evaporation Rate (butyl acetate = 1): 12.8

Appearance and Odor: Colorless liquid with a sweetish, chloroform-like odor. The odor threshold is 44 ppm.

Section 4. Fire and Explosion Data

Flash Point: None (in conventional CC tests)	**Autoignition Temperature:** 932 °F (500 °C)	**LEL:** 7% v/v	**UEL:** 16% v/v

Extinguishing Media: *Noncombustible liquid* whose ***vapor*** burns in the presence of excess oxygen or a strong ignition source. For small fires, use dry chemical or carbon dioxide (CO_2). For large fires use fog or regular foam. If these materials are unavailable, a water spray may be used but be aware that water reacts slowly with methyl chloroform to release hydrochloric acid.
Unusual Fire or Explosion Hazards: Vapors are heavier than air and may travel to a strong ignition source and flash back. Air/vapor mixtures may explode when heated. Container may explode in heat of fire. Exposure to open flames or arc welding can produce hydrogen chloride and phosgene.
Special Fire-fighting Procedures: Methyl chloroform's burning rate is 2.9 mm/min. Since fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides limited protection. Wear clothing specifically recommended by the manufacturer for use in fires involving methyl chloroform. Apply cooling water to container sides until after fire is extinguished. Stay away from ends of tanks. Isolate area for 1/2 mile if fire involves tank, truck, or rail car. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Methyl chloroform is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can occur in contact with aluminum trichloride.
Chemical Incompatibilities: Methyl chloroform is incompatible with sodium hydroxide, nitrogen tetroxide, oxygen (liquid or gas), strong oxidizers, and chemically active metals like aluminum, zinc, and magnesium powders; reacts violently with caustics to form dichloroacetylene; reacts slowly with water to form hydrochloric acid; forms shock sensitive mixtures with potassium; and polymerizes in contact with aluminum trichloride.
Conditions to Avoid: Exposure to moisture, strong ignition sources, and arc-welding units, and contact with incompatibles.
Hazardous Products of Decomposition: Thermal oxidative decomposition (temperatures >500 °F, contact with hot metals, or under UV rays) of methyl chloroform can produce carbon dioxide (CO_2) and toxic dichloroacetylene, hydrogen chloride, and phosgene gases.

Section 6. Health Hazard Data

Carcinogenicity: The IARC (Class 3, inadequate evidence),(164) NTP,(142) and OSHA(164) do not list methyl chloroform as a carcinogen.
Summary of Risks: Methyl chloroform is considered one of the least toxic of the liquid chlorinated hydrocarbons. It is irritating to eyes, skin, and respiratory tract. Although low in systemic toxicity, methyl chloroform is an anesthetic capable of causing death at high concentrations (>15,000 ppm), generally in poorly ventilated, enclosed areas. Quick and complete recovery is observed after prompt removal of unconscious persons from area of exposure. Like many other solvents, methyl chloroform sensitizes the heart to epinephrine (blood pressure-raising hormone) and may induce cardiac arrhythmias and arrest.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous (CNS) and cardiovascular (CVS) systems.

Continue on next page

Section 6. Health Hazard Data, *continued*

Primary Entry Routes: Inhalation, skin contact. **Acute Effects:** Methyl chloroform defats the skin causing irritation, redness, dryness, and scaling. Contact with eyes produces irritation and mild conjunctivitis. Vapor inhalation can cause headache, dizziness, equilibrium disturbances, and in high concentrations may lead to CNS depression, unconsciousness, and coma. During a 60-min exposure period these effects are observed: 100 ppm is the observed odor threshold, at 500 ppm there is obvious odor and decreased reaction time, 1000 ppm causes slight equilibrium loss, at 5000 ppm there is definite incoordination, and 20,000 ppm produces surgical strength anesthesia with possible death. Mild liver and kidney dysfunction may occur after CNS depression recovery. Although unlikely, if ingestion occurs, symptoms include nausea, vomiting, diarrhea, and possible esophageal burns. The acute lethal human dose is ~500 to 5000 mg/kg. **Chronic Effects:** None reported.

FIRST AID

Eyes: Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. *Do not* allow victim to rub or keep eyes tightly shut. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician.
Inhalation: Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center, and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. When deciding whether to induce vomiting, carefully consider amount ingested, time since ingestion, and availability of medical help. If large amounts are recently ingested (absorption into the body is not yet likely to have occurred), and medical help or transportation to a medical facility is not readily available, induce vomiting. Otherwise, vomiting is not recommended since aspiration of vomitus can produce chemical pneumonitis.
Note to Physicians: Do not use adrenaline or sympathomimetic amines in treatment because of the increased cardiac sensitivity involved.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate area, deny entry, and stay upwind. Shut off all ignition sources. If possible without risk, shut off leak. Cleanup personnel should wear fully encapsulating vapor-protective clothing. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material. Using nonsparking tools, place in suitable containers for disposal or reclamation. For large spills, dike far ahead of liquid spill for later disposal or reclamation. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120).
Environmental Transport: In water, methyl chloroform's half-life is hours to weeks depending on wind and mixing conditions. It is very persistent in groundwater. On land it volatilizes due to its high vapor pressure and leaches extensively. When released to the atmosphere, methyl chloroform can be transported long distances and returned to earth via rain. It is slowly degraded by reaction with hydroxyl radicals and has a half-life of 6 months to 25 years. The Natural Resources Defenses Council reported recently that methyl chloroform depletes ozone.
Ecotoxicity Values: *Pimephales promelas* (fathead minnow), LC_{50}: 52.8 mg/L/96 hr; *Poecilia reticulata* (guppy), LC_{50}: 133 ppm/7 day.
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U226
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Reportable Quantity (RQ), 1000 lb (454 kg) [* per RCRA, Sec. 3001, CWA, Sec. 307(a), and CAA, Sec. 112]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear splash-proof, protective chemical safety goggles or faceshields, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy.
Respirator: Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. Select respirator based on its suitability to provide adequate worker protection for given working conditions, level of airborne contamination, and presence of sufficient oxygen. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas.
Other: Wear chemically protective gloves, boots, aprons, and gauntlets to prevent repeated or prolonged skin contact. Viton and butyl rubber [with breakthrough times (BTs) of >8 hr and 4 to 7.9 hr, respectively] are recommended materials for protective gear. *Do not use* neoprene, polyvinyl chloride (PVC), natural rubber, or polyethylene because these materials have a BT of <1 hr.
Ventilation: Provide general and local exhaust (in some cases, explosion-proof) ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred since it prevents contaminant dispersion into work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean personal protective equipment.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in cool, dry, well-ventilated (use pressure-vacuum ventilation) area away from ignition sources, arc-welding operations, and incompatibles (Sec. 5). Regularly monitor inhibitor levels. *Do not* store in aluminum containers or use pressure-spraying equipment when methyl chloroform is involved.
Engineering Controls: To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. To prevent static sparks, electrically ground and bond all equipment used in methyl chloroform manufacturing, use, storage, transfer, and shipping.
Administrative Controls: Consider preplacement and periodic medical exams of exposed workers that emphasize CNS, CVS, liver and skin.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: 1,1,1-Trichloroethane
DOT Hazard Class: ORM-A
ID No.: UN2831
DOT Label: None
DOT Packaging Exceptions: 173.505
DOT Packaging Requirements: 173.605

IMO Shipping Name: 1,1,1-Trichloroethane
IMO Hazard Class: 6.1
ID No.: UN2831
IMO Label: St. Andrews Cross
IMDG Packaging Group: III

MSDS Collection **References:** 26, 38, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 148, 153, 159, 162, 163, 164
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MPH, MD; **Edited by:** JR Stuart, MS

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Material Safety Data Sheets Collection:

Sheet No. 317
Toluene
Issued: 8/79 Revision: E, 9/92 Errata: 2/94

Section 1. Material Identification

Toluene ($C_6H_5CH_3$) Description: Derived from petroleum i.e., dehydrogenation of cycloparaffin fractions followed by the aromatization of saturated aromatic hydrocarbons or by fractional distillation of coal-tar light oil and purified by rectification. Used widely as a solvent (replacing benzene in many cases) for oils, resins, adhesives, natural rubber, coal tar, asphalt, pitch, acetyl celluloses, cellulose paints and varnishes; a diluent for photogravure inks, raw material for organic synthesis (benzoyl & benzilidene chlorides, saccharine, TNT, toluene diisocyanate, and many dyestuffs), in aviation and high octane automobile gasoline, as a nonclinical thermometer liquid and suspension solution for navigational instruments.
Other Designations: CAS No. 108-88-3, Methacide, methylbenzene, methylbenzol, phenylmethane, toluol, Tolu-sol.
Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Toluene is an eye, skin, and respiratory tract irritant becoming narcotic at high centrations. Liver and kidney damage has occurred. Pregnant women chronically exposed to toluene have shown teratogenic effects. Toluene is highly flammable.

R 1
I 3
S 2*
K 3
* Skin absorption

NFPA


HMIS
H 2- Chronic effects
F 3
R 0
PPE-Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Toluene, < 100%; may contain a small amount of benzene (~ 1%), xylene, and nonaromatic hydrocarbons.

1991 OSHA PELs
8-hr TWA: 100 ppm (375 mg/m^3)
15-min STEL: 150 ppm (560 mg/m^3)

1990 IDLH Level
2000 ppm

1990 NIOSH RELs
TWA: 100 ppm (375 mg/m^3)
STEL: 150 ppm (560 mg/m^3)

1992-93 ACGIH TLV (Skin)
TWA: 50 ppm (188 mg/m^3)

1990 DFG (Germany) MAK*
TWA: 100 ppm (380 mg/m^3)
Half-life: 2 hr to end of shift
Category II: Substances with systemic effects
Peak Exposure Limit: 500 ppm, 30 min average value, 2/shift

1985-86 Toxicity Data†
Man, inhalation, TC_{Lo}: 100 ppm caused hallucinations, and changes in motor activity and changes in psychophysiological tests.
Human, oral, LD_{Lo}: 50 mg/kg; toxic effects not yet reviewed
Human, eye: 300 ppm caused irritation.
Rat, oral, LD_{50}: 5000 mg/kg
Rat, liver: 30 µmol/L caused DNA damage.

* Available information suggests damage to the developing fetus is probable.
†See NIOSH, *RTECS* (XS5250000), for additional irritation, mutation, reproductive, and toxicity data.

Section 3. Physical Data

Boiling Point: 232 °F (110.6 °C)
Melting Point: -139 °F (-95 °C)
Molecular Weight: 92.15
Density: 0.866 at 68 °F (20/4 °C)
Surface Tension: 29 dyne/cm at 68 °F (20 °C)
Viscosity: 0.59 cP at 68 °F (20 °C)
Refraction Index: 1.4967 at 20 °C/D
Water Solubility: Very slightly soluble, 0.6 mg/L at 68 °F (20 °C)
Other Solubilities: Soluble in acetone, alcohol, ether, benzene, chloroform, glacial acetic acid, petroleum ether, and carbon disulfide.
Vapor Pressure: 22 mm Hg at 68 °F (20 °C); 36.7 mm Hg at 86 °F (30 °C)
Saturated Vapor Density (Air = 0.075 lb/ft^3 or 1.2 kg/m^3): 0.0797 lb/ft^3 or 1.2755 kg/m^3
Odor Threshold (range of all referenced values): 0.021 to 69 ppm

Appearance and Odor: Colorless liquid with a sickly sweet odor.

