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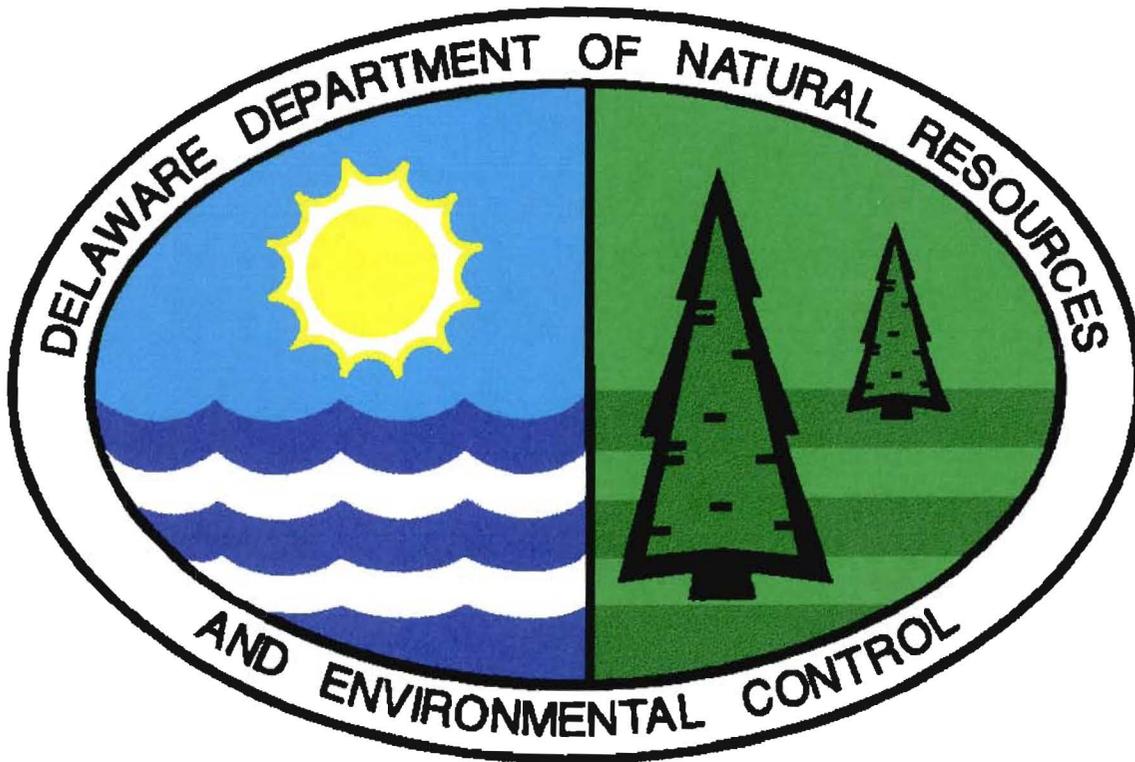
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FINAL PLAN OF REMEDIAL ACTION

Sardo and Sons Warehouse Site
Operable Unit 1 (OU-1)

Wilmington, Delaware

DE-1105



April 2002

Department of Natural Resources and Environmental Control
Division of Air and Waste Management
Site Investigation and Restoration Branch

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1.0 INTRODUCTION

The Sardo and Sons Warehouse Site (site) Operable Unit-1 (OU-1) is located on the eastern half of the property at 710 South Madison Street, between South Madison Street and the Christina River in Wilmington, Delaware (Figure 1). In order to determine the potential for environmental liability prior to the sale of the site, the Riverfront Development Corporation (RDC) entered into the Department of Natural Resources and Environmental Control (Department) Voluntary Cleanup Program (VCP) under the provisions of the Delaware Hazardous Substance Cleanup Act (HSCA), 7 Del. C. Chapter 91. Through a VCP Agreement, the RDC agreed to investigate the potential risks posed to the public health, welfare and the environment at the site. The RDC contracted Duffield Associates, Inc. (DAI) to perform a Remedial Investigation (RI) of the site.

The site was divided into two (2) Operable Units (OUs) to assess future development options. OU-1 consists of the eastern portion of the site and OU-2 is the western portion (see Figure 1).

The purpose of the RI was to: 1) understand the nature and extent of any soil, sediment and/or groundwater contamination at the site, and to 2) evaluate risks to public health, welfare and the environment associated with any identified contamination. RDC agreed to perform, if necessary, a Feasibility Study (FS) that would identify and recommend a Remedial Action, if required by the Department. RDC desires to obtain a Certification of Completion of Remedy from DNREC upon completion of all required tasks.

This document is the Department's final plan of remedial action (final plan) for the OU-1 portion of the site. It is based on the results of previous investigations performed at the site. This Final Plan is issued under the provisions of the HSCA and the Regulations Governing Hazardous Substance Cleanup (Regulations). It presents the Department's assessment of the potential health and environmental risks posed by OU-1.

In March 2002, DNREC issued the proposed plan of remedial action (proposed plan) for the site based on previous investigations. As described in Section 12 of the Regulations, DNREC provided notice to the public and an opportunity for the public to comment on the proposed plan. At the comment period's conclusion, DNREC reviewed and considered all of the comments received, and then issued this final plan. The final plan designates the selected remedy for OU-1. The proposed plan, the previous investigations of the site, the comments received from the public, DNREC responses to those comments, and the final plan will constitute the Remedial Decision Record. No comments from the public were received.

Section 2.0 presents a summary of the site description, history and previous investigations of the site. Section 3.0 provides a description of the investigation results. Section 4.0 presents a discussion of the Remedial Action Objectives (RAOs). Section 5.0 presents the final plan of remedial action for OU-1. Section 6.0 discusses public participation requirements and Section 7.0 presents the director's declaration.

2.0 SITE DESCRIPTION AND HISTORY

The site is located at 710 South Madison Street, south of the intersection with Beech Street in the City of Wilmington, New Castle County, Delaware (see Figure 1). The site consists of approximately 4.9± acres and consists of one parcel, New Castle County tax parcel number #26-049.00-004. The site previously was part of a shipyard and later was the site of a warehouse company. The site reportedly operated as a shipyard during World War II and possibly earlier. The site is bounded to the north by the Kahunaville Restaurant, to the west by South Madison Street, to the south by P&C Roofing, and to the east by a riverwalk and the Christina River. The site was previously occupied by a large warehouse building and concrete pad. The warehouse building has since been demolished.

The site is currently owned by the RDC. The OU-1 portion of the site is proposed for redevelopment as a restaurant and hotel complex. In November 1998, RDC entered into a VCP Agreement with DNREC to conduct an investigation and, if necessary, a cleanup of the site.

2.1 Site and Project History

The site was previously occupied by a large warehouse constructed in the early 1940s as part of a naval shipyard. Prior to the 1940s, the site appears to have been undeveloped. More recently, the warehouse was used for bulk materials storage. A number of environmental investigations have been carried out at the site and they are summarized below.

3.0 INVESTIGATION RESULTS

Several investigations have been conducted at the Sardo and Sons site, consisting of both OU-1 and OU-2.

3.1 Preliminary Environmental Assessment

A Preliminary Environmental Assessment (PEA) of the Sardo and Sons Property, 710 South Madison Street, May 1995, was prepared by Duffield Associates, Inc.

According to the PEA, Sardo and Sons, Inc. purchased the property in 1994. The warehouse was reportedly constructed in approximately 1943 and was utilized as a part of the Dravo Shipyard. It was used as a commercial warehouse facility since approximately 1965. The warehouse was about 80,000 square feet in size.

