ESI, Higher Priority
9/13/93

# FINAL

## Site Inspection Prioritization

**Monsanto Company Inc.**
**Columbia, Maury County, Tennessee**
**EPA ID No. TND004048104**
**WasteLAN No. 3608**

Prepared Under:
EPA Work Assignment No. 12
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By

B&V Waste Science and Technology
Project No. 52012.081

For the

Waste Management Division
U.S. Environmental Protection Agency
Region IV

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# Final
# Site Investigation Prioritization
# Monsanto Company, Inc.
# Columbia, Maury County, Tennessee
# EPA ID Nº TND004048104
# WasteLAN Reference Nº 3608

## 1.0 Introduction

The United States Environmental Protection Agency (U.S. EPA), Waste Management Division, Region IV contracted with B&V Waste Science and Technology Corp. to conduct a site investigation prioritization (SIP) for the Monsanto Company site near Columbia, Maury County, Tennessee. This study was performed under the authorization of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) and the Superfund Amendments and Reauthorization Act of 1986 (SARA).

The SIP will update the site investigation completed by the Tennessee Department of Health and Environment on April 9, 1984, which was performed prior to the implementation of the revised Hazard Ranking System. Sources of information used in this evaluation include U.S. EPA CERCLA file material, as well as documentation obtained from Columbia, Maury County, and Tennessee officials. The SIP will quantify threats posed by the site and provide sufficient documentation to decide on an appropriate future course of action.

## 2.0 Site Description and Operational History

### 2.1 Location

The Monsanto Company is located two miles west of Columbia, Maury County, Tennessee, on Monsanto Road (Ref. 1). The geographic coordinates are 35°39'50.75" latitude north and 87°07'10.67" longitude west (Ref. 2).

The climate of Maury County is temperate, with moderate winters and warm, but not hot, summers (Ref. 3, p. 3). Columbia, Tennessee receives an annual mean precipitation of 52 inches (Ref. 4, p. 43). The mean annual lake pan evaporation in the Columbia area is 38 inches (Ref. 4, p. 63). Therefore, the net annual precipitation in the area is 14 inches. The two year, 24-hour rainfall is 3.7 inches (Ref. 5, p. 96).