Section 4. Fire and Explosion Data

Flash Point: 40 °F (4.4 °C) CC	**Autoignition Temperature:** 896 °F (480 °C)	**LEL:** 1.27% v/v	**UEL:** 7.0% v/v

Extinguishing Media: Toluene is a Class 1B flammable liquid. To fight fire, use dry chemical carbon dioxide, or 'alcohol-resistant' foam. Water spray may be ineffective as toluene floats on water and may actually spread fire. **Unusual Fire or Explosion Hazards:** Concentrated vapors are heavier than air and may travel to an ignition source and flash back. Container may explode in heat of fire. Toluenes' burning rate = 5.7 mm/min and its flame speed = 37 cm/sec. Vapor poses an explosion hazard indoors, outdoors, and in sewers. May accumulate static electricity. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing provides only limited protection. Apply cooling water to sides of tanks until well after fire is out. Stay away from ends of tanks. For massive fire in cargo area, use monitor nozzles or unmanned hose holders; if impossible, withdraw from fire and let burn. Withdraw immediately if you hear a rising sound from venting safety device or notice any tank discoloration due to fire because a BLEVE (boiling liquid expanding vapor explosion) may be imminent. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Toluene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization can't occur. **Chemical Incompatibilities:** Strong oxidizers, concentrated nitric acid, nitric acid + sulfuric acid, dinitrogen tetroxide, silver perchlorate, bromine trifluoride, tetranitromethane, and 1,3-dichloro-5,5-dimethyl-2,4-imidazolididione. **Conditions to Avoid:** Contact with heat, ignition sources, or incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of toluene can produce carbon dioxide, and acrid, irritating smoke.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list toluene as a carcinogen. **Summary of Risks:** Toluene is irritating to the eyes, nose, and respiratory tract. Inhalation of high concentrations produces a narcotic effect sometimes leading to coma as well as liver and kidney damage. 93% of inhaled toluene is retained in the body of which 80% is metabolized to benzoic acid, then to hippuric acid and excreted in urine. The remainder is metabolized to *o*-cresol and excreted or exhaled unchanged. Toluene metabolism is inhibited by alcohol ingestion and is synergistic with benzene, asphalt fumes, or chlorinated hydrocarbons (i.e. perchloroethylene). Toluene is readily absorbed through the skin at 14 to 23 mg/cm^2/hr. Toluene is absorbed quicker during exercise than at rest and appears to be retained longer in obese versus thin victims; presumably due to its lipid solubility. There is inconsistent data on toluene's ability to damage bone marrow; chronic poisoning has resulted in anemia and leucopenia with biopsy showing bone marrow hypo-plasia. These reports are few and some authorities argue that the effects may have been due to benzene contaminants. Chronic inhalation during pregnancy has been associated with teratogenic effects on the fetus including microcephaly, CNS dysfunction, attentional deficits, developmental delay + language impairment, growth retardation, and physical defects including a small midface, short palpebral fissures, with deep-set eyes, low-set ears, flat nasal bridge with a small nose, micrognathia, and blunt fingertips. There is some evidence that toluene causes an autoimmune illness in which the body produces antibodies that cause inflammation of its own kidney.

Continue on next page

Section 6. Health Hazard Data

Medical Conditions Aggravated by Long-Term Exposure: Alcoholism and CNS, kidney, skin, or liver disease. **Target Organs:** CNS, liver, kidney, skin. **Primary Entry Routes:** Inhalation, skin contact/absorption. **Acute Effects:** Vapor inhalation causes respiratory tract irritation, fatigue, weakness, confusion, dizziness, headache, dilated pupils, watering eyes, nervousness, insomnia, parasthesis, and vertigo progressing to narcotic coma. Death may result from cardiac arrest due to ventricular fibrillation with catecholamines loss. Liquid splashed in the eye causes conjunctival irritation, t ient corneal damage and possible burns. Prolonged skin contact leads to drying and fissured dermatitis. Ingestion causes GI tract irritation and toms associated with inhalation. **Chronic Effects:** Symptoms include mucous membrane irritation, headache, vertigo, nausea, appetite loss and alcohol intolerance. Repeated heavy exposure may result in encephalopathies (cerebellar ataxia and cognitive dysfunction), liver enlargement, and kidney dystrophy (wasting away). Symptoms usually appear at workdays end, worsen at weeks end and decrease or disappear over the weekend.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult an ophthalmologist immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water to dilute. *Do not* induce vomiting because of danger of aspiration into the lungs. Gastric lavage may be indicated if large amounts are swallowed; potential toxicity needs to be weighed against aspiration risk when deciding for or against gastric lavage. **Note to Physicians:** Monitor cardiac function. If indicated, use epinephrine and other catecholamines carefully, because of the possibility of a lowered myocardial threshold to the arrhythmogenic effects of such substances. Obtain CBC, electrolytes, and urinalysis. Monitor arterial blood gases. If toluene has > 0.02% (200 ppm) benzene, evaluate for potential benzene toxicity. BEI: hippuric acid in urine, sample at shift end (2.5 g/g creatinine); Toluene in venous blood, sample at shift end (1.0 mg/L).

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Cleanup personnel protect against inhalation and skin/eye contact. Use water spray to cool and disperse vapors but it may not prevent ignition in closed spaces. Cellosolve, hycar absorbent materials, and fluorocarbon water can also be used for vapor suppression/containment. Take up small spill with earth, sand, vermiculite, or other absorbent, noncombustible material. Dike far ahead of large spills for later reclamation or disposal. For water spills, (10 ppm or greater) apply activated carbon at 10X the spilled amount and remove trapped material with suction hoses or use mechanical dredges/lifts to remove immobilized masses of pollutants and precipitates. Toluene can undergo fluidized bed incineration at 842 to 1796 °F (450 to 980 °C), rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C), or liquid injection incineration at 1202 to 2912 °F (650 to 1600 °C). Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Blue gill, LC_{50} = 17 mg/L/24 hr; shrimp (*Crangonfracis coron*), LC_{50} = 4.3 ppm/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 36.2 mg/L/96 hr. **Environmental Degradation:** If released to land, toluene evaporates and undergoes microbial degradation. In water, toluene volatilizes and biodegrades with a half-life of days to several weeks. In air, toluene degrades by reaction with photochemically produced hydroxyl radicals.
Disposal: Treat contaminated water by gravity separation of solids, followed by skimming of surface. Pass through dual media filtration and carbon absorption units (carbon ratio 1 kg to 10 kg soluble material). Return waste water from backwash to gravity separator. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U220
SARA Extremely Hazardous Substance (40 CFR 355), TPQ: Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg)
er RCRA, Sec. 3001; CWA, Sec. 311 (b)(4); CWA, Sec. 307 (a)]
Listed as a SARA Toxic Chemical (40 CFR 372.65): Not listed

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses with shatter-resistant glass and side-shields or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For < 1000 ppm, use any chemical cartridge respirator with appropriate organic vapor cartridges, any supplied-air respirator (SAR), or SCBA. For < 2000 ppm, use any SAR operated in continuous-flow mode, any SAR or SCBA with a full facepiece, or any air-purifying respirator with a full facepiece having a chin-style, front or back mounted organic vapor canister. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a written respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent skin contact. Polyvinyl alcohol with a breakthrough time of > 8 hr, Teflon and Viton are recommended as suitable materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove toluene from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in a cool, dry, well-ventilated area away from ignition sources and incompatibles. Outside or detached storage is preferred. If stored inside, use a standard flammable liquids warehouse, room, or cabinet. To prevent static sparks, electrically ground and bond all equipment used with toluene. Do not use open lights in toluene areas. Install Class 1, Group D electrical equipment. Check that toluene is free of or contains < 1% benzene before use. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. **Administrative Controls:** Adopt controls for confined spaces (29 CFR 1910.146) if entering areas of unknown toluene levels (holes, wells, storage tanks). Consider preplacement and periodic medical exams of exposed workers that emphasize the CNS, liver, kidney, and skin. Include hemocytometric and thrombocyte count in cases where benzene is a contaminant of toluene. Monitor air at regular intervals to ensure effective ventilation.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Toluene	**Packaging Authorizations**	**Quantity Limitations**	**Vessel Stowage Requirements**
Hazard Class: 3	**a) Exceptions:** 150	**a) Passenger Aircraft or Railcar:** 5L	**Vessel Stowage:** B
.: UN1294	**b) Non-bulk Packaging:** 202	**b) Cargo Aircraft Only:** 60L	**Other:** --
DOT Packing Group: II	**c) Bulk Packaging:** 242		
DOT Label: Flammable Liquid			
Special Provisions (172.102): T1			

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 140, 148, 153, 159, 163, 164, 167, 169, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** PA Roy, CIH, MPH; **Medical Review:** AC Darlington, MD, MPH

Material Safety Data Sheet

from Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 679

1,1,2-TRICHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

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Material Name: 1,1,2-TRICHLOROETHANE

Description (Origin/Uses): Prepared by the catalytic chlorination of ethane or ethylene. Used as a solvent for fats, waxes, natural resins, and alkaloids.

Other Designations: ß-Trichloroethane; Ethane Trichloride; Vinyl Trichloride; $CH_2ClCHCl_2$; CAS No. 0079-00-5

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

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Genium

HMIS
H 1
F 0
R 0
PPG*
*See sect. 8

R 1
I 4
S 2
K 0

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
1,1,2-Trichloroethane, CAS No. 0079-00-5 *This material can be absorbed through intact skin, which contributes to overall exposure. **See NIOSH, *RTECS* (KJ3150000), for additional data with references to irritative, tumorigenic, and mutagenic effects.	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 10 ppm, 45 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 10 ppm, 45 mg/m³ **NIOSH REL** Lowest Feasible Level **Toxicity Data**** Rat, Oral, LD_{50}: 580 mg/kg Rat, Inhalation, LC_{Lo}: 500 ppm (8 Hrs)

SECTION 3. PHYSICAL DATA

Boiling Point: 237°F (114°C)
Melting Point: -33°F (-36°C)
% Volatile by Volume: 100
Vapor Pressure: 19 Torrs at 68°F (20°C)

Molecular Weight: 133 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity (H_2O = 1): 1.4416 at 68°F (20°C)

Appearance and Odor: A colorless, nonflammable liquid; sweet, pleasant odor resembling chloroform.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2-Trichloroethane does not burn. Use an extinguishing agent such as "alcohol" foam, water spray, carbon dioxide, or dry chemical to put out the surrounding fire.

Unusual Fire or Explosion Hazards: None reported.

Special Fire-fighting Procedures: Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode to protect against the harmful effects of the surrounding fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2-Trichloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur.

Chemical Incompatibilities: 1,1,2-Trichloroethane can react dangerously with strong caustics such as sodium hydroxide and chemically active metals such as sodium, potassium, powdered magnesium, aluminum, and sodium-potassium alloys.

Conditions to Avoid: Prevent exposure to these incompatible materials.

Hazardous Products of Decomposition: Thermal-oxidative degradation of this liquid can produce toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: 1,1,2-Trichloroethane is not listed as a carcinogen by the NTP, IARC, or OSHA.
Summary of Risks: Inhaling 1,1,2-trichloroethane vapor or absorbing the liquid through the skin depresses the central nervous system (CNS), which can progress to narcosis. Administration of this liquid to experimental animals has produced liver damage (fatty degeneration) and has induced cancer of the liver in mice. 1,1,2-Trichloroethane is 10 to 20 times more toxic than the trichloroethylene congener. **Medical Conditions Aggravated by Long-Term Exposure:** Persons with a history of chronic respiratory, liver, or kidney disease may be at increased risk from exposure to this liquid. Preplacement questionnaires are recommended. **Target Organs:** Skin, eyes, CNS, respiratory system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** Irritation of skin, eyes, nose, throat, and mucous membranes; and anesthesia manifested by CNS effects such as headache, dizziness, drowsiness, and incoordination. **Chronic Effects:** Liver and kidney damage and eventually coma and death may occur. Removal from exposure will reverse this progression.
FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. **Skin.** Rinse the affected area with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel should wear protective clothing and equipment (see sect. 8). Soak up the spilled 1,1,2-trichloroethane onto a suitable absorbent such as vermiculite or sawdust and place it into containers suitable for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).

EPA Designations (40 CFR 302.4)
RCRA Waste, No. U227
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, and gauntlets, etc., to prevent skin contact with 1,1,2-trichloroethane. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale 1,1,2-trichloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2-trichloroethane in closed containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Storage facilities must have adequate ventilation because this volatile liquid can evaporate and build up hazardous concentrations in these areas.

Transportation Data (49 CFR 172.101-2): Not Listed

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

Prepared by PJ Igoe, BS
Industrial Hygiene Review: DJ Wilson, CIH
Medical Review: W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 312
Trichloroethylene

Issued: 7/79 Revision: F, 9/92

Section 1. Material Identification

39

Trichloroethylene (C_2HCl_3) Description: Derived by treating tetrachloroethane with lime or other alkali in the presence of water, or by thermal decomposition of tetrachloroethane followed by steam distillation. Stabilizers such as epichlorohydrin, isobutanol, carbon tetrachloride, chloroform, benzene, or pentanol-2-triethanolamine are then added. Used as a degreasing solvent in electronics and dry cleaning, a chemical intermediate, a refrigerant and heat-exchange liquid, and a diluent in paint and adhesives; in oil, fat, and wax extraction and in aerospace operations (flushing liquid oxygen). Formerly used as a fumigant (food) and anesthetic (replaced due to its hazardous decomposition in closed-circuit apparatus).