Review of historical photos and maps noted several aboveground storage tanks of various sizes on surrounding properties.

The warehouse consisted of a redwood frame structure on a concrete pad. No floor drains were reported in the building. The exterior of the building was constructed with asbestos containing cement. Some white asbestos containing pipe insulation was noted on the interior of the warehouse prior to demolition. A rail pit and a pump pit were located inside the warehouse. A loading dock was present on the east side of the building. The building was reportedly connected to the City of Wilmington municipal water and sewer system.

Two (2) 4,000 gallon underground storage tanks (USTs) were removed from the southern end of the property in May of 1995. According to the DNREC UST Program evaluation, soil materials near the tanks consisted of select fill materials, mixed slag and miscellaneous fill. Soil samples from the sidewalls and bottom of the tank excavation, as well as the excavated soil piles were collected for analysis of total petroleum hydrocarbons (TPH) and benzene, toluene, ethylbenzene and xylene (BTEX).

Analytical results from the soil samples collected around the tank indicated TPH concentrations ranging from 100 milligrams/kilogram (mg/kg) to 810 mg/kg. No "free" petroleum product was noted during the removal.

3.2 *Brownfield Preliminary Assessment*

In December 1997, DNREC conducted a Brownfield Preliminary Assessment (BPA) of the Sardo and Sons Warehouse site. The BPA included five test pit excavations and the installation of two groundwater monitoring wells across the site. Sediment samples were collected from storm drains and the westerly bank of the Christina River. Soil and sediment samples were field screened by DNREC mobile laboratory, and selected samples submitted to a DNREC approved laboratory for confirmatory analysis.

The results of the investigation indicated that site soils contained elevated levels of metals, primarily arsenic, chromium and lead, and polynuclear aromatic hydrocarbons (PAHs). Arsenic concentrations in soils ranged from 9.4 mg/kg to 6,810 mg/kg and lead ranged from 190 mg/kg to 1,350 mg/kg. Chromium concentrations were as high as 1,240 mg/kg. PAHs detected above DNREC Uniform Risk-Based Standards (URS) values for restricted (i.e., commercial/industrial) or unrestricted (i.e., residential) use during the investigation included benzo(a)pyrene (2.3 mg/kg to 23.0 mg/kg), benzo(b)fluoranthene (2.3 mg/kg to 24.0 mg/kg), benzo(a)anthracene (2.5 mg/kg to 29.0 mg/kg), dibenz(a,h)anthracene (0.64 mg/kg to 1.7 mg/kg) and indeno(1,2,3-cd)pyrene (1.7 mg/kg to 17.0 mg/kg). The applicable standards are shown in Appendix 1.

Groundwater analysis indicated water samples collected from below the original marsh deposits contained semivolatile organic compounds (SVOCs), typical of coal tar products, and BTEX compounds at concentrations exceeding DNREC's URS for drinking water. SVOCs detected above applicable URS values included naphthalene (1,200 ug/L) and carbazole (8.0 ug/L). Volatile organic compounds (VOCs) detected included benzene (970 ug/L) and ethylbenzene (930 ug/L). Based on this investigation, DNREC recommended additional assessment of the site to determine the potential risks to public health and the environment. The applicable standards are shown in Appendix 2.

3.3 *Environmental Soils Evaluation*

Following DNREC BPA, in October 1998, DAI completed an Environmental Soils Evaluation (ESE) to further delineate and characterize the soil conditions at the site. Nine direct push soil borings and eight test pit excavations were completed to collect soil samples for laboratory analysis. Field observations characterized the fill materials into two distinct layers: surface fill materials and subsurface fill materials. Observations during the ESE indicated that surface fill material was present throughout most of the site to an average depth of approximately five feet. Material encountered below the surface fill (subsurface fill) consisted of sandy and silty soils, with varying amounts of debris (ash/cinder, wood, metal, apparent residual materials from leather tannery operations, brick and concrete) to depths averaging 10 feet, while depths of up to eighteen feet of debris were observed. Apparent native soils were encountered with varying amounts of sand, gravel and clay (marsh deposits) at an average depth of approximately ten feet. Laboratory analytic data indicated elevated concentrations of metals (arsenic up to 299 mg/kg, lead up to 18,500 mg/kg) and PAHs well above restricted or unrestricted use URS values in soils in areas of the site. The highest concentrations of PAHs detected above DNREC restricted or unrestricted use URS values during the investigation included benzo(a)pyrene (430 mg/kg), benzo(b)fluoranthene (580 mg/kg), benzo(a)anthracene (520 mg/kg), dibenz(a,h)anthracene (56 mg/kg) and indeno(1,2,3-cd)pyrene (190 mg/kg). Also detected in one sample were benzo(k)fluoranthene (230 mg/kg), fluoranthene (1,800 mg/kg), pyrene (1,200 mg/kg), and chrysene (480 mg/kg). The applicable standards are shown in Appendix 1.

3.4 *Remedial Investigation*

DAI conducted an RI at the site in the fall of 1999. The RI included eighteen direct push soil borings and the installation of four shallow (water table) wells and two deep (underlying aquifer) wells. The shallow wells were screened approximately 10 to 15 feet below ground surface. The deep wells were completed to a depth approximately 11 to 12 feet below the bottom of the apparent "marsh deposits." Screen intervals for the deep wells ranged from 26 to 44 feet below ground surface. Five composite surface soil samples and twenty-four grab subsurface soil samples were collected and submitted for laboratory analysis. Groundwater samples were collected from the new wells, as well as the two deep wells previously installed by DNREC.

The results of the RI indicate the presence of a large volume of soil containing arsenic, lead, and PAHs at concentrations above unrestricted and restricted use URS values. Soil samples containing apparent tannery waste materials were also observed at several locations on the OU-2 portion of the site. Arsenic was detected at concentrations greater than the restricted use URS of 4.0 mg/kg in 24 of the 28 soil samples analyzed ranging from 1.8 mg/kg to 3,690 mg/kg. The average arsenic concentration in soils was 429 mg/kg.

Two of the 28 samples collected contained chromium at concentrations greater than the restricted use URS of 610 mg/kg. Chromium concentrations ranged from 5.2 mg/kg to 1,950 mg/kg. The average concentration of chromium in soils was 21 mg/kg.

Eight of the 28 samples collected contained lead at a concentration greater than the restricted use URS of 1,000 mg/kg. Lead concentrations ranged from 1.1 mg/kg to 11,100 mg/kg. The average concentration of lead in soils was 1,852 mg/kg.

Twelve of the 29 samples analyzed for SVOCs contained one or more PAH compounds at concentrations greater than the restricted use URS. These included benzo(a)pyrene (which ranged from below the method detection limit ["ND"] to 46 mg/kg), benzo(b)fluoranthene (ND to 59 mg/kg), benzo(a)anthracene (ND to 62 mg/kg), dibenz(a,h)anthracene (ND to 5.3 mg/kg) and indeno(1,2,3-cd)pyrene (ND to 19 mg/kg).

Laboratory analysis of groundwater samples indicated the presence of metals and PAHs in the shallow unconfined aquifer and benzene and PAHs in the deeper confined aquifers at concentrations above the URS values for groundwater.

Arsenic concentrations in the shallow groundwater samples ranged from 3.2 ug/L to 575 ug/L and lead ranged from ND to 121 ug/L. Concentrations of VOCs in shallow wells included benzene, ranging from ND to 13.0 ug/L. Multiple PAHs were also detected in shallow groundwater at concentrations greater than the groundwater URS value including benzo(a)pyrene (ND to 6.0 mg/L), benzo(b)fluoranthene (ND to 7.0 ug/L), benzo(a)anthracene (ND to 7.0 ug/L), indeno(1,2,3-cd)pyrene (ND to 3.0 ug/L), naphthalene (ND to 5.0 ug/L) and 2-methylnaphthalene (ND to 76.0 ug/L).