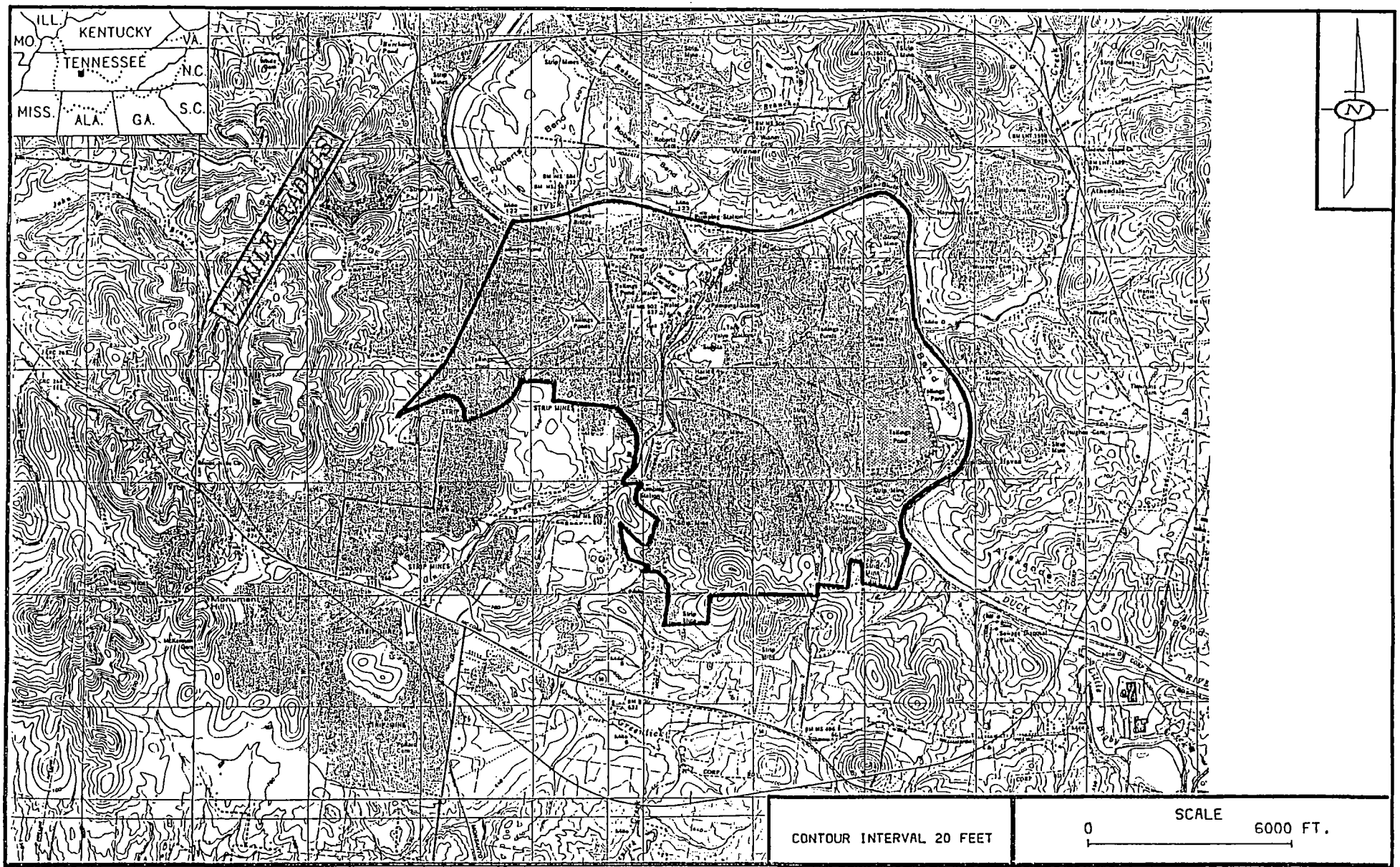
## 2.2 Site Description

Monsanto has operated an elemental phosphorus plant at Columbia, Tennessee, since 1936, processing phosphate ore to produce elemental phosphorus (Ref. 6, p. 1-1). The site borders the Duck River for five miles, and the Greenlick Creek flows through the middle of the site for four miles before emptying into the Duck River. Plant operations have been spread over a large part of the 6400 acres, but the main office and most of the buildings onsite are located on Monsanto Road, beside Greenlick Creek (Ref. 1). The site location is shown on Figure 1. The site layout is shown on Figure 2.

Phosphate rock is converted into elemental phosphorus at Monsanto by the electric-furnace phosphorus and acid process. In this process, phosphate rock is ground and mixed with sand and coke. This mixture is added to an electric furnace and is reduced at an elevated temperature. Slag and ferrophosphorus run off separately, and phosphorus vapor and carbon dioxide are drawn off. The phosphorus vapor is condensed and is transported in tank cars to consuming centers (Ref. 7, p. 257).

Production activities at the plant concluded in 1986. Monsanto had planned to close the site completely, but near the end of 1989 the longer range marketing outlook for drummed phosphorus improved. Since that time, Monsanto has continued to use the phosphorus handling area facilities for the drumming operation (Ref. 8).

Monsanto has stored or disposed of waste fluids and materials on the 6400 acre plant property continually since the operation began. A study conducted for Monsanto by Engineering-Science identified twenty-one sites on the property as areas that possibly received waste or were process or storage areas (Ref. 6, p. 1-1), (Fig. 2). The study involved sampling, and focused on groundwater contamination, with some samples of surface water and composite soil borings also taken. Only inorganic analyses of