Other Designations: CAS No. 79-01-6; acetylene trichloride; Algylen; Anamenth; Benzinol; Cecolene; Chlorylen; Dow-Tri; ethylene trichloride; Germalgene; Narcogen; Triasol; trichloroethene; TCE; 1,1,3-trichloroethylene.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: TCE is irritating and toxic to the central nervous system (CNS). Inhalation of high concentrations have lead to death due to ventricular fibrillation. Chronic exposure may lead to heart, liver, and kidney damage. The liquid is absorbed through the skin. Although it has a relatively low flash point, TCE burns with difficulty.

R 1
I 2
S 2*
K 3
* Skin absorption

NFPA

HMIS
H 2†
F 2
R 0
PPE‡
† Chronic Effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Trichloroethylene, < 100% [contains stabilizers (Sec. 1)].

1991 OSHA PELs
8-hr TWA: 50 ppm (270 mg/m^3)
15-min STEL: 200 ppm (1080 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH REL
10-hr TWA: 25 ppm (~135 mg/m^3)

1992-93 ACGIH TLVs
TWA: 50 ppm (269 mg/m^3)
STEL: 200 ppm (1070 mg/m^3)

1990 DFG (Germany) MAK
Ceiling: 50 ppm (270 mg/m^3)
Category II: Substances with systemic effects
Half-life: 2 hr to shift length
Peak Exposure Limit: 250 ppm, 30 min average value; 2 peaks/shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 160 ppm/83 min caused hallucinations and distorted perceptions.
Human, lymphocyte: 5 mL/L caused DNA inhibition.
Rabbit, skin: 500 mg/24 hr caused severe irritation.
Rabbit, eye: 20 mg/24 hr caused moderate irritation.
Mouse, oral, TD_{Lo}: 455 mg/kg administered intermittently for 78 weeks produced liver tumors.

* See NIOSH, *RTECS* (KX4550000), for additional irritation, mutation, reproductive, tumorigenic and toxicity data.

Section 3. Physical Data

Boiling Point: 189 °F (87 °C)
Freezing Point: -121 °F (-85 °C)
Viscosity: 0.0055 Poise at 77 °F (25 °C)
Molecular Weight: 131.38
Density: 1.4649 at 20/4 °C
Refraction Index: 1.477 at 68 °F (20 °C/D)
Odor Threshold: 82 to 108 ppm (*not an effective warning*)

Vapor Pressure: 58 mm Hg at 68 °F (20 °C); 100 mm Hg at 32 °F (0 °C)
Saturated Vapor Density (Air = 0.075 lbs/ft^3; 1.2 kg/m^3): 0.0956 lbs/ft^3; 1.53 kg/m^3
Water Solubility: Very slightly soluble; 0.1% at 77 °F (25 °C)
Other Solubilities: Highly soluble in organic solvents (alcohol, acetone, ether, carbon tetrachloride, & chloroform) and lipids.
Surface Tension: 29.3 dyne/cm

Appearance and Odor: Clear, colorless (sometimes dyed blue), mobile liquid with a sweet chloroform odor.

Section 4. Fire and Explosion Data

Flash Point: 90 °F (32 °C) CC	**Autoignition Temperature:** 788 °F (420 °C)	**LEL:** 8% (25 °C); 12.5% (100 °C)	**UEL:** 10% (25 °C); 90% (100 °C)

Extinguishing Media: A Class 1C Flammable Liquid. Although it has a flash point of 90 °F, TCE burns with difficulty. For small fires, use dry chemical, carbon dioxide, water spray, or regular foam. For large fires, use water spray, fog, or regular foam. **Unusual Fire or Explosion Hazards:** Vapor/air mixtures may explode when ignited. Container may explode in heat of fire. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighters' protective clothing provides only limited protection against TCE. Apply cooling water to sides of container until well after fire is out. Stay away from ends of tanks. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: TCE slowly decomposes in the presence of light and moisture to form corrosive hydrochloric acid. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Include alkalis (sodium hydroxide), chemically active metals (aluminum, beryllium, lithium, magnesium, sodium, potassium, and titanium), epoxides, and oxidants (nitrogen tetraoxide, perchloric acid). Contact with 1-chloro-2,3-epoxy propane or the mono and di 2,3-epoxypropyl ethers of 1,4-butanediol + 2,2-bis-4(2',3'-epoxypropoxy)-phenylpropane can, in the presence of catalytic quantities of halide ions, cause dehydrochlorination of TCE to explosive dichloroacetylene. **Conditions to Avoid:** Exposure to light, moisture, ignition sources, and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of TCE (above 300 °C) or exposure to ultraviolet light can produce carbon dioxide (CO_2) and toxic dichloro acetylene (explosive), chlorine, hydrogen chloride, and phosgene gas.

Section 6. Health Hazard Data

Carcinogenicity: The following agencies have rated TCE's carcinogenicity: IARC (Class 3, limited animal evidence & insufficient human data), Germany MAK (Class B, justifiably suspected of having carcinogenic potential), & NIOSH (Class X, carcinogen defined with no further categorization). **Summary of Risks:** TCE vapor is irritating to the eyes, nose, and respiratory tract and inhalation of high concentrations can lead to severe CNS effects such as unconsciousness, ventricular arrythmias, and death due to cardiac arrest. Mild liver dysfunction was also seen at levels high enough to produce CNS effects. Contact with the liquid is irritating to the skin and can lead to dermatitis by defatting the skin. Chronic toxicity is observed in the victims increasing intolerance to alcohol characterized by 'degreasers flush', a transient redness of the face, trunk, and arms. The euphoric effect of TCE has led to craving, and habitual sniffing of its vapors.

Continue on next page

Section 6. Health Hazard Data, *Continued*

TCE crosses the placental barrier and thus exposes the fetus (any effects are yet unknown). There are increased reports of menstrual disorders in women workers and decreased libido in males at exposures high enough to cause CNS effects. TCE is eliminated unchanged in expired air and as metabolites (trichloroacetic acid & trichloroethanol) in blood and urine. **Medical Conditions Aggravated by Long-Term Exposure:** Disorders of he nervous system, skin, heart, liver, and kidney. **Target Organs:** Respiratory, central & peripheral nervous, and cardiovascular (heart) systems, liver, kidney, and skin. **Primary Entry Routes:** Inhalation, skin and eye contact, and ingestion (rarely). **Acute Effects:** Vapor inhalation can cause eye, nose, and throat irritation, nausea, blurred vision, overexcitement, headache, drunkenness, memory loss, irregular heartbeat (resulting in sudden death), unconsciousness, and death due to cardiac failure. Skin contact with the liquid can cause dryness and cracking and prolonged exposure (generally if the victim is unconscious) can cause blistering. Eye contact can cause irritation and watering, with corneal epithelium injury in some cases. Ingestion of the liquid can cause lip, mouth, and gastrointestinal irritation, irregular heartbeat, nausea and vomiting, diarrhea (possibly blood-stained), drowsiness, and risk of pulmonary edema (fluid in lungs). **Chronic Effects:** Effects may persist for several weeks or months after repeated exposure. Symptoms include giddiness, irritability, headache, digestive disturbances, mental confusion, intolerance to alcohol (degreasers flush), altered color perception, loss or impairment of sense of smell, double vision, and peripheral nervous system function impairment including persistent neuritis, temporary loss of sense of touch, and paralysis of the fingers from direct contact with TCE liquid.

FIRST AID **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, have that *conscious and alert* person drink 1 to 2 glasses of water, then induce vomiting. Do not give milk, as its fat content (TCE is lipid soluble) may inhance gastrointestinal absorption of TCE. **Note to Physicians:** TCE elimination seems to be triphasic with half lives at 20 min, 3 hr, and 30 hr. Some success is seen in treating patients with propranolol, atropine, and disulfiram. Monitor urine and blood (lethal level = 3 to 110 µg/mL) metabolites. BEI = 100 mg/g creatinine (trichloroacetic acid) in urine, *sample at end of workweek.* BEI = 4 mg/L (trichloroethanol) in blood, *sample at end of shift at end of the workweek.* These tests are not 100% accurate indicators of exposure; monitor TCE in expired air as a confirmatory test.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Immediately notify safety personnel, isolate and ventilate area, deny entry, and stay upwind. Shut off all ignition sources. For small spills, take up with earth, sand, vermiculite, or other absorbent, noncombustible material and place in suitable container for later disposal. For large spills, flush to containment area where density stratification will form a bottom TCE layer which can be pumped and containerized. Report any release in excess of 1000 lbs. Follow applicable OSHA regulations (29 CFR 1910.120). **Ecotoxicity Values:** Bluegill sunfish, LC_{50} = 44,700 µg/L/96 hr; fathead minnow (*Pimephales promelas*), LC_{50} = 40.7 mg/L/96 hr. **Environmental Degradation:** In air, TCE is photooxidized with a half-life of 5 days and reported to form phosgene, dichloroacetyl chloride, and formyl chloride. In water it evaporates rapidly in minutes to hours. TCE rapidly evaporates and may leach since it does not absorb to sediment. **Soil Absorption/Mobility:** TCE has a Log K_{oc} of 2, indicating high soil mobility. **Disposal:** Waste TCE can be poured on dry sand and allowed to vaporize in isolated location, purified by distillation, or returned to supplier. A potential candidate for rotary kiln incineration at 1508 to 2912 °F (820 to 1600 °C) with an acid scrubber to remove halo acids. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations

ARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33 & 261.31): No. U228 & F002 (*spent solvent*)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 100 lb (45.4 kg) [* per RCRA, Sec. 3001, CWA Sec. 311 (b)(4), & CWA Sec. 307 (a)]

OSHA Designations

Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear chemical safety goggles (cup-type or rubber framed, equipped with impact-resistant glass), per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. At any detectable concentration, wear a SCBA with a full facepiece operated in pressure demand or other positive pressure mode. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* If respirators are used, OSHA requires a respiratory protection program that includes at least: medical certification, training, fit-testing, periodic environmental monitoring, maintenance, inspection, cleaning, and convenient, sanitary storage areas. **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets made from Viton or Neoprene to prevent skin contact. *Do not* use natural rubber or polyvinyl chloride (PVC). **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.[103] **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes and launder before reuse. Remove this material from your shoes and clean personal protective equipment. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Prevent physical damage to containers. Store in steel drums, in a cool, dry, well-ventilated area away from sunlight, heat, ignition sources, and incompatibles (Sec. 5). Store large quantities in galvanized iron, black iron, or steel containers; small amounts in dark (amber) colored glass bottles. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Design processes so that the operator is not directly exposed to the solvent or its vapor. Do not use open electric heaters, high-temperature processes, arc-welding or open flames in TCE atmospheres. **Administrative Controls:** Consider preplacement and periodic medical exams of exposed workers with emphasis on skin, respiratory, cardiac, central and peripheral nervous systems, and liver and kidney function. Employ air and biological monitoring (BEIs). Instruct employees on safe handling of TCE.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Trichloroethylene
OT Hazard Class: 6.1
D No.: UN1710
DOT Packing Group: III
DOT Label: Keep Away From Food
DOT Special Provisions (172.102): N36, T1

Packaging Authorizations
a) Exceptions: 173.153
b) Non-bulk Packaging: 173.203
c) Bulk Packaging: 173.241

Quantity Limitations
a) Passenger Aircraft or Railcar: 60L
b) Cargo Aircraft Only: 220L

Vessel Stowage Requirements
a) Vessel Stowage: A
b) Other: 40

MSDS Collection **References:** 26, 73, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 168, 171, 174, 175, 176, 180.
Prepared by: M Gannon, BA; **Industrial Hygiene Review:** D Wilson, CIH; **Medical Review:** AC Darlington, MD

Material Safety Data Sheet

from Genium's Reference Collection
Genium Publishing Corporation
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GENIUM PUBLISHING CORP.

No. 677

1,1,2,2-TETRACHLOROETHANE

Issued: November 1988

SECTION 1. MATERIAL IDENTIFICATION

27

Material Name: 1,1,2,2-TETRACHLOROETHANE

Genium

Description (Origin/Uses): Used as a solvent primarily for cleaning and extraction procedures and as a chemical intermediate in the manufacture of trichloroethylene and tetrachloroethylene; and as an analytic reagent by textile manufacturers in polymer characterization tests.

Other Designations: Acetylene Tetrachloride; *sym*-Tetrachloroethane; $CHCl_2CHCl_2$; CAS No. 0079-34-5

Manufacturer: Contact your supplier or distributor. Consult the latest edition of the *Chemicalweek Buyers' Guide* (Genium ref. 73) for a list of suppliers.