In the deep groundwater samples, benzene concentrations ranged from 2.0 ug/L to 75.0 ug/L, naphthalene ranged from ND to 1,300 ug/L) and 2-methylnaphthalene ranged from (ND to 32.0 ug/L).

Elevated concentrations of lead and PAHs in the soils are generally distributed across the site. The apparent tannery waste material containing the majority of the arsenic was found to be generally located on the western half of the site (OU-2).

In April 2001, DAI proceeded with an additional Groundwater Evaluation consisting of the installation of two additional groundwater monitoring wells. One well was located near the center of the site, and the other replaced a shallow monitoring well that had been destroyed. The purpose of the Groundwater Evaluation investigation was to supplement the previous groundwater data with a more detailed study of flow direction, gradient and potential tidal influences related to the Christina River, as well as to assess arsenic and organic compound concentrations.

The analytical results indicated the presence of benzene and SVOCs in three deep wells at concentrations exceeding the groundwater URS. SVOCs were also detected in one shallow well above the groundwater URS. Arsenic was detected in three shallow monitoring wells above the groundwater URS.

According to the Groundwater Evaluation Report, water level measurements in the shallow monitoring wells collected during a 72-hour test indicated a low gradient groundwater table condition beneath the site, suggesting lateral groundwater flow away from the river (westerly flow) under the majority of the site. In addition, the data indicate the presence of a groundwater divide under the extreme eastern portion of the site, with flow toward the river.

During the RI, the owner conducted an Interim Action removal, consisting of the excavation and proper off-site disposal of two hot-spot areas of soil. Both hot-spot locations were located on the northeastern portion of the site on OU-1. One hot-spot, near sample location GP-11B (HTP-s) contained a high lead concentration (11,000 mg/kg). The other sample location, DTP-1 (HTP-1) contained high PAH concentrations totaling approximately 10,000 mg/kg, and was described as containing a tar-like substance. HTP-2 was approximately 28' long x 20' wide x 7' deep and HTP-1 was approximately 27' long x 27' wide x 7' deep. Approximately 395 tons of material was removed, sampled and disposed of at an approved facility. The excavation locations are shown in Figure 4. The excavations were subsequently sampled and backfilled with clean fill materials.

3.4.1 General Information

The former warehouse structure and foundation has been demolished and debris removed from the site. All surrounding buildings and structures are currently connected to City of Wilmington water and sewer systems. The USTs previously located on the site have been removed and properly disposed.

3.4.2 Site Soils – OU-1

Based on the sampling and analysis during the previous investigations, the apparent tannery waste material is located beneath the OU-2 area of the site.

Sample results for OU-1 from the previous investigations indicate arsenic, lead, and PAHs at concentrations above unrestricted and restricted use URS values. Arsenic was detected at concentrations ranging from ND to 170 mg/kg. The average arsenic concentration in soils was 23 mg/kg. The applicable standards are shown in Appendix 1.

Chromium was detected in OU-1 samples at concentrations ranging from 6.2 mg/kg to 110 mg/kg. The average concentration of chromium in soils was 24 mg/kg. Lead concentrations ranged from 0.84 mg/kg to 9,320 mg/kg. The average concentration of lead in soils was 1,396 mg/kg.

SVOCs contained one or more PAH compounds at concentrations greater than the restricted use URS. These included benzo(a)pyrene (0.063 mg/kg to 19 mg/kg), benzo(b)fluoranthene (0.11 mg/kg to 76 mg/kg), benzo(a)anthracene (0.078 mg/kg to 22 mg/kg), dibenz(a,h)anthracene (0.015 mg/kg to 5.0 mg/kg) and indeno(1,2,3-cd)pyrene (0.078 mg/kg to 20 mg/kg).

The risk assessment calculations were evaluated based on the 95% Upper Confidence Limit (UCL) of the mean concentration for each substance detected at concentrations above the unrestricted URS. The risk assessment for OU-1 consisted of 21 sample points in the vadose (unsaturated) zone and above, across approximately two and one-half acres. Potential cancer risks and hazard indices were calculated for OU-1 and OU-2.

3.4.3 Groundwater

The results of shallow groundwater sampling at the site indicated that groundwater beneath the site contains concentrations of metals, most notably arsenic and lead, and VOCs and SVOCs which exceed the DNREC URS for groundwater. Deep groundwater (>26 feet below ground surface) also contains VOCs and SVOCs, primarily benzene and PAHs, which exceed the DNREC URS for groundwater. There are no known users of local groundwater for drinking water supply near the site.

Based on sampling and analytical data, and field observations, it appears that the organic compounds are the result of an off-site source or sources, especially in the deeper confined aquifer. The metals present in the shallow groundwater samples appear to be related to the fill materials, including apparent tannery waste, present on the site.

3.4.4 Sediment

Limited sediment sampling was conducted along the Christina River during the BPA and other investigations since 1995. Sampling results indicate that the Christina River sediments through the Wilmington corridor contain elevated concentrations of PAHs, PCBs and metals.

3.4.5 Summary

The results of the investigations indicated that the site contains elevated concentrations of arsenic, chromium, lead, and PAHs in soil samples at the site, which exceeded the DNREC URS for restricted and unrestricted use.

Groundwater at the site is contaminated with arsenic, lead, benzene and PAHs in exceedence of the DNREC URS for groundwater. There are no known users of local groundwater as a drinking water source in the area. Data indicate a probable groundwater divide on the eastern half of the property with groundwater beneath the western portion of the site flowing predominantly to the west and southwest, and water beneath the extreme eastern portion of the site flowing to the river.

Sediment sampling from the Christina River, collected during several different investigations near the site, found elevated levels of some PAHs and metals above the DNREC URS for sediment. The site is separated from the river by a narrow strip of property that has been developed as part of the riverwalk.

The site is proposed to be developed with a concrete pad, restaurants and a parking lot.

DAI performed a Preliminary Risk Assessment (PRA) to evaluate the possible effects on human health and the environment from the use of OU-1 consistent with the proposed use discussed above. The PRA evaluated the soil analytical results in relation to the URS for Protection of Human Health in a Non-Critical Water Resource Area under restricted use conditions for surface soils.

Based upon the data evaluated for OU-1, exposure to shallow soils using an adult site worker scenario, the estimated cumulative increased cancer risk would be 1×10^{-5} , which is the upper limit normally considered acceptable for restricted land use under the DNREC Remediation Standards Guidance. The calculated Hazard Index (HI), or total of all hazard quotients, was 0.4 less than the target value of 1.0, for the OU-1 soils. The 95% UCL value for lead concentrations for the soil samples from OU-1 is 1,120 mg/kg, exceeding the DNREC-SIRB restricted use URS of 1,000 mg/kg (Appendix 3).

4.0 REMEDIAL ACTION OBJECTIVES

According to Section 8.4 (1) of the Regulations, site-specific RAOs must be established for all plans of Remedial Action. The Regulations provide that DNREC-SIRB set objectives for land use, resource use, and cleanup levels that are protective of human health and the environment.

Qualitative objectives describe, in general terms, what the ultimate result of the Remedial Action, if necessary, should be. The following qualitative objectives are determined to be appropriate for the site:

- control potential human exposure (dermal, inhalation and ingestion) to impacted soils;
- control potential human exposure (ingestion and inhalation) to impacted groundwater;
- control potential erosion of impacted soils to the Christina River; and
- control the flow of groundwater contaminated by metals, volatile and semivolatile organic compounds into the Christina River above the Delaware Surface Water Quality Standards.