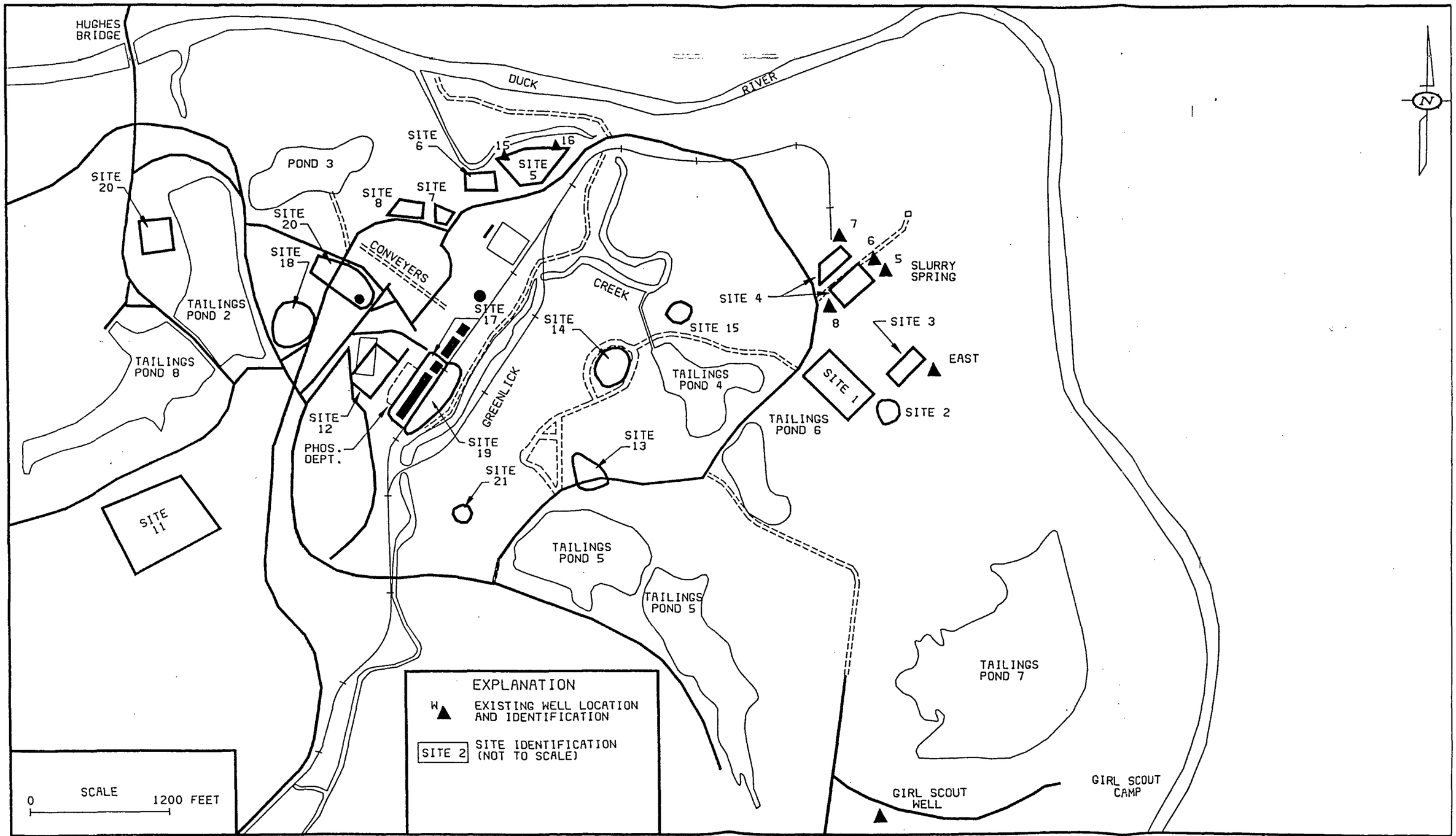



BASE MAP IS A PORTION OF THE USGS 7.5 MINUTE QUADRANGLES, WILLIAMSPORT, TENN., GODWIN, TENN., 1988 MOUNT PLEASANT, TENN., 1986 AND COLUMBIA, TENN., 1989.

SITE SCIENCE AND TECHNOLOGY CORP.

SITE LAYOUT MAP
MONSANTO COMPANY
COLUMBIA, MAURY COUNTY, KENTUCKY

FIGURE 1




WASTE SCIENCE AND TECHNOLOGY CORP

SITE LAYOUT MAP
MONSANTO COMPANY
COLUMBIA, MAURY, COUNTY, TENNESSEE

FIGURE 2

the samples were done, and there is no information about possible organic contamination available for the Monsanto property.

The 21 sites identified by the study are summarized in Table 1. Of these twenty-one sites, Sites 2, 14, 16, and 21 were dropped from consideration when interviews with present and past employees of Monsanto indicated that they were not disposal sites, or that they contained very little waste. Sites 1 and 10 were permitted landfills, and they were also removed from consideration. A discussion of the remaining 15 sites follows.

Site 3 is an inactive phosphorus barrel dump. Plant personnel reported that drums of phosphorus containing materials were brought to site 3 for disposal from the 1950's until 1978 when the area was closed and capped. The analysis of composite soil borings showed relatively high levels of phosphate (19,144 mg/kg), fluoride (1,035 mg/kg), cyanide (259 mg/kg), and lead (206 mg/kg), (Ref. 6, pp. 3-26, 27).

Site 4 is a disposal area for a variety of wastes. Among these wastes are coke dust and slurry waste from the phosphorus still and centrifuge, treater oil sludge, and large metallic structural debris. There is some evidence that barrels were dumped here also. Composite soil borings showed elemental phosphorus (10,000 mg/kg), phosphate (15,324 mg/kg), fluoride (15,324 mg/kg), lead (111 mg/kg), arsenic (4.4 mg/kg), and cyanide (50 mg/kg), (Ref. 6, pp. 3-7-10).

Site 5 was originally a tailings pond used for disposal of waste products from the phosphate ore beneficiation process. The site was later used as a sanitary landfill and solid waste disposal site from the 1950's until 1978. The site has been closed and graded, and has a grass cover. Exploratory borings revealed phosphorus-containing materials, metal, and cable at the site. Analysis of the composite soil boring samples showed chromium (64 mg/kg) and lead (108 mg/kg), (Ref. 6, pp. 3-27, 28).