HMIS			
H	2	R	1
F	0	I	4
R	0	S	–
PPG*		K	–

*See sect. 8

SECTION 2. INGREDIENTS AND HAZARDS

SECTION 2. INGREDIENTS AND HAZARDS	%	EXPOSURE LIMITS
1,1,2,2-Tetrachloroethane, CAS No. 0079-34-5 *This material can be absorbed through intact skin, which contributes to overall exposure. **See NIOSH, *RTECS* (KI8575000), for additional data with references to reproductive, tumorigenic, and irritative effects.	Ca 100	**OSHA PEL (Skin*)** 8-Hr TWA: 1 ppm, 7 mg/m³ **ACGIH TLV (Skin*), 1988-89** TLV-TWA: 1 ppm, 7 mg/m³ **Toxicity Data**** Human, Oral, TD_{Lo}: 30 mg/kg Human, Inhalation, TC_{Lo}: 1000 mg/m³ (30 Mins) Rat, Oral, LD_{50}: 800 mg/kg

SECTION 3. PHYSICAL DATA

Boiling Point: 295°F (146°C)
Melting Point: -47°F (-44°C)
% Volatile by Volume: Ca 100
Vapor Pressure: 6 Torrs at 77°F (25°C)*

Molecular Weight: 168 Grams/Mole
Solubility in Water (%): Insoluble
Specific Gravity ($H_2O = 1$): 1.58658 at 77°F (25°C)

Appearance and Odor: A colorless, nonflammable, heavy, mobile liquid; sweetish, suffocating, characteristic chloroform odor. The odor recognition threshold is reported to be less than 3 ppm.

*At 77°F (25°C) the concentration of 1,1,2,2-tetrachloroethane in saturated air is approximately 7900 ppm.

SECTION 4. FIRE AND EXPLOSION DATA

Flash Point*	Autoignition Temperature*	LEL*	UEL*

Extinguishing Media: *1,1,2,2-Tetrachloroethane does not burn. Use extinguishing agents that will put out the surrounding fire. **Unusual Fire or Explosion Hazards:** None reported. **Special Fire-fighting Procedures:** Wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode to protect against the effects of the nearby fire.

SECTION 5. REACTIVITY DATA

Stability/Polymerization: 1,1,2,2-Tetrachloroethane is stable in closed containers during routine operations at room temperature. Hazardous polymerization cannot occur. **Chemical Incompatibilities:** Hazardous reactions between 1,1,2,2-tetrachloroethane and 2,4-dinitrophenyl disulfide, nitrogen tetroxide, chemically active metals such as potassium; and strong caustics such as potassium hydroxide, sodium, sodium-potassium alloy, hot iron, aluminum, and zinc in the presence of steam are reported. **Conditions to Avoid:** Prevent exposure to the incompatible chemicals listed above. Contact with water causes appreciable hydrolysis that will degrade and decompose this liquid. **Hazardous Products of Decomposition:** Thermal-oxidative degradation of 1,1,2,2-tetrachloroethane can produce highly toxic gases such as carbon monoxide (CO) and oxides of chlorine (ClO_x).

SECTION 6. HEALTH HAZARD INFORMATION

Carcinogenicity: NIOSH lists 1,1,2,2-tetrachloroethane as a carcinogen.
Summary of Risks: 1,1,2,2-Tetrachloroethane is absorbed through intact skin in significant amounts; one human fatality has been attributed to this route of exposure. This liquid is considered to be one of the most toxic of the common chlorinated hydrocarbons, particularly with respect to the liver. Severely acute exposure causes depression of the central nervous system (CNS), which can cause death within 12 hours. **Medical Conditions Aggravated by Long-Term Exposure:** None reported. **Target Organs:** Skin, eyes, respiratory system, CNS, gastrointestinal system, liver, and kidneys. **Primary Entry:** Inhalation, skin contact/absorption. **Acute Effects:** The initial symptoms of exposure are lacrimation, salivation, and irritation of the nose and throat; continued exposure can lead to nausea, vomiting, and narcosis. Also, low blood pressure and cardiac rhythm abnormalities; respiratory depression; nausea, vomiting, burns of the esophagus, and diarrhea; and anesthesia with dizziness leading to loss of consciousness and coma; plus possible transient liver and kidney changes.
Chronic Effects: The two sets of manifestations are (1) malaise, drowsiness, decreased appetite, then nausea and retching, a bad taste in the throat, constipation, headache, pale stools, jaundice, and dark urine, as well as mental confusion, stupor, and coma; and (2) hand

SECTION 6. HEALTH HAZARD INFORMATION, cont.

tremors, sensation of deafness, numbness in hands and feet, a decrease in reflexes, headache, and nausea. FIRST AID: Eyes. Immediately flush eyes, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 minutes. Skin. Rinse the affected areas with flooding amounts of water, then wash it with soap and water. **Inhalation.** Remove the exposed person to fresh air; restore and/or support his or her breathing as needed. Have qualified medical personnel administer oxygen as required. Keep the exposed person warm and at rest until medical help is available. **Ingestion.** Unlikely. Should this type of exposure occur, give the exposed person 3 glasses of water to drink and induce vomiting, then repeat this procedure. **Get medical help (in plant, paramedic, community) for all exposures.** Seek prompt medical assistance for further treatment, observation, and support after first aid. **Note to Physician:** Workers exposed to this liquid should be evaluated with a full battery of tests for the liver, kidneys, and CNS systems, as well as the blood.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Spill/Leak: Notify safety personnel, evacuate unnecessary personnel, and provide adequate ventilation. Cleanup personnel must be properly clothed and equipped to protect the skin and eyes against any contact with the liquid as well as inhalation of its vapor (see sect. 8). Vacuum the spilled 1,1,2,2-tetrachloroethane and pump it into suitable containers for disposal. **Waste Disposal:** Contact your supplier or a licensed contractor for detailed recommendations. Follow Federal, state, and local regulations.

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000 Subpart Z).
EPA Designations (40 CFR 302.4)
RCRA Waste, No. U209
CERCLA Hazardous Substance, Reportable Quantity: 1 lb (0.454 kg), per the Clean Water Act (CWA), § 307 (a); and the Resource Conservation and Recovery Act (RCRA), § 3001.

SECTION 8. SPECIAL PROTECTION INFORMATION

Goggles: Always wear protective eyeglasses or chemical safety goggles. Where splashing of this liquid is possible, wear a full face shield. Follow OSHA eye- and face-protection regulations (29 CFR 1910.133). **Respirator:** Use a NIOSH-approved respirator per Genium reference 88 for the maximum-use concentrations and/or the exposure limits cited in section 2. Follow OSHA respirator regulations (29 CFR 1910.134). For emergency or nonroutine operations (spills or cleaning reactor vessels and storage tanks), wear an SCBA. **Warning:** Air-purifying respirators will *not* protect workers in oxygen-deficient atmospheres. **Other:** Wear impervious gloves, boots, aprons, gauntlets, etc., to prevent skin contact with this liquid. **Ventilation:** Install and operate general and local ventilation systems powerful enough to maintain airborne levels of this material below the OSHA PEL standard cited in section 2. Local exhaust ventilation is preferred because it prevents dispersion of the contaminant into the general work area by eliminating it at its source. Consult the latest edition of Genium reference 103 for detailed recommendations. **Safety Stations:** Make emergency eyewash stations, safety/quick-drench showers, and washing facilities available in work areas. **Contaminated Equipment:** Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. Do *not* wear contact lenses in any work area. Remove contaminated clothing and launder it before wearing it again; clean this material from your shoes and equipment. **Comments:** Practice good personal hygiene; always wash thoroughly after using this material and before eating, drinking, smoking, using the toilet, or applying cosmetics. Keep it off your clothing and equipment. Avoid transferring it from your hands to your mouth while eating, drinking, or smoking. Do *not* eat, drink, or smoke in any work area. Do not inhale 1,1,2,2-tetrachloroethane vapor.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Storage/Segregation: Store 1,1,2,2-tetrachloroethane in closed, airtight containers in a cool, dry, well-ventilated area away from incompatible chemicals (see sect. 5). **Special Handling/Storage:** Provide storage areas with adequate ventilation to prevent concentrations of the vapor from building up beyond the occupational exposure limits cited in section 2.

Transportation Data (49 CFR 172.101-2)

DOT Shipping Name: Tetrachloroethane
DOT Hazard Class: ORM-A
ID No. UN1702
DOT Packaging Requirements: 49 CFR 173.620
DOT Packaging Exceptions: 49 CFR 173.505

IMO Shipping Name: 1,1,2,2-Tetrachloroethane
IMO Hazard Class: 6.1
IMO Label: Poison
IMDG Packaging Group: II

References: 1, 38, 84-94, 100, 116, 117, 120, 122.

Prepared by: PJ Igoe, BS
Industrial Hygiene Review: DJ Wilson, CIH
Medical Review: W Silverman, MD

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Material Safety Data Sheets Collection:

Sheet No. 703
1,2-Dichloroethylene

Issued: 4/90

Section 1. Material Identification

31

1,2-Dichloroethylene Description: An industrial solvent composed of 60% cis- and 40% trans-isomers. Both isomers, cis and trans, are made by partial chlorination of acetylene. Used as a general solvent for organic materials, lacquers, dye extraction, thermoplastics, organic synthesis, and perfumes. The trans-isomer is more widely used in industry than either the cis-isomer or the mixture. Toxicity also varies between the two isomers.
Other Designations: CAS No. 0540-59-0; $C_2H_2Cl_2$; acetylene dichloride; *cis*-1,2-dichloroethylene; *sym*-dichloroethylene; *trans*-1,2-dichloroethylene, dioform.
Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

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K	1

NFPA

HMIS

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F	3
R	1
PPG*	

* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

1,2-Dichloroethylene, ca 100%

OSHA PEL
8-hr TWA: 790 mg/m^3, 200 ppm

ACGIH TLV, 1989-90
TLV-TWA: 790 mg/m^3, 200 ppm

NIOSH REL, 1987
790 mg/m^3, 200 ppm

Toxicity Data*
Rat, oral, LD_{50}: 770 mg/kg; toxic effects not yet reviewed
Frog, inhalation, TC_{Lo}: 117 mg/m^3 inhaled for 1 hr affects the peripheral nerve and sensation (flaccid paralysis without anesthesia); behavior (excitement); lungs, thorax, or respiration (respiratory depression)

* See NIOSH, *RTECS* (KV9360000), for additional toxicity data.

Section 3. Physical Data

Boiling Point: 119 °F/48 °C
Melting Point: -56 to -115 °F/-49 to -82 °C/
Vapor Pressure: 180 to 264 torr at 68 °F/20 °C
Vapor Density (Air = 1): 3.4

Molecular Weight: 96.95 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.27 at 77 °F/25 °C
Water Solubility: Insoluble

Appearance and Odor: A colorless, low-boiling liquid with a pleasant odor.

Section 4. Fire and Explosion Data

Flash Point: 37 °F/2.8 °C, CC	**Autoignition Temperature:** 860 °F/460 °C	**LEL:** 5.6% v/v	**UEL:** 12.8% v/v

Extinguishing Media: Use dry chemical, CO_2, halon, water spray, or standard foam. Water may be ineffective unless used to blanket the fire.
Unusual Fire or Explosion Hazards: This material's vapors are a dangerous fire hazard and moderate explosion hazard when exposed to any heat or ignition source or oxidizer.
Special Fire-fighting Procedures: Since fire may produce toxic fumes, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode and a fully encapsulating suit. Vapors may travel to heat or ignition sources and flash back. Stay upwind and out of low areas. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: This material is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur.
Chemical Incompatibilities: This material is incompatible with alkalies, nitrogen tetraoxide, difluoromethylene, strong oxidizers, and dihypofluorite. When in contact with copper or copper alloys or by reaction with potassium hydroxide, explosive chloroacetylene may be released.
Conditions to Avoid: Addition of hot liquid to cold 1,2-dichloroethylene may cause sudden emission of vapor that could flash back to an ignition source.
Hazardous Products of Decomposition: Thermal oxidative decomposition of 1,2-dichloroethylene can produce highly toxic fumes of chlorine (Cl^-).

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Material Safety Data Sheets Collection:

Sheet No. 708
Vinylidene Chloride

Issued: 4/90

Section 1. Material Identification 31

Vinylidene Chloride Description: Prepared from ethylene chloride. Also prepared from vinyl chloride by successive chlorination and dehydrochlorination steps. Used primarily as a co-monomer in producing vinylidene copolymers (Saran®, Velon®) for films and coatings. Also used in producing methyl chloroform, vinyl chloride resins, plastics, chloracetyl chloride; in adhesives; as a component of synthetic fibers; a chemical intermediate in vinylidene fluoride synthesis; and for 1,1,1-trichloroethane. A common constituent in our environment, measurable quantities of vinylidene chloride are found in poorly ventilated areas with a high concentration of plastics. It is a notable contaminant in recycled air environments such as nuclear submarines and spacecraft.