These objectives are consistent with the current and proposed use of the site as a non-residential use in an urban setting, State regulations governing water supply, and worker health and safety.

Quantitative objectives define specific levels of remedial action to achieve protection of human health and the environment. Based on the qualitative objectives, the quantitative objectives will be to ensure that future site users, such as site workers, construction workers, visitors, and trespassers, do not come in contact with soils that contain elevated levels of metals and PAHs above the established restricted use URS values.

Based on the qualitative objectives, the quantitative objectives are:

1. Prevent human exposure to soils and groundwater contaminated by VOCs, PAHs, and metals that would result in a carcinogenic risk exceeding 1×10^{-5} , a hazard index of 1.0 or lead concentrations exceeding 1,000 mg/kg.
2. Prevent erosion of surface soils contaminated above DNREC URS for protection of the environment into the Christina River.

3. Prevent discharge of groundwater contaminated by metals and volatile and semivolatile organic compounds into the Christina River above the Delaware Surface Water Quality Standards.

The compounds that pose a potential hazard that were detected in groundwater are arsenic, lead, benzene and PAHs. There are no known users of local groundwater as a primary drinking water source in the area and no use of groundwater at the site. Investigations conducted at the site indicate a low gradient groundwater table condition beneath the site, suggesting lateral groundwater flow away from the river (westerly flow) under the majority of the site. In addition, the data indicate a groundwater divide under the extreme eastern portion of the site, with flow toward the river. DAI conducted an Additional Groundwater Evaluation (December 21, 2001) at the site at the request of DNREC. Mass loading calculations under a worst-case scenario indicate that site related arsenic concentrations reaching the river would be well below the applicable "Surface Water Quality Criteria for the Protection of Aquatic Life." This additional groundwater investigation was only designed to determine if there was any unacceptable impact on the river, based solely on releases of hazardous substances from groundwater at the site; it did not evaluate the cumulative effect of releases from the site and from any potential off-site sources. If any future regional groundwater study indicates that the contribution of site related contaminants are part of an unacceptable regional impact on the groundwater or the river, then additional remedies may be required at the site.

Based on this information, metal and organic compound concentrations in the groundwater, regardless of their source, do not pose a current risk to human health. In addition, the site is located within the boundaries of the Groundwater Management Zone (GMZ) for the City of Wilmington, established in August 2001, that will ensure that the Division of Air and Waste Management (DAWM) and the Division of Water Resources (DWR) will mutually review any water well permits at the site.

5.0 FINAL PLAN OF REMEDIAL ACTION

Based upon the information and results of the investigations performed at the Sardo and Sons OU-1 site, DNREC has determined that the preferred remedy conveyed in the proposed plan should be adopted as the final plan, and shall be implemented. The final plan for the Sardo and Sons Warehouse Site OU-1 calls for placement of a containment system and institutional controls, consisting of the following:

1. Placement of a cap and cover in the form of concrete pad-based structures and associated asphalt parking areas. Building structures will have a passive gas venting system included in the construction to eliminate any possible accumulation of VOCs resulting from off-site sources.
2. Placement of a geotextile fabric and a minimum of one foot of clean fill material to eliminate direct contact with surface soils at the OU-1 portion of the site in areas not covered by concrete building pads or asphalt parking areas.

3. Development of a Soils Management Plan to address disposition of any contaminated soils disturbed during OU-1 construction activities.
4. Development of a Health and Safety Plan to address construction worker health and safety during OU-1 construction activities.
5. Placement of a deed restriction on the property limiting the property to restricted land use (non-residential uses) and prohibiting any digging, trenching or excavation activities on OU-1 without prior approval of SIRB.
6. Placement of a Groundwater Management Zone and associated deed restriction at OU-1 to prevent future use of the groundwater beneath the site without prior approval of DNREC.
7. Development of a semi-annual Groundwater Quality Monitoring Program for the OU-1 portion of the site for a minimum of three years.
8. Development of an Operations and Maintenance (O&M) Plan for the site to insure future maintenance of the cap and cover.
9. In the event that a proposed regional groundwater study indicates that the contribution of site-related contaminants is part of an unacceptable cumulative regional impact on groundwater or the river, additional remedies may be required at the site.

6.0 PUBLIC PARTICIPATION

The Department actively solicited public comments or suggestions on the proposed plan and welcomed opportunities to answer questions. The public comment period for the proposed plan began on Friday, March 8, 2002, and concluded at the close of business on Thursday, March 28, 2002. No written comments or requests for a public hearing were received by DNREC.

7.0 DECLARATION

This Final Plan of Remedial Action for the Sardo and Sons Warehouse Site, OU-1 is protective of human health, welfare and the environment and is consistent with the requirements of the Delaware Hazardous Substance Cleanup Act.



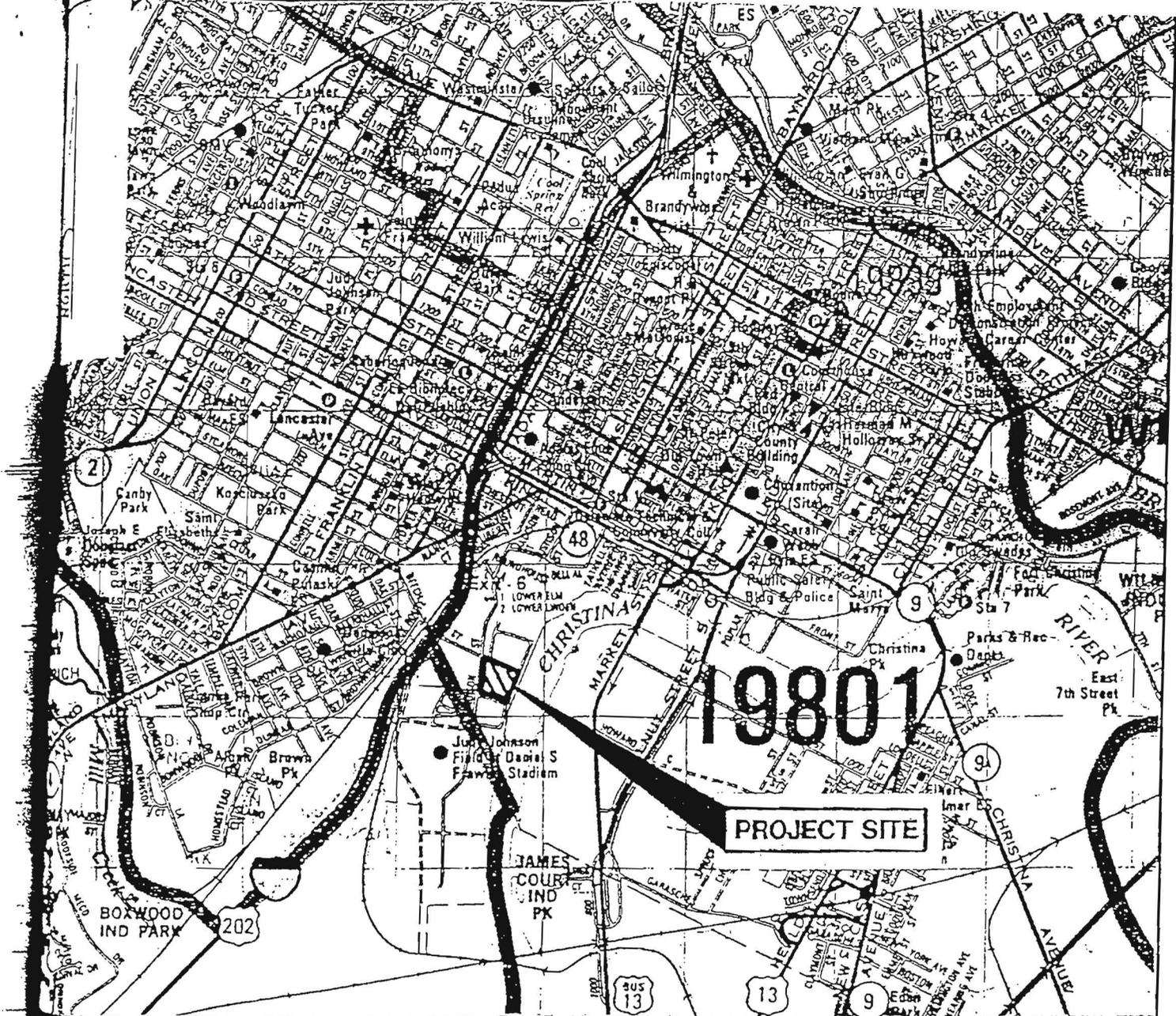
John Blevins
Director, Division of Air and Waste Management