Site 6 was used as a storage area for treater oil from the treater explosion seals, and to remove phosphorus from the oil. The oily sludge that remained after phosphorus was removed from the oil was dumped on the ground in this area. Chemical analysis of the composite soil boring samples revealed phosphate (46,078 mg/kg), fluoride (282 mg/kg), and lead (72 mg/kg), (Ref. 6, p. 3-28).

# TABLE 1
## Site Summary
### Monsanto Company
### Columbia, Maury County, Tennessee

| Site Number | Description | Surface Area (Acres) | Volume (yards$^3$) | Status | Monitoring Program |
|---|---|---|---|---|---|
| 1 | Permitted phosphorus landfill | 8 | 60,000 | Not covered | 11 wells |
| 2 | Equipment erection site | unknown | unknown | Not covered | None |
| 3 | Barrel dump | 0.3 | 9,000 | Covered | 2 wells |
| 4 | Phosphorus slurry dump | 8.6 | 45,000 | Covered | 5 wells |
| 5 | Sanitary / solid waste dump | 1.8 | 507,000 | Covered | 2 wells |
| 6 | Treater oil site | 0.1 | 1,900 | Covered | 2 wells |
| 7 | Dust collector site | 1.4 | 97,000 | Not covered | None |
| 8 | No. 3 pond solids storage | 2.1 | 61,000 | Not covered | None |
| 9 | No. 3 pond - phossy process water | 13.1 | 740,000 | Not covered | 15 wells |
| 10 | Sanitary / solid waste landfill | 2 | 40,000 | Not covered | 3 wells |
| 11 | No. 3 pond solids disposal | 14.5 | 608,000 | Not covered | 4 wells |
| 12 | Phosphorus tank farm | 1.2 | 35,000 | Covered | 7 wells |
| 13 | Coke dust dump | 6.5 | 400,000 | Covered | 2 wells |
| 14 | Phosphorus containing metal dump | unknown | unknown | Removed | None |
| 15 | Wrecked phosphorus rail car scrap | unknown | unknown | Not covered | None |
| 16 | CWS Building (spills, leaks) | unknown | unknown | Not covered | None |
| 17 | Phosphorus and furnace department | 4 | 58,000 | Not covered | None |
| 18 | No. 3 pond solids disposal | 1.4 | 108,000 | Covered | None |
| 19 | Furnace rail yard | 5.4 | 69,000 | Not covered | 3 wells |
| 20 | Million-gallon tank site | 9 | 726,000 | Covered | None |
| 21 | Phosphorus pipe dump | unknown | unknown | Covered | None |

Site 7 is a dust storage pile that was first used in 1981. Dust collector dust and treater dust were still being stored at this site when the site investigation was conducted in 1985. Composite soil boring samples showed phosphate (87,581 mg/kg), fluoride (478 mg/kg), and chromium (98 mg/kg), (Ref. 6, pp. 3-28, 29).

Site 8 is a closed storage area for phossy water pond solids. Solids from the Number 3 phossy water pond were placed at this site from 1973 until early 1985. The area has been diked and graded, but not capped. Composite soil boring samples showed phosphate (57,843 mg/kg), fluoride (2,141 mg/kg), and lead (132 mg/kg), (Ref. 6, p. 3-29).

Site 9 is a phossy process water pond, and is also known as Pond Number 3. The site contains 90 million gallons of phossy water, and 750,000 cubic yards of sediment. Samples of the phossy water contained fluorides (523 mg/L), lead (0.27 mg/L), arsenic (1.86 mg/L), cyanide (0.6 mg/L), and elemental phosphorus (1.1 mg/L). The sediments from Pond Number 3 contained phosphorus (150 mg/kg), phosphate (28 mg/kg), fluorides (73,000 mg/kg), cadmium (2.4 mg/kg), chromium (39 mg/kg), lead (170 mg/kg), and arsenic (14.5 mg/kg), (Ref. 6, pp. 3-15-19).

Site 11 is a disposal area for solids from Pond Number 3. This site was first used in 1973, and was still being used in 1985. Composite soil boring analysis showed phosphates (63,725 mg/kg), fluorides (1,103 mg/kg), and lead (162 mg/kg), (Ref. 6, pp. 3-29, 30).

Site 12 includes the remnants of 12 gunnite tanks that contained elemental phosphorus, phossy water, and phos mud. These tanks apparently leaked materials into the underlying rock and soils, and they have since been filled with slag and covered over with soil. Composite soil boring analysis showed elemental phosphorus (28,000 mg/kg), phosphate (116,667 mg/kg), and arsenic (4.3 mg/kg), (Ref. 6, p. 3-21).

Site 13 was used between 1940 and 1982 for disposal of coke fines and dust collector dust. Composite