Other Designations: CAS No. 0075-35-4; $C_2H_2Cl_2$; 1,1-DCE; 1,1-dichloroethene; *asym*-dichloroethylene; VDC; vinylidene dichloride.

Manufacturer: Contact your supplier or distributor. Consult the latest *Chemicalweek Buyers' Guide*[73] for a suppliers list.

Comment: At temperatures above 32 °F/0 °C and especially in the presence of oxygen or other suitable catalysts, vinylidene chloride polymerizes to a plastic. Therefore, commercial products may contain small proportions of inhibitors to preserve the monomer.

R 3
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K 4

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HMIS
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PPG*
* Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Vinylidene chloride, ca 100%

OSHA PEL
8-hr TWA: 1 ppm, 4 mg/m^3

ACGIH TLVs, 1989-90
TLV-TWA: 5 ppm, 20 mg/m^3
TLV-STEL: 20 ppm, 79 mg/m^3

NIOSH REL, 1987
None established

Toxicity Data*
Mouse, skin, TD_{Lo}: 4840 mg/kg has tumorigenic effects on skin, appendages, lungs, thorax, and respiration
Rat, inhalation, LC_{50}: 6350 ppm/4 hr
Human, inhalation, TC_{Lo}: 25 ppm produces changes in behavior (general anesthetic), the liver, kidney, ureter, and bladder

* See NIOSH, *RTECS* (YZ8061000), for additional mutative, reproductive, tumorigenic, and toxicity data.

Section 3. Physical Data

Boiling Point: 89.1 °F/31.7 °C at 760 mm Hg
Melting Point: -188.5 °F/-122.5 °C
Vapor Pressure: 591 mm Hg at 77 °F/25 °C
Vapor Density (Air = 1): 3.4
Molecular Weight: 96.94 g/mol
Specific Gravity (H_2O = 1 at 39 °F/4 °C): 1.2129 at 68 °F/20 °C
Water Solubility: Sparingly soluble (0.04 % wt/vol in water at 68 °F/20 °C)

Appearance and Odor: Colorless, volatile liquid with a mild, sweet odor that resembles chloroform. Most persons can detect vinylidene chloride at 1000 ppm, but others can detect it at less than 500 ppm. Neither odor is adequate to warn of excessive exposure.

Section 4. Fire and Explosion Data

Flash Point: -19 °F/-28 °C	**Autoignition Temperature:** 1058 °F/570 °C	**LEL:** 5.6% v/v	**UEL:** 11.4% v/v

Extinguishing Media: Use dry chemical, alcohol foam, or carbon dioxide. Use water to cool fire-exposed containers.

Unusual Fire or Explosion Hazards: Vinylidene chloride is a very flammable and volatile liquid with a burning rate of 2.7 mm/min. This material is a very dangerous fire hazard and moderately explosive when exposed to heat or flame. It may explode spontaneously since the vapor forms explosive mixtures with air. At elevated temperatures, polymerization may take place and containers may rupture.

Special Fire-fighting Procedures: Since vinylidene chloride may be poisonous if inhaled or absorbed through the skin, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in the pressure-demand or positive-pressure mode with a fully encapsulating suit. Keep unnecessary people away from the hazard area. Vapors may travel to an ignition source and flash back. Be aware of runoff from fire control methods. Do not release to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Vinylidene chloride is self-reactive. If stored between -40 °F/-40 °C and 77 °F/25 °C in air without an inhibitor, this material rapidly absorbs oxygen and forms a violently explosive peroxide. The heat of polymerization is -185 cal/g (inhibited). When unstable, vinylidene chloride decomposes into chlorine, hydrogen chloride, phosgene, and formaldehyde. Hazardous polymerization can occur if exposed to sunlight, air, copper, aluminum, or heat.

Chemical Incompatibilities: This material reacts violently with chlorosulfonic acid, nitric acid, and oleum; and vigorously with oxidizing materials.

Hazardous Products of Decomposition: Thermal oxidative decomposition of vinylidene chloride can produce highly toxic fumes of chlorine (Cl_2) and hydrogen chloride (HCl).

Section 6. Health Hazard Data

Carcinogenicity: Neither the NTP, IARC, nor OSHA lists vinylidene chloride as a carcinogen, although the ACGIH suggests it is a suspected carcinogen. Various animal studies suggest a high rate of cancer in species-specific testing; application to humans does not appear valid.
Summary of Risks: Vinylidene chloride is an irritant to the skin, eyes, and mucous membranes, although any inhibitor in vinylidene chloride may partly cause the irritation. VDC is narcotic at concentrations greater than 4000 ppm, and has caused liver and kidney injury in experimental animals. Solutions containing the inhibitor MEHQ (monomethyl ether of hydroquinone) may cause leucoderma (white skin) and serious eye injury.
Medical Conditions Aggravated by Long-Term Exposure: None reported.
Target Organs: Skin, eyes, central nervous system, liver, and kidneys.
Primary Entry Routes: Inhalation.
Acute Effects: Inhalation of VDC causes narcosis and respiratory irritation. Concentrations of 4000 ppm lead to symptoms of drunkenness and eventually unconsciousness if the exposure continues. In monkey studies, exposure to 200 ppm caused acute liver injury with a mechanism similar to carbon tetrachloride. Animal studies indicate acute kidney changes in high-level exposures. Eye contact may cause conjunctivitis, transient corneal injury, and iritis. VDC also causes skin and mucous membrane irritation.
Chronic Effects: With chronic inhalation, vinylidene chloride may cause hepatic and renal dysfunction. In monkey studies, long-term inhalation at a 48-ppm level caused liver and kidney damage and death.
FIRST AID
Eyes: Flush immediately, including under the eyelids, gently but thoroughly with flooding amounts of running water for at least 15 min.
Skin: *Quickly* remove contaminated clothing. After rinsing affected skin with flooding amounts of water, wash it with soap and water.
Inhalation: Remove exposed person to fresh air and support breathing as needed.
Ingestion: Never give anything by mouth to an unconscious or convulsing person. If ingested, have a *conscious* person drink 1 to 2 glasses of water, then induce repeated vomiting until vomit is clear.
After first aid, get appropriate in-plant, paramedic, or community medical support.
Physician's Note: Solutions containing increased MEHQ concentrations are caustic and should not be removed by emesis. There is no specific treatment for VDC intoxication, but if significant amounts have been ingested, monitor the patient for liver and kidney failure.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: *Design and practice a vinylidene chloride spill control and countermeasure plan (SCCP).* Notify safety personnel, evacuate all unnecessary personnel from hazard area, remove all heat and ignition sources, and ventilate area. Cleanup personnel should protect against inhalation and skin and eye contact. For lab spills, absorb the spill with paper towels and place in a hood to allow liquid to evaporate. For large spills, absorb bulk spill with cement powder, fly ash, sawdust, or commercial sorbents. Place waste in appropriate disposal containers. Follow applicable OSHA regulations (29 CFR 1910.120).
Disposal: Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.
EPA Designations
RCRA Hazardous Waste (40 CFR 261.33): Not listed
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4), Reportable Quantity (RQ): 5000 lb (2270 kg) [* per Clean Water Act, Sec. 31 (b)(4), Sec. 307(a); per RCRA, Sec. 3001]
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
OSHA Designations
Air Contaminant (29 CFR 1910.1000, Subpart Z): Not listed

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133).
Respirator: Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a NIOSH-approved respirator. Respiratory canisters containing alkaline materials should not be used because dichloro acetylene can be formed. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA.
Warning: Air-purifying respirators do *not* protect workers in oxygen-deficient atmospheres.
Other: Wear impervious gloves, boots, aprons, and gauntlets to prevent skin contact. Rubber gloves are recommended.
Ventilation: Provide general and local explosion-proof ventilation systems to maintain airborne concentrations below the OSHA PEL and ACGIH TLVs (Sec. 2). Local explosion-proof exhaust ventilation is preferred since it prevents contaminant dispersion into the work area by controlling it at its source.(103)
Safety Stations: Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities.
Contaminated Equipment: Never wear contact lenses in the work area: soft lenses may absorb, and all lenses concentrate, irritants. Remove this material from your shoes and equipment. Launder contaminated clothing before wearing.
Comments: Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store vinylidene chloride in tanks with nickel, glass, or baked phenolic linings at 14 °F/-10 °C in the absence of light, air, water, and other polymerization initiators under a nitrogen blanket (at 10-psi pressure and an oxygen content less than 100 ppm). Outside or detached storage is preferable. If stored inside, store in a standard flammable liquids storage cabinet separate from oxidizing materials and incompatible materials (Sec. 5).

Engineering Controls: VDC requires special handling, precautions, and employee training. Do not handle VDC without adequate ventilation and personal protective gear. Limit exposures to vinylidene chloride by improving housekeeping procedures. Keep VDC away from all heat and ignition sources. All engineering systems should be of maximum explosion-proof design, electrically grounded, and bonded.

Transportation Data (49 CFR 172.101, .102)

DOT Shipping Name: Vinylidene chloride, inhibited
DOT Hazard Class: Flammable liquid
ID No.: UN1303
DOT Label: Flammable liquid
DOT Packaging Requirements: 173.119
DOT Packaging Exceptions: 173.118

IMO Shipping Name: Vinylidene chloride, inhibited
IMO Hazard Class: 3.1
IMO Label: Flammable liquid
IMDG Packaging Group: I
ID No.: UN1303

***MSDS Collection* References:** 7, 26, 38, 53, 73, 84, 85, 87, 89, 100, 103, 124, 126, 127, 129, 134, 136
Prepared by: MJ Allison, BS; **Industrial Hygiene Review:** DJ Wilson, CIH; **Medical Review:** W Silverman, MD M8

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Material Safety Data Sheets Collection:

Sheet No. 318
Xylene *(Mixed Isomers)*

Issued: 11/80 Revision: E, 9/92 Errata: 12/94

Section 1. Material Identification

45

Xylene (Mixed Isomers) (C_8H_{10}) Description: The commercial product is a blend of the three isomers [*ortho*-(*o*-), *meta*-(*m*-), *para*-(*p*-)] with the largest proportion being *m*- xylene. Xylene is obtained from coal tar, toluene by transalkylation, and pseudocumene. Used in the manufacture of dyes, resins, paints, varnishes, and other organics; as a general solvent for adhesives, a cleaning agent in microscope technique; as a solvent for Canada balsam microscopy; as a fuel component; in aviation gasoline, protective coatings, sterilizing catgut, hydrogen peroxide, perfumes, insect repellants, pharmaceuticals, and the leather industry; in the production of phthalic anhydride, isophthalic, and terephthalic acids and their dimethyl esters which are used in the manufacture of polyester fibers; and as an indirect food additive as a component of adhesives. Around the home, xylene is found as vehicles in paints, paint removers, degreasing cleaners, lacquers, glues and cements and as solvent/vehicles for pesticides.

Other Designations: CAS No. 1330-20-7 [95-47-6; 108-38-3; 106-42-3 (*o*-, *m*-, *p*-isomers)], dimethylbenzene, methyltoluene, NCI-C55232, Violet 3, xylol.

Manufacturer: Contact your supplier or distributor. Consult latest *Chemical Week Buyers' Guide*(73) for a suppliers list.

Cautions: Xylene is an eye, skin, and mucous membrane irritant and may be narcotic in high concentrations. It is a dangerous fire hazard.

R 1
I 2
S 2
K 3

NFPA
3
2 0
–

HMIS
H 2†
F 3
R 0
PPE ‡
† Chronic Effects
‡ Sec. 8

Section 2. Ingredients and Occupational Exposure Limits

Xylene (mixed isomers): the commercial product generally contains ~ 40% *m*-xylene; 20% each of *o*-xylene, *p*-xylene, and ethylbenzene; and small quantities of toluene. Unpurified xylene may contain pseudocumene.