4/15/02

Date

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Figure 1 PROJECT LOCATION MAP



NOTE:

THIS LOCATION SKETCH IS ADAPTED FROM "ADC'S STREET MAP OF NEW CASTLE COUNTY, DELAWARE," MAP 8.

**SITE LOCATION SKETCH
FORMER SARDO WAREHOUSE**

WILMINGTON
NEW CASTLE COUNTY ~ DELAWARE

**DUFFIELD
ASSOCIATES**

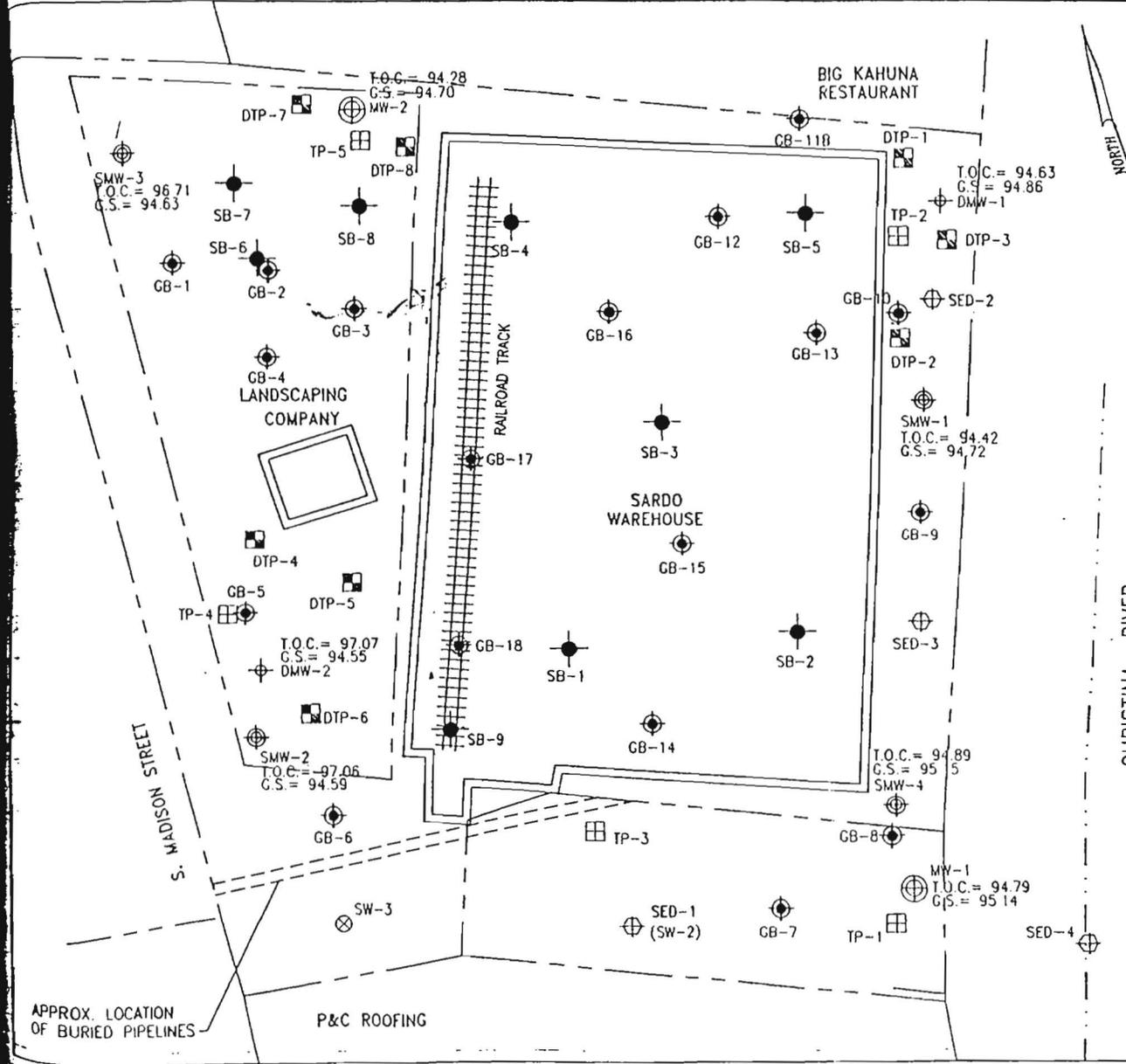
DUFFIELD ASSOCIATES, INC.
CONSULTANTS IN THE GEOSCIENCES
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TEL (302)239-8834 FAX (302)239-8485
E-MAIL: DUFFIELD@DUFFNET.COM

Drawn: DSH Chk'd: Date: 25 AUGUST 1998

Scale: 1" = 2000' (APPROX.) W.O.: 3054.EG

Drawing No: A-3054EG-1 FIGURE 1

Figure 2 BORING AND SAMPLING LOCATION PLAN



NOTE:

- 1.) THIS LOCATION SKETCH IS ADAPTED FROM "SAMPLING LOCATION MAP," PREPARED BY DNREC - SIRB AND DOES NOT REPRESENT A PHYSICAL SITE SURVEY.
- 2.) ELEVATIONS PRESENTED ON THIS SKETCH ARE RELATIVE TO A GENERAL SITE-SPECIFIC DATUM AND ARE NOT REFERENCED TO A SEA LEVEL DATUM.

LEGEND:

- ☐ APPROXIMATE LOCATION OF DNREC-SIRB TEST PIT
- ⊕ APPROXIMATE LOCATION OF DNREC-SIRB SEDIMENT SAMPLING
- ⊕ APPROXIMATE LOCATION OF DNREC-SIRB MONITORING WELL
- ⊗ APPROXIMATE LOCATION OF DNREC-SIRB SURFACE WATER SAMPLING
- APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. GEOPROBE SOIL CORING (JULY 1998)
- ⊠ APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. TEST PIT (JULY 1998)
- ⊕ APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. GEOPROBE SOIL CORING (NOVEMBER 1999)
- ⊕ APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. SHALLOW MONITORING WELL (NOVEMBER 1999)
- ⊕ APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. DEEP MONITORING WELL (NOVEMBER 1999)

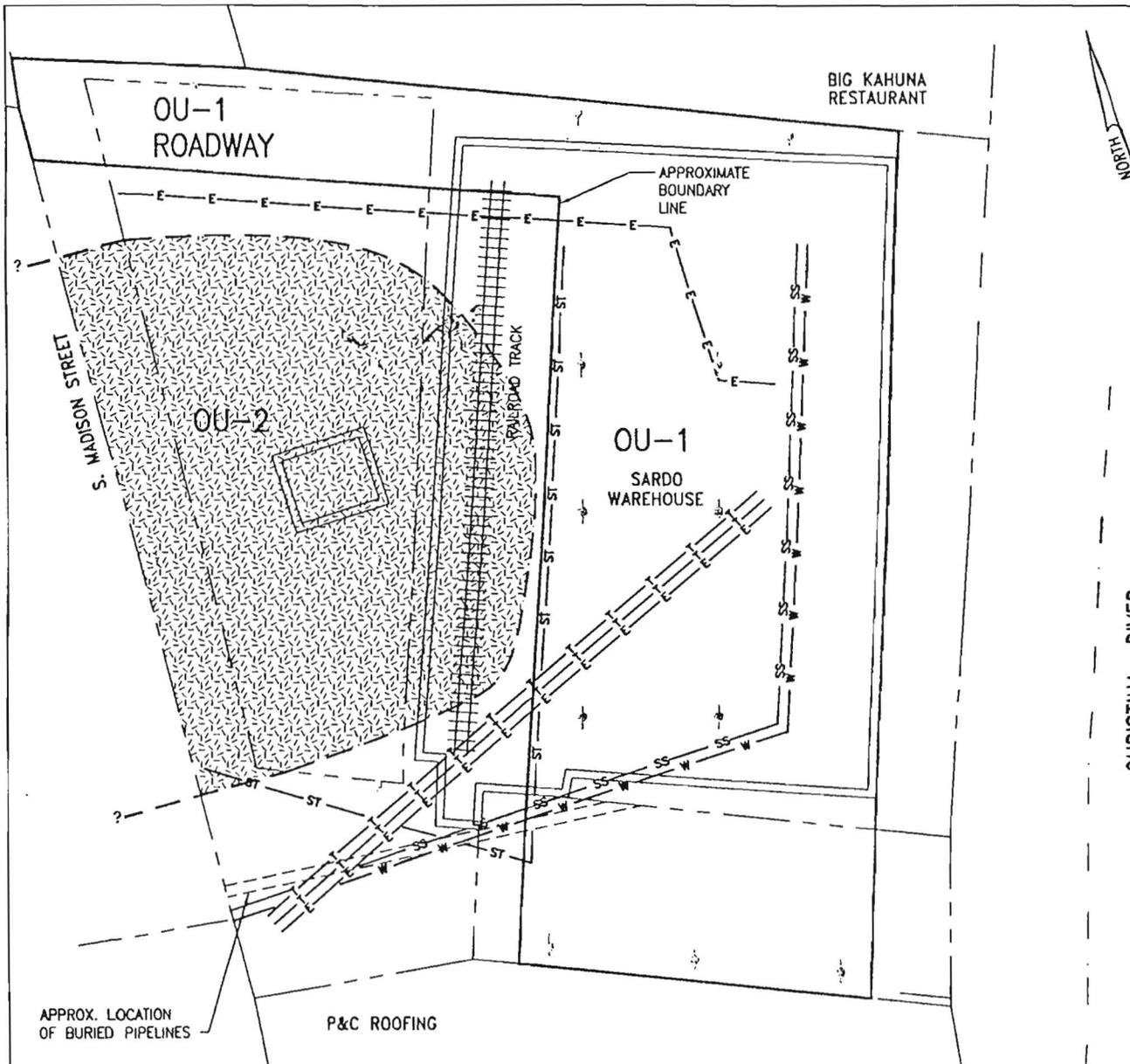
T.O.C. TOP OF CASING ELEVATION
 G.S. GROUND SURFACE ELEVATION

**SAMPLING LOCATION SKETCH
 FORMER SARDO WAREHOUSE
 WILMINGTON
 NEW CASTLE COUNTY ~ DELAWARE**

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Drawn: DSH/JJV Chk'd:	Date: 25 AUGUST 2000
Scale: 1" = 80' (APPROX.)	W.O.: 3054.EH
Drawing No: B-3054EH-2	FIGURE 2

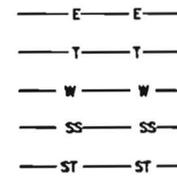
Figure 3 PROPOSED OPERABLE UNIT - 1 (OU-1)



NOTE:

1.) THIS LOCATION SKETCH IS ADAPTED FROM "SAMPLING LOCATION MAP," PREPARED BY DNREC - SIRB AND DOES NOT REPRESENT A PHYSICAL SITE SURVEY.

LEGEND:



PROPOSED UTILITIES

E — E — ELECTRICAL CONDUIT
 T — T — TELECOMMUNICATIONS CONDUIT
 W — W — WATERLINE
 SS — SS — SANITARY SEWER
 ST — ST — STORMWATER