1991 OSHA PELs
8-hr TWA: 100 ppm (435 mg/m^3)
15-min STEL: 150 ppm (655 mg/m^3)

1990 IDLH Level
1000 ppm

1990 NIOSH RELs
TWA: 100 ppm (435 mg/m^3)
STEL: 150 ppm (655 mg/m^3)

1992-93 ACGIH TLVs
TWA: 100 ppm (434 mg/m^3)
STEL: 150 ppm (651 mg/m^3)
BEI (Biological Exposure Index): Methylhippuric acids in urine at end of shift: 1.5 g/g creatinine

1990 DFG (Germany) MAK
TWA: 100 ppm (440 mg/m^3)
Category II: Substances with systemic effects
Half-life: < 2 hr
Peak Exposure: 200 ppm, 30 min, average value, 4 peaks per shift

1985-86 Toxicity Data*
Human, inhalation, TC_{Lo}: 200 ppm produced olfaction effects, conjunctiva irritation, and other changes involving the lungs, thorax, or respiration.
Man, inhalation, LC_{Lo}: 10000 ppm/6 hr; toxic effects not yet reviewed.
Human, oral, LD_{Lo}: 50 mg/kg; no toxic effect noted.
Rat, oral, LD_{50}: 4300 mg/kg; toxic effect not yet reviewed.
Rat, inhalation, LC_{50}: 5000 ppm/4 hr; toxic effects not yet reviewed.

* See NIOSH, *RTECS* (XE2100000), for additional toxicity data.

Section 3. Physical Data

Boiling Point Range: 279 to 284 °F (137 to 140 °C)*
Boiling Point: *ortho:* 291 °F (144 °C); *meta:* 281.8 °F (138.8 °C); *para:* 281.3 °F (138.5 °C)
Freezing Point/Melting Point: *ortho:* -13 °F (-25 °C); *meta:* -53.3 °F (- 47.4 °C); *para:* 55 to 57 °F (13 to 14 °C)
Vapor Pressure: 6.72 mm Hg at 70 °F (21 °C)
Saturated Vapor Density (Air = 1.2 kg/m^3): 1.23 kg/m^3, 0.077 lbs/ft^3

Appearance and Odor: Clear, sweet-smelling liquid.

* Materials with wider and narrower boiling ranges are commercially available.

Molecular Weight: 106.16
Specific Gravity: 0.864 at 20 °C/4 °C
Water Solubility: Practically insoluble
Other Solubilities: Miscible with absolute alcohol, ether, and many other organic liquids.
Octanol/Water Partition Coefficient: logKow = 3.12-3.20
Odor Threshold: 1 ppm
Viscosity: <32.6 SUS

Section 4. Fire and Explosion Data

Flash Point: 63 to 77 °F (17 to 25 °C) CC	**Autoignition Temperature:** 982 °F (527 °C) (*m*-)	**LEL:** 1.1 (*m*-, *p*-); 0.9 (*o*-)	**UEL:** 7.0 (*m*-, *p*-); 6.7 (*o*-)

Extinguishing Media: For small fires, use dry chemical, carbon dioxide (CO_2), water spray or regular foam. For large fires, use water spray, fog or regular foam. Water may be ineffective. Use water spray to cool fire-exposed containers. **Unusual Fire or Explosion Hazards:** Xylene vapors or liquid (which floats on water) may travel to an ignition source and flash back. The heat of fire may cause containers to explode and/or produce irritating or poisonous decomposition products. Xylene may present a vapor explosion hazard indoors, outdoors, or in sewers. Accumulated static electricity may occur from vapor or liquid flow sufficient to cause ignition. **Special Fire-fighting Procedures:** Because fire may produce toxic thermal decomposition products, wear a self-contained breathing apparatus (SCBA) with a full facepiece operated in pressure-demand or positive-pressure mode. Structural firefighter's protective clothing will provide limited protection. If feasible and without risk, move containers from fire area. Otherwise, cool fire-exposed containers until well after fire is extinguished. Stay clear of tank ends. Use unmanned hose holder or monitor nozzles for massive cargo fires. If impossible, withdraw from area and let fire burn. Withdraw immediately in case of any tank discoloration or rising sound from venting safety device. Do not release runoff from fire control methods to sewers or waterways.

Section 5. Reactivity Data

Stability/Polymerization: Xylene is stable at room temperature in closed containers under normal storage and handling conditions. Hazardous polymerization cannot occur. Xylene is easily chlorinated, sulfonated, or nitrated. **Chemical Incompatibilities:** Incompatibilities include strong acids and oxidizers and 1,3-dichloro-5,5-dimethyl-2,4-imidazolidindione (dichlorohydrantoin). Xylene attacks some forms of plastics, rubber, and coatings. **Conditions to Avoid:** Avoid heat and ignition sources and incompatibles. **Hazardous Products of Decomposition:** Thermal oxidative decomposition of xylene can produce carbon dioxide, carbon monoxide, and various hydrocarbon products.

Section 6. Health Hazard Data

Carcinogenicity: The IARC,(164) NTP,(169) and OSHA(164) do not list xylene as a carcinogen. **Summary of Risks:** Xylene is an eye, mucous membrane, and respiratory tract irritant. Irritation starts at 200 ppm; severe breathing difficulties which may be delayed in onset can occur at high concentrations. It is a central nervous system (CNS) depressant and at high concentrations can cause coma. Kidney and liver damage can occur with xylene exposure. With prolonged or repeated cutaneous exposure, xylene produces a defatting dermatitis. Chronic toxicity is not well defined, but it is less toxic than benzene. Prior to the 1950s, benzene was often found as a contaminant of xylene and the effects attributed to xylene such as blood dyscrasias are questionable. Since the late 1950s, xylenes have been virtually benzene-free and blood dyscrasias have not been associated with xylenes. Chronic exposure to high concentrations of xylene in animal studies have demonstrated mild reversible decrease in red and white cell counts as well as increases in platelet counts.

Continue on next page

Section 6. Health Hazard Data, *continued*

Menstrual irregularity was reported in association with workplace exposure to xylene perhaps due to effects on liver metabolism. Xylene crosses the human placenta, but does not appear to be teratogenic under conditions tested to date. **Medical Conditions Aggravated by Long-Term Exposure:** CNS, respiratory, eye, skin, gastrointestinal (GI) , liver and kidney disorders. **Target Organs:** CNS, eyes, GI tract, liver, kidneys, and skin. **Primary Entry Routes:** Inhalation, skin absorption (slight), eye contact, ingestion. **Acute Effects:** Inhalation of high xylene concentrations may cause dizziness; nausea, vomiting, and abdominal pain; eye, nose, and throat irritation; respiratory tract irritation leading to pulmonary edema (fluid in lung); drowsiness; and unconsciousness. Direct eye contact can result in conjunctivitis and corneal burns. Ingestion may cause a burning sensation in the oropharynx and stomach and transient CNS depression. **Chronic Effects:** Repeated or prolonged skin contact may cause drying and defatting of the skin leading to dermatitis. Repeated eye exposure to high vapor concentrations may cause reversible eye damage, peripheral and central neuropathy, and liver damage. Other symptoms of chronic exposure include headache, fatigue, irritability, chronic bronchitis, and GI disturbances such as nausea, loss of appetite, and gas.

FIRST AID *Emergency personnel should protect against exposure.* **Eyes:** *Do not* allow victim to rub or keep eyes tightly shut. Gently lift eyelids and flush immediately and continuously with flooding amounts of water until transported to an emergency medical facility. Consult a physician immediately. **Skin:** *Quickly* remove contaminated clothing. Rinse with flooding amounts of water for at least 15 min. Wash exposed area with soap and water. For reddened or blistered skin, consult a physician. Carefully dispose of contaminated clothing as it may pose a fire hazard. **Inhalation:** Remove exposed person to fresh air and support breathing as needed. Monitor exposed person for respiratory distress. **Ingestion:** Never give anything by mouth to an unconscious or convulsing person. Contact a poison control center and unless otherwise advised, *do not induce vomiting!* If spontaneous vomiting should occur, keep exposed person's head below the hips to prevent aspiration (breathing liquid xylene into the lungs). *Aspiration of a few millimeters of xylene can cause chemical pneumonitis, pulmonary edema, and hemorrhage.* **Note to Physicians:** Hippuric acid or the ether glucuronide of *ortho*-toluic acid may be useful in diagnosis of *meta-*, *para-* and *ortho*-xylene exposure, respectively. Consider gastric lavage if a large quantity of xylene was ingested. Proceed gastric lavage with protection of the airway from aspiration; consider endotracheal intubation with inflated cuff.

Section 7. Spill, Leak, and Disposal Procedures

Spill/Leak: Notify safety personnel, evacuate all unnecessary personnel, remove all heat and ignition sources, and ventilate spill area. Cleanup personnel should protect against vapor inhalation and skin or eye contact. If feasible and without undue risk, stop leak. Use appropriate foam to blanket release and suppress vapors. Water spray may reduce vapor, but does not prevent ignition in closed spaces. For small spills, absorb on paper and evaporate in appropriate exhaust hood or absorb with sand or some non-combustible absorbent and place in containers for later disposal. For large spills dike far ahead of liquid to contain. Do not allow xylene to enter a confined space such as sewers or drains. On land, dike to contain or divert to impermeable holding area. Apply water spray to control flammable vapor and remove material with pumps or vacuum equipment. On water, contain material with natural barriers, booms, or weirs; apply universal gelling agent; and use suction hoses to remove spilled material. Report any release in excess of 1000 lb. Follow applicable OSHA regulations (29 CFR 1910.120). **Environmental Transport:** Little bioconcentration is expected. Biological oxygen demand 5 (after 5 days at 20 °C): 0.64 (no stated isomer). **Ecotoxicity values:** LD_{50}, Goldfish, 13 mg/L/24 hr, conditions of bioassay not specified, no specific isomer. **Environmental Degradation:** In the atmosphere, xylenes degrade by reacting with photochemically produced hydroxyl radicals with a half-life ranging from 1-1.7 hr. in the summer to 10-18 hr in winter or a typical loss of 67-86% per day. Xylenes are resistant to hydrolysis. **Soil Absorption/Mobility:** Xylenes have low to moderate adsorption to soil and when spilled on land, will volatilize and leach into groundwater. **Disposal:** As a hydrocarbon, xylene is a good candidate for controlled incineration. Contact your supplier or a licensed contractor for detailed recommendations. Follow applicable Federal, state, and local regulations.

EPA Designations
SARA Extremely Hazardous Substance (40 CFR 355): Not listed
Listed as a SARA Toxic Chemical (40 CFR 372.65)
Listed as a RCRA Hazardous Waste (40 CFR 261.33): No. U239, F003 (spent solvent)
Listed as a CERCLA Hazardous Substance* (40 CFR 302.4): Final Reportable Quantity (RQ), 1000 lb (454 kg) [* per Clean Water Act, Sec. 311(b)(4); per RCRA, Sec. 3001]

OSHA Designations
Listed as an Air Contaminant (29 CFR 1910.1000, Table Z-1-A)

Section 8. Special Protection Data

Goggles: Wear protective eyeglasses or chemical safety goggles, per OSHA eye- and face-protection regulations (29 CFR 1910.133). Because contact lens use in industry is controversial, establish your own policy. **Respirator:** Seek professional advice prior to respirator selection and use. Follow OSHA respirator regulations (29 CFR 1910.134) and, if necessary, wear a MSHA/NIOSH-approved respirator. For concentrations >1000 ppm, use any chemical cartridge respirator with organic vapor cartridges; any powered, air-purifying respirator with organic vapor cartridges; any supplied-air respirator; or any self-contained breathing apparatus. For emergency or nonroutine operations (cleaning spills, reactor vessels, or storage tanks), wear an SCBA. *Warning! Air-purifying respirators do not protect workers in oxygen-deficient atmospheres.* **Other:** Wear chemically protective gloves, boots, aprons, and gauntlets to prevent all skin contact. With breakthrough times > 8 hr, consider polyvinyl alcohol and fluorocarbon rubber (Viton) as materials for PPE. **Ventilation:** Provide general and local exhaust ventilation systems to maintain airborne concentrations below the OSHA PELs (Sec. 2). Local exhaust ventilation is preferred because it prevents contaminant dispersion into the work area by controlling it at its source.(103) **Safety Stations:** Make available in the work area emergency eyewash stations, safety/quick-drench showers, and washing facilities. **Contaminated Equipment:** Separate contaminated work clothes from street clothes. Launder contaminated work clothing before wearing. Remove this material from your shoes and clean PPE. **Comments:** Never eat, drink, or smoke in work areas. Practice good personal hygiene after using this material, especially before eating, drinking, smoking, using the toilet, or applying cosmetics.