POLE BASE
 ESTIMATED EXTENT OF TANNERY WASTE AREA

APPROXIMATE LOCATION SKETCH, OU1, OU2,
 AND PROPOSED UTILITIES

FORMER SARDO WAREHOUSE

WILMINGTON
 NEW CASTLE COUNTY ~ DELAWARE



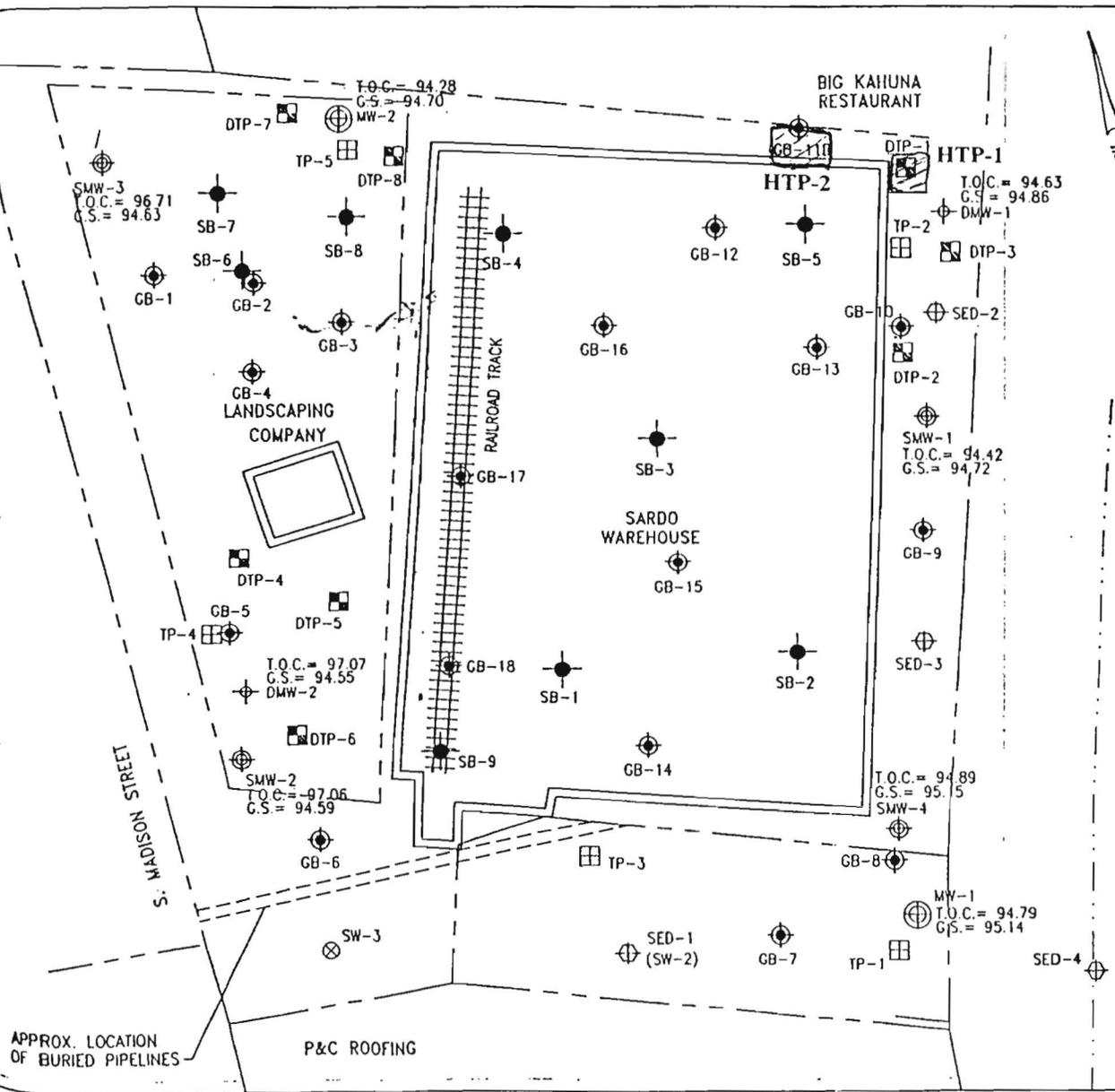
DUFFIELD ASSOCIATES

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Drawn: JGE	Chk'd: <i>[Signature]</i>	Date: 29 AUGUST 2001
Scale: 1" = 80' (APPROX.)		W.O.: 3054.E0
Drawing No: B-3054E0-01		FIGURE 1

Figure 4 LOCATION OF INTERIM ACTION HOT SPOT REMOVAL



NOTE:

- 1.) THIS LOCATION SKETCH IS ADAPTED FROM "SAMPLING LOCATION MAP," PREPARED BY DNREC - SIRB AND DOES NOT REPRESENT A PHYSICAL SITE SURVEY.
- 2.) ELEVATIONS PRESENTED ON THIS SKETCH ARE RELATIVE TO A GENERAL SITE-SPECIFIC DATUM AND ARE NOT REFERENCED TO A SEA LEVEL DATUM.

LEGEND:

- APPROXIMATE LOCATION OF DNREC-SIRB TEST PIT
- APPROXIMATE LOCATION OF DNREC-SIRB SEDIMENT SAMPLING
- APPROXIMATE LOCATION OF DNREC-SIRB MONITORING WELL
- APPROXIMATE LOCATION OF DNREC-SIRB SURFACE WATER SAMPLING
- APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. GEOFROBE SOIL CORING (JULY 1998)
- APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. TEST PIT (JULY 1998)
- APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. GEOFROBE SOIL CORING (NOVEMBER 1999)
- APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. SHALLOW MONITORING WELL (NOVEMBER 1999)
- APPROXIMATE LOCATION OF DUFFIELD ASSOCIATES, INC. DEEP MONITORING WELL (NOVEMBER 1999)
- T.O.C. TOP OF CASING ELEVATION
- G.S. GROUND SURFACE ELEVATION

**SAMPLING LOCATION SKETCH
FORMER SARDO WAREHOUSE
WILMINGTON
NEW CASTLE COUNTY ~ DELAWARE**

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Drawn: DSH/J.V. Chk'd:	Date: 25 AUGUST 2000
Scale: 1" = 60' (APPROX.)	W.O.: 3054.EH
Drawing No: B-3054EH-2	FIGURE 2

APPENDIX 1 UNIFORM RISK-BASED STANDARDS FOR SOIL SAMPLES

UNIFORM RISK-BASED STANDARDS FOR SOIL SAMPLES

	URS for Unrestricted Use, Non-critical Water Resource Area (mg/kg)	URS for Restricted Use, Non-critical Water Resource Area (mg/kg)
TAL METALS		
Antimony	3	82
Arsenic	0.4	4
Cadium	4	100
Chromium VI/III	270/12,000	610/310,000
Copper	310	8,200
Iron	2,300	61,000
Lead	400	1,000
Manganese	160	4100
Zinc	2,300	61,000
TCL SEMIVOLATILE COMPOUNDS		
Benzo(a)anthracene	0.9	8
Benzo(b)fluoranthene	0.9	8
Benzo(k)fluoranthene	9	78
Benzo(a)pyrene	0.09	0.8
Indeno(1,2,3-cd)pyrene	0.9	8
Dibenz(a,h)anthracene	0.09	0.8

**APPENDIX 2 UNIFORM RISK-BASED STANDARDS FOR GROUNDWATER
SAMPLES**

UNIFORM RISK-BASED STANDARDS FOR GROUNDWATER SAMPLES

	URS for Groundwater (mg/l)
BTEX & MTBE	
Benzene	0.005
TCL SEMIVOLATILE COMPOUNDS	
4-Methylphenol	0.018
2,4-Dimethylphenol	0.073
Naphthalene	0.02
2-Methylnaphthalene	0.012
Acenaphthene	0.037
Dibenzofuran	0.002
Fluorene	0.024
Carbazole	0.003
Benzo(a)anthracene	0.00009
Benzo(b)fluoranthene	0.00009
Benzo(k)fluoranthene	0.0009
Benzo(a)pyrene	0.0002
Indeno(1,2,3-cd)pyrene	0.00009
PRIORITY POLLUTANT METALS	
Arsenic	0.050
Lead	0.015