Section 9. Special Precautions and Comments

Storage Requirements: Store in clearly labelled, tightly closed, containers in a cool, well-ventilated place, away from strong oxidizing materials and heat and ignition sources. During transferring operations, electrically ground and bond metal containers. **Engineering Controls:** To reduce potential health hazards, use sufficient dilution or local exhaust ventilation to control airborne contaminants and to maintain concentrations at the lowest practical level. Use hermetically sealed equipment, transfer xylene in enclosed systems, avoid processes associated with open evaporating surfaces, and provide sources of gas release with enclosures and local exhaust ventilation. Use Class I, Group D electrical equipment. **Administrative Controls:** Establish air and biological monitoring programs and evaluate regularly. Consider preplacement and periodic medical examinations including a complete blood count, a routine urinalysis, and liver function tests. Consider hematologic studies if there is any significant contamination of the solvent with benzene. If feasible, consider the replacement of xylene by less toxic solvents such as petrol (motor fuel) or white spirit. Before carrying out maintenance and repair work, steam and flush all equipment to remove any xylene residues.

Transportation Data (49 CFR 172.101)

DOT Shipping Name: Xylenes
DOT Hazard Class: 3
ID No.: UN1307
DOT Packing Group: II
DOT Label: Flammable Liquid
Special Provisions (172.102): T1

Packaging Authorizations
a) Exceptions: 173.150
b) Nonbulk Packaging : 173.202
c) Bulk Packaging: 173.242

Quantity Limitations
a) Passenger, Aircraft, or Railcar: 5L
b) Cargo Aircraft Only: 60L

Vessel Stowage Requirements
a) Vessel Stowage: B
b) Other: –

***MSDS Collection* References:** 26, 73, 89, 100, 101, 103, 124, 126, 127, 132, 133, 136, 139, 140, 148, 149, 153, 159, 163, 164, 167, 171, 174, 176, 180.
Prepared by: MJ Wurth, BS; **Industrial Hygiene Review:** PA Roy, MPH, CIH; **Medical Review:** W Silverman, MD

APPENDIX D
HEAT STRESS/COLD STRESS GUIDELINES

Cold Stress Guidelines

	Symptoms	What to do
Mild Hypothermia	▪ Body Temp 98-90°F ▪ Shivering ▪ Lack of coordination, stumbling, fumbling hands ▪ Slurred speech ▪ Memory loss ▪ Pale, cold skin	▪ Move to warm area ▪ Stay active ▪ Remove wet clothes and replace with dry clothes or blankets ▪ Cover the head ▪ Drink warm (not hot) sugary drink
Moderate Hypothermia	▪ Body temp 90-86°F ▪ Shivering stops ▪ Unable to walk or stand ▪ Confused irrational	▪ All of the above, plus: ▪ Call 911 ▪ Cover all extremities complexly ▪ Place very warm objects, such as hot packs on the victim's head, neck, chest and groin
Severe Hypothermia	▪ Body temp 86-78°F ▪ Severe muscle stiffness ▪ Very sleepy or unconscious ▪ Ice cold skin ▪ Death	▪ Call 911 ▪ Treat victim very gently ▪ Do not attempt to re-warm
Frostbite	▪ Cold, tingling, stinging or aching feeling in the frostbitten area, followed by numbness ▪ Skin color turns red, then purple, then white or very pale skin ▪ Cold to the touch ▪ Blisters in severe cases	▪ Call 911 ▪ Do not rub the area ▪ Wrap in soft cloth ▪ If help is delayed, immerse in warm, not hot, water
Trench Foot	▪ Tingling, itching or burning sensation ▪ Blisters	▪ Soak feet in warm water, then wrap with dry cloth bandages ▪ Drink a warm sugary drink

HEAT STRESS GUIDELINES

Form	Signs & Symptoms	Care	Prevention[3]
Heat Rash	Tiny red vesicles in affected skin area. If the area is extensive, sweating can be impaired.	Apply mild lotions and cleanse the affected area.	Cool resting and sleeping areas to permit skin to dry between heat exposures
Heat Cramps	Spasm, muscular pain (cramps) in stomach area and extremities (arms and legs).	Provide replacement fluids with minerals (salt) such as Gatorade.	Adequate salt intake with meals[1] ACCLIMATIZATION[2]
Heat Exhaustion	Profuse sweating, cool (clammy) moist skin, dizziness, confusion, pale skin color, faint, rapid shallow breathing, headache, weakness, muscle cramps.	Remove from heat, sit or lie down, rest, replace lost water with electrolyte replacement fluids (water, Gatorade) take frequent sips of liquids in amounts greater than required to satisfy thirst.	ACCLIMATIZATION[2] Adequate salt intake with meals [1] only during early part of heat season. Ample water intake, frequently during the day
Heat Stroke	HOT Dry Skin. Sweating has stopped. Mental confusion, dizziness, nausea, severe headache, collapse, delirium, coma.	HEAT STROKE IS A MEDICAL EMERGENCY - Remove from heat. - COOL THE BODY AS RAPIDLY AS POSSIBLE by immersing in cold (or cool) water, or splash with water and fan. Call for Emergency Assistance. Observe for signs of shock.	ACCLIMATIZATION[2] Initially moderate workload in heat (8 to 14 days). Monitor worker's activities.

Footnotes:

1.) American diets are normally high in salt, sufficient to aid acclimatization. However, during the early part of the heat season, (May, June), one extra shake of salt during one to two meals per day may help, so long as this is permitted by your physician. Check with your personal physician.

2.) ACCLIMATIZATION - The process of adapting to heat is indicated by worker's ability to perform hot jobs less fluid loss, lower concentrations of salt loss in sweat, and a reduced core (body) temperature and heart rate.

3.) Method to Achieve Acclimatization - Moderate work or exercise in hot temperatures during early part of heat season. Adequate salt (mineral) and water intake. Gradually increasing work time in hot temperatures. Avoid alcohol. Normally takes 8 to 14 days to achieve acclimatization. Lost rapidly, if removed from strenuous work (or exercise) in hot temperature for more than approximately five days.

Appendix D

Community Air Monitoring Plan

GEI Consultants

Geotechnical
Environmental and
Water Resources
Engineering

Community Air Monitoring Plan

Troy (Liberty Street) Non-Owned Former MGP Site

Troy, New York

Submitted to:
National Grid Company
300 Erie Boulevard West
Syracuse, New York 13202

Submitted by:
GEI Consultants, Inc.
455 Winding Brook Drive
Glastonbury, CT 06033
860-368-5300

June 2013
Project #099330-2-1203

Jerry Zak
Project Manager

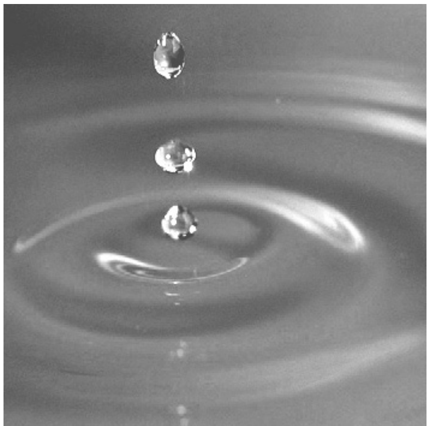

Table of Contents

Tables (in text)

Abbreviations and Acronyms

BTEX	Benzene, toluene, ethylbenzene, xylenes
CAMP	Community Air-Monitoring Plan
COCs	Constituents of Concern
GEI	GEI Consultants, Inc.
HASP	Health and Safety Plan
LEL	Lower Explosive Limit
MGP	Manufactured Gas Plant
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
PAH	Polynuclear Aromatic Hydrocarbon
PID	Photoionization Detector
RA	Remedial Action
RAWP	Remedial Action Work Plan
VOCs	Volatile Organic Compounds
SVOCs	Semvolatile Organic Compounds

MEASUREMENTS

µg/m^3	micrograms per cubic meter
ppm	parts per million

1. Introduction

This document provides the Community Air Monitoring Plan (CAMP) that will be implemented during the Remedial Action (RA) at the Troy Liberty Street Non-Owned Former manufactured gas plant (MGP) site, located on Liberty Street in the City of Troy, New York. The location and layout of the site is shown in Figure 2 of the Remedial Action Work Plan (RAWP).

The Liberty Street MGP site is located in a commercial and residential neighborhood. This CAMP presents methods and procedures that will be used to provide protection to potential receptors by assuring that the investigation work activities do not spread constituents off-site through the air.

The CAMP specifically applies to the RA phase of work for the Liberty Street site. The RA fieldwork is scheduled to be performed in late summer and fall of 2013, as described in the work plan, dated June 2013 to New York State Department of Environmental Conservation (NYSDEC) and New York State Department of Health (NYSDOH) from National Grid.

The RA fieldwork involves the installation of an excavation support system, the excavation of MGP-source material, dewatering, backfill and compaction, restoration activities, and collection of soil samples.

It is possible that follow-on explorations occur, such as test pits, monitoring wells, and soil borings. This CAMP is intended to cover those potential activities as well.

The objectives of this CAMP are to:

- Ensure that the airborne concentrations of constituents of concern (COCs) are minimized to protect human health and the environment;
- Provide an early warning system so that potential emissions can be controlled on site at the source; and
- Measure and document the concentrations of airborne COCs to confirm compliance with regulatory limits.

Air monitoring will be performed around the site perimeter, and will measure the concentrations of organic vapors and dust during all ground-intrusive activities (including excavation, backfill and compaction, restoration and the potential for test pits, soil borings and monitoring well installations).

This CAMP is a companion to GEI Consultants, Inc.'s (GEI's) site-specific Health and Safety Plan (HASP). The HASP is a separate document and is directed primarily toward protection of on-site workers within the designated work zones.

2. Constituents of Concern and Action Levels

The Troy Liberty Street MGP is known to have tar impacts dating from the site's historical use as a MGP. As such, the COCs are volatile and semivolatile organic compounds (VOCs and SVOCs). The primary VOCs of concern are benzene, ethylbenzene, toluene, and xylenes (BTEX). VOCs are more volatile than SVOCs and are generally of greater concern when monitoring the air quality during MGP site investigations.

Airborne dust may also be a concern (though most of the site is paved) and must be monitored and controlled due to its ability to co-transport adsorbed constituents and because of its nuisance properties.

Odors, though not necessarily indicative of high constituent concentrations, could create a nuisance and will be monitored and controlled to the extent practicable.

State and federal regulatory agencies have provided action levels for many of these constituents. The action levels are the allowable concentrations above which respiratory protection or other health and safety controls are required. For work at the Troy Liberty Street MGP site, the following levels should not be exceeded for more than 15 consecutive minutes at the downwind perimeter of the Site:

Benzene	1 part per million (ppm)
Total VOCs	5 ppm
Dust	150 micrograms per cubic meter (µg/m3)

The action levels cited here are above (in addition to) the background ambient (upwind) concentration.

The perimeter and work zone air monitoring will be conducted during intrusive activities. Table 3 below provides a summary of real time air monitoring action levels and contingency plans for work zone activities.

Table 1
Work Zone Air Monitoring Action Levels

Air Monitoring Instrument	Monitoring Location	Action Level	Site Action
Photoionization Detector (PID)	Breathing Zone	0.5 ppm	Use Dräger Chip Measurement System (CMS) tube for benzene or Z-nose® to verify if concentration is benzene.
PID	Breathing Zone	0 - 10 ppm	No respiratory protection is required.
		10 - 250 ppm	Stop work, withdrawal from work area, institute engineering controls, if levels persist Upgrade to Level C.
		> 250 ppm	Stop work, withdraw from work area; notify Project Manager (PM) & Corporate Health and Safety Officer (CHSO).
Oxygen meter (O_2)	Breathing Zone	< 20.75%	Stop work; withdraw from work area; ventilate area, notify PM & CHSO.
		> 21.1%	Stop work; withdraw from work area; notify PM & CHSO.
Hydrogen Sulfide (H_2S) meter	Breathing Zone	<5 ppm	No respiratory protection is required.
		>5 ppm	Stop work, cover excavation, withdraw from work area, institute engineering controls, and notify PM & CHSO.
Hydrogen Cyanide (HCN) meter	Breathing Zone	<1.0 ppm	Run CMS Dräger tube, continue monitoring with real time meter, and continue work if CMS Dräger Tube Reading is less than 2ppm.
		1.0< HCN <2.0 ppm	Run CMS Dräger tube and confirm concentration is less than 2.0 ppm, notify SSO and CHSO. Run CMS Dräger tube for sulfur dioxide, hydrogen sulfide, and phosphine chip potential interferences. Continue to monitor with real time meter.
		>2.0 ppm	Stop work, and move (with continuous HCN monitoring meter) at least 25 feet upwind of the excavation until continuous meter reads less than 1 ppm, Notify PM & CHSO. Run CMS Dräger hydrogen cyanide chip and re-evaluate activity, continue monitoring with a real time meter, resume work if concentrations read less than 1.0 ppm.
Combustible Gas Indicator (CGI)	Excavation/Work Zone	< 10 % Lower Explosive Limit (LEL)	Investigate possible causes, allow excavation to ventilate; use caution during procedures.
		> 10% LEL	Stop work; allow excavation, borehole to ventilate to < 10% LEL; if ventilation does not result in a decrease to < 10% LEL, withdraw from work area; notify PM & CHSO.
Particulate Meter	Excavation/ Work Zone	0.150 ug/m^3	Implement work practices to reduce/minimize airborne dust generation, e.g., spray/misting of soil with water.

3. Air Monitoring Equipment and Methods

Air quality monitoring will be performed for total VOCs, benzene, and dust as outlined below.

Two perimeter locations and one work zone location will be established each day and an air monitoring technician will check the instrumentation at each of these locations frequently during the work. Typically, there will be monitoring locations at one upwind site perimeter location and one downwind perimeter location. Upwind concentrations will be measured at the start of each workday and periodically thereafter to establish background conditions. Field personnel will be prepared to monitor multiple locations in the event that there is little wind or if the wind direction changes frequently.

The monitoring instruments will be calibrated at the start of each work day, and again during the day if the performance of an instrument is in question.

3.1 VOC, Lower Explosive Limit, and Benzene Monitoring

VOC monitoring will be performed using two field photoionization detectors (PIDs) (RAE Systems MiniRAE or equivalent) located at the upwind and downwind stations, and one multi-gas meter (RAE Systems MultiRAE or equivalent) located at the work zone station. The monitoring instruments will be checked by a technician every 15 minutes, and the real-time measurements recorded. The PIDs will be equipped with an audible alarm to indicate exceedance of the action level. The multi-gas meter located at the work zone station is also intended to monitor the lower explosive limit (LEL).

If requested by the NYSDEC, 15-minute running average concentrations may be calculated, which can then be compared to the action levels. If real-time measurements of total VOCs indicate that the action level is exceeded, then the benzene concentration will also be determined at that location using benzene-specific colorimetric tubes.

PID measurements will be made at one upwind and one downwind location around the work area. The locations of the instruments may be changed during the day to adapt to changing wind directions.

3.2 Particulate (Dust) Monitoring

Particulate (dust) monitoring will be performed during any intrusive activity at the Site, including RA activities. Three particulate monitors (TSI DustTrak or equivalent) will be used for continuous real-time dust monitoring at the upwind, downwind, and work zone stations. The monitoring instruments will be checked periodically by a technician, to ensure proper operations and the real-time measurements will be recorded.

In addition, fugitive dust migration will be visually assessed during all work activities, and the observations recorded.

Measurements will be made at one upwind and one downwind location around the work area. The locations of the instruments may be changed during the day to adapt to changing wind directions.

4. Emission Control Plan

Odor, vapor, and dust control will be required for this project due to the close proximity of commercial buildings and public roadways and sidewalks. The attached Table 1 provides a response chart for the monitoring and control of vapor emissions. Table 2 provides a list of emergency contacts.

If the concentration of total VOCs at the site perimeter exceeds 5 ppm (or the benzene level exceeds 1 ppm) above background over a 15-minute period, the work activities will be temporarily halted. If the total VOC level then decreases below 5 ppm (and the benzene level drops below 1 ppm) over background, work activities will resume. If the total VOC levels at the site perimeter persist at levels in excess of 5 ppm (or the benzene level persists over 1 ppm) over background, work activities will be halted, the source of the vapors identified, and corrective actions taken to abate the emissions until the concentrations drop below the action levels.

Site perimeter dust concentrations will also be monitored continuously. In addition, dust migration will be visually assessed during all work activities. If the downwind dust level is 150 $\mu g/m^3$ greater than the background level for a 15-minute period, or if airborne dust is observed leaving the work area, then dust suppression techniques will be employed. Work may continue with dust suppression techniques provided that downwind dust levels do not exceed 150 $\mu g/m^3$ above the background level and provided that no visible dust is migrating from the work area.

Typical emission control measures may include:

- Apply water for dust suppression
- Relocate operations, if applicable
- Reassess the existing control measures

Table 2 Vapor Emission Response Chart

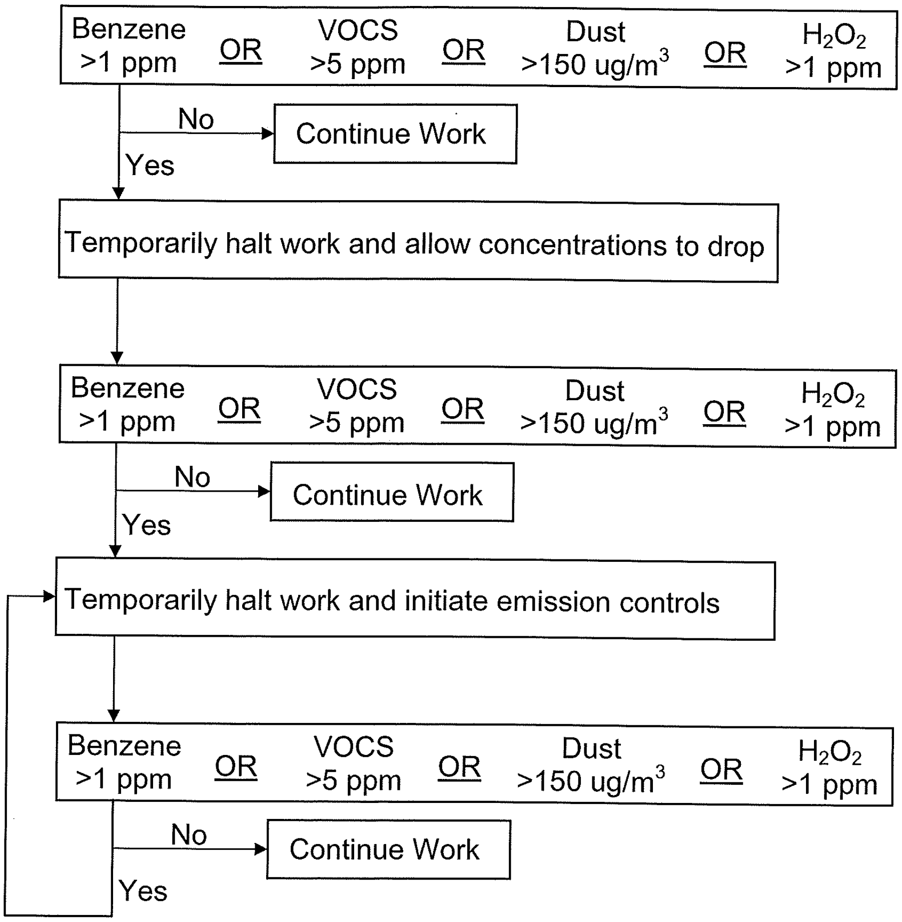

Table 3 Emergency Contacts and Telephone Numbers

Fire:	911	
Police:	911	
Ambulance:	911	
Hospital:	Samaritan Hospital 2215 Burdett Avenue Troy, NY 12304 (518) 271-3300	
GEI Contacts:	Jerry Zak Dan Kopcow	(860) 558-3866 (cell) (607) 206-9075 (cell)
National Grid Contact:	Jim Morgan	(607) 264-7081 (cell)

5. Odor Control Procedures

This section outlines the procedures to be used to control odors that may be generated during the RA and any follow-on field activities. The remedial program will be conducted using techniques that may generate odors including excavation support system installation and excavation and backfill. Subsurface soil borings and monitoring wells may also be installed. The remainder of this section is intended to provide site managers, representatives of NYSDEC and NYSDOH, and the public with information summarizing typical odor control options, and to provide some guidance for their implementation. A description of potential sources of odor and methods to be used for odor control is presented in the following sections.

5.1 Potential Sources of Odors

Generally, the residuals encountered at former MGP sites are well defined. They are related to residual coal tar-like materials and petroleum, and principally contain VOCs, polynuclear aromatic hydrocarbons (PAHs), and a number of inorganic constituents, including metal-complexed cyanide compounds, and metals. Constituents of MGP tar or petroleum products can produce odor emissions during investigation activities when they are unearthed during backhoe test pits or soil borings. When this occurs, VOCs and light-end SVOCs can volatilize into the ambient air. Some MGP residuals can cause distinctive odors that are similar to mothballs, roofing tar, or asphalt driveway sealer. However, the constituent concentrations generally associated with these odors are typically significantly less than levels that might pose a potential health risk. It is important to note that the CAMP will provide for continual monitoring of VOCs and dust during fieldwork to monitor for any potential release of constituents which may pose a threat to health.

5.2 Odor Monitoring

The field investigation personnel will record observations of odors generated during the implementation of the Work Plan. When odors attributable to the uncovering of impacted media are generated in the work area during intrusive activities such as excavation, observations will also be made at the downwind limit of the MGP site, in order to assess the potential for off-site odors. The downwind odor monitoring will be performed in conjunction with the PID and dust monitoring program described in this CAMP.

Upon detection of odors at the site perimeter, site controls, starting in the work area, will be implemented. The site controls described in the following sections will be used to assist with odor mitigation. Note that the goal of the Odor Mitigation Plan is to minimize, and to prevent where practicable, the off-site migration of odors. Due to the short distances between any work area at the Site and the property line, site controls will be implemented proactively when odors are detected in the breathing zone at any work area.

5.3 General Site Controls

Several general excavation or drilling procedure site controls that will be implemented include:

- Every effort will be made to minimize the amount of time that impacted material is exposed to ambient air at the Site.
- Drill cuttings and excavated material will be containerized or covered as soon as possible.
- Meteorological conditions are also a factor in the generation and migration of odors. Some site activities may be limited to times when specific meteorological conditions prevail, such as when winds are blowing away from a specific receptor.

5.4 Secondary Site Controls

If substantial odors still present an issue following implementation of the above procedures, secondary controls will be enacted. The site manager will work through the applicable list of secondary controls until the perimeter odor issues are resolved. The site manager will work closely with National Grid and NYSDEC during this task. Final selection of controls will be dependent on field conditions encountered. Secondary controls include the following:

- For stockpiled impacted soil, temporary tarps or polyethylene covers will be used to control odors.
- The placement of portable barriers close to small active source areas (test pits) can elevate the discharge point of emissions to facilitate dispersion and minimize the effect on downwind receptors. The barriers can be constructed using materials such as plastic “Jersey barriers”, or fence poles and visual barrier fabric/plastic. The barriers are placed as temporary two- or three-sided structures around active test pit or other intrusive investigation areas, oriented such that the barriers are placed on the upwind and downwind sides of the source. If only one side of the source can be accessed, then the barrier should be placed on the downwind side.
- Two agents that can be sprayed over impacted soil have been determined to be effective in controlling emissions. They include odor suppressant solution (BioSolve™), and hydromulch. These agents may be used where tarps cannot be effectively deployed over the source material, or where tarps are ineffective in controlling odors:
    - BioSolve™ can provide immediate, localized control of odor emissions.

- Hydromulch – Although it is unlikely that it will be necessary, a modified hydromulch slurry may be used to cover inactive sources for extended periods of time (up to several days). The hydromulch, typically cellulose fibers (HydroSealR) is modified by mixing a tackifier (glue) with the mulch and water to form a slurry. It is applies using a standard hydroseed applicator to a thickness of ¼ inch. The material forms a sticky, cohesive, and somewhat flexible cover. Reapplication may be necessary if the applied layer becomes desiccated or begins to crack.

5.5 Record Keeping and Communication

Similar to readings recorded during the monitoring specified in the CAMP, all odor monitoring results will be recorded in the field log book or other air monitoring forms, and be available for review by the agencies.

The site supervisor will also provide information on odor monitoring and odor management to residents of the neighborhood should they inquire. In the event that odors persist after these efforts, work will be temporarily discontinued until a mutually agreeable solution with National Grid, NYSDEC, and NYSDOH staff can be worked out which allows the work to be completed while minimizing the off-site transport of nuisance odors.

6. Documentation and Reporting

Data generated during perimeter air monitoring will be recorded in field logs and summarized daily in spreadsheets. The electronic measurements from the PIDs and dust meters will be downloaded each day, reviewed, and archived. Exceedances of the action levels, if any, and the actions to be taken to mitigate the situation, will be discussed immediately with the on-site representatives. Summaries of all air monitoring data will be provided to NYSDEC as requested.