APPENDIX 3 SUMMARY OF ULC CALCULATIONS

SUMMARY OF UCL CALCULATIONS

**VADOSE ZONE SOILS - OPERABLE UNIT EAST
FORMER SARDO WAREHOUSE
WILMINGTON, DELAWARE**

Operable Unit East Sample I.D.	Depth to Saturated Soil (feet)	Depth of Unit Sampled (feet)	Is Sampled Unit In Vadose Zone? (YES/NO)	B(a)p	B(b)f	B(a)a	I(1,2,3-cd)p	D(a,h)a	As	Fe	Pb	Cr
				(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
DTP-3 (6.9)	7.2	3-7	YES	NT	NT	NT	NT	NT	17.3	NT	540	17.3
GB-10R (10-10.8)	Not recorded	5.2-12.1	YES (assumed)	0.18	0.24 ^{low}	0.19	0.1	0.33	170 ^{hi}	62800	3480	88.4
GB-13R (8-9)	8	6.1-14.6	YES	3.8	5	5.2	2.4	0.65	23.5	NT	1330	54
GB-14R (6-7)	Not recorded	1.4-10.4	YES (assumed)	0.33	0.33	0.33	0.33	0.33	1.8 ^{low}	7360 ^{low}	0.84 ^{low}	6.2 ^{low}
GB-15R (5-7)	Not recorded	4.9-8.6	YES (assumed)	0.46	0.55	0.49	0.29	0.077	16	NT	466	17.7
GB-7R (7-8.3)	8	5-8.6	YES	0.92	0.85	1.2	0.28	0.1	NT	NT	NT	NT
GB-8R (2.5-3.5)	5	2.3-8.3	YES	2.6	2.8	3.7	1.1	1.2	36.7	NT	9320 ^{hi}	110 ^{hi}
GB-9R (5-6)	8	1.4-14.2	YES	0.4	0.49	0.55	0.19	0.33	21.1	NT	158	11.2
HTP-1, E. Wall (6.5-7)	7	4.5-7	YES	7	8.9	7	4.1	0.83	16.8	NT	322	NT
HTP-1, N. Wall (6.5-7)	7	4.5-7	YES	1.5	2.2	1.5	1	0.27	33.2	NT	1010	NT
HTP-1, S. Wall (6.5-7)	7	4.5-7	YES	19 ^{hi}	76 ^{hi}	22 ^{hi}	20 ^{hi}	5 ^{hi}	35.2	NT	4720	NT
HTP-1, W. Wall (6.5-7)	7	4.5-7	YES	1.5	2.1	1.5	0.94	0.22	8.5	NT	352	NT
HTP-2, Bottom (7-8)	7	6-...	YES	0.79	1.6	1.2	0.49	0.22	42	NT	846	NT
HTP-2, E. Wall (6.5-7)	7	6-...	YES	0.063	0.11	0.078	0.062	0.015	ND	NT	13.6	NT
HTP-2, N. Wall (6.5-7)	7	6-...	YES	1	4.3	3.6	1.4	0.65	51.3	NT	586	NT
HTP-2, S. Wall (6.5-7)	7	6-...	YES	0.98	3.6	1.9	0.77	0.35	27.7	NT	637	NT
HTP-2, W. Wall (6.5-7)	7	6-...	YES	0.94	1.4	1.2	0.56	0.18	36.8	NT	599	NT
SB-1 (7-7.6)	12	7-7.6	YES	3.2	4.9	3.5	1.5	0.45	60.4	62500	2860	43.7
SB-2 (7-8)	11.5	7-8	YES	0.71	1.2	1	0.26	0.1	25.9	218000 ^{hi}	2820	8.6
SB-3 (10.7-11)	11	10.7-13.5	YES	0.3	0.62	0.32	0.14	0.045	14.6	47800	490	11
SB-5 (10.7-15)	11	10.7-18	YES	0.32	0.48	0.36	0.21	0.061	23.7	84100	4120	32
SMW-1 (6-7)	7	5.4-8.3	YES	0.33	0.33	0.33	0.33	0.33	4	NT	8.7	14.6
TP-1B (6)	6	2-6	YES	2.3	2.3	2.5	1.7	0.64	25.2	25500	753	39.5
DTP-1 (10)	5	5.5-10	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
DTP-2 (10.5)	5.5	5.5-11	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
DTP-2 (7-8)	5.5	5.5-11	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
GB-12R (9.5-10.3)	9	9.5-16.5	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
HTP-1, Bottom (8.5-9)	7	7-...	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
TP-2B (6-8)	6	6-8	NO	NA	NA	NA	NA	NA	NA	NA	NA	NA
	7.5	= Average Depth to Saturated Soil (feet)										

RESULTS FOR LOG-TRANSFORMED DATA

Number	21	20	21	21	21	19	5	20	11
Mean	0.81	1.3	1.0	0.51	0.23	23	52,592	NA	24
95% UCL	1.2	2.0	1.6	0.76	0.34	30	NA	NA	36
CoV	0.17	0.16	0.17	0.18	0.20	0.06	NA	NA	0.08

Abbreviations	
UCL	Upper Confidence Limit
CoV	Coefficient of Variation
mg/kg	milligrams per kilogram
NA	Not applicable
NT	Not tested
B(a)p	benzo(a)pyrene
B(b)f	benzo(b)fluoranthene
B(a)a	benzo(a)anthracene
I(1,2,3-cd)p	Indeno(1,2,3-cd)pyrene
D(a,h)a	Dibenz(a,h)anthracene
As	Arsenic
Fe	Iron
Pb	Lead
Cr	Chromium

Notes: Concentrations are converted to micrograms per kilogram prior to logarithmic transform. Statistical results are converted back into units of mg/kg as indicated above.

This table is part of a February 2001, "Remedial Investigation Report, Former Sarco and Sons Warehouse," and should be viewed only in that context.

SUMMARY OF RISK ASSESSMENT CALCULATIONS

VADOSE ZONE SOILS - OPERABLE UNIT EAST
FORMER SARDO WAREHOUSE
WILMINGTON, DELAWARE

OPERABLE UNIT EAST

Substance	URS for Restricted Use, Non-Critical Water Resource Area (mg/kg)	CPSo	RfDo	RBC (mg/kg)	Estimated Target Cancer Risk (TR)	Estimated Hazard Quotient (THQ)
PAHs						
benzo(a)pyrene	0.8	7.30E+00	NA	1.2	2E-06	NA
benzo(b)fluoranthene	8	7.30E-01	NA	2.0	3E-07	NA
benzo(a)anthracene	8	7.30E-01	NA	1.6	2E-07	NA
indeno(1,2,3-cd)pyrene	8	7.30E-01	NA	0.8	1E-07	NA
dibenz(a,h)anthracene	0.8	7.30E+00	NA	0.34	4E-07	NA
Arsenic	4	1.50E+00	3.00E-04	30	8E-06	0.05
Chromium	610 (Chromium VI)	NA	3.00E-03	36	NA	0.006
Iron *	61,000	NA	3.00E-01	218,000	NA	0.4
Lead	1,000	NA	NA	NA	NA	NA

CUMULATIVE ESTIMATED RISK = 1E-05 0.4

EQUATIONS USED TO CALCULATE CANCER RISK

RBC Equation for Commercial/Industrial Soil Ingestion, Carcinogenic Substances	Cancer Risk Equation (Derived from RBC Equation)
$RBC = \frac{(TR)(BWa)(ATc)}{(EFo)(EDo)(IRSa/10^6)(FC)(CPSo)}$	$TR = \frac{(RBC)(EFo)(EDo)(IRSa/10^6)(FC)(CPSo)}{(BWa)(Atc)}$ (Calculated Cancer Risk)

EQUATIONS USED TO CALCULATE HAZARD INDEX

RBC Equation for Commercial/Industrial Soil Ingestion, Non-Carcinogenic Substances	Hazard Index Equation (Derived from RBC Equation)
$RBC = \frac{(THQ)(RfDo)(BWa)(ATn)}{(EFo)(EDo)(IRSa/10^6)(FC)}$	$HI = THQ = \frac{(RBC)(EFo)(EDo)(IRSa/10^6)(FC)}{(RfDo)(BWa)(Atn)}$

CONSTANTS			COMPOUND-SPECIFIC VARIABLES	
Atc	Averaging time carcinogens (days)	= 25,550	CPSo =	Carcinogenic potency slope oral (risk/milligram/kilogram/day)
IRSa =	Soil ingestion, adult (milligrams/day)	= 100	RBC =	Risk-Based Concentration (usually this is a 95% UCL in mg/kg)
EFo =	Exposure frequency (days/year)	= 250	RfDo =	Reference dose oral (milligrams/kilogram/day)
EDo =	Exposure duration (years)	= 25	THQ =	Target hazard Quotient
FC =	Fraction of contaminated soil ingested (unitless)	= 0.5	HI =	Hazard Index
BWa =	Body weight, adult (kg)	= 70		
Atn =	Averaging time non-carcinogens (days)	= EDo (365)		
Efo =	Exposure frequency (days/year)	= 250		

Notes:

This table is part of a February 2001, "Remedial Investigation Report," and should be viewed only in that context.

* = Because the number of samples for iron were less than 10, the 95% UCL is not calculated. The 95% UCL concentration shown is actually a maximum concentration.

PAH = Polynuclear aromatic hydrocarbon.
NA = Not applicable
UCL = Upper confidence limit

W.O.3054.EI
Duffield Associates, Inc.,
February 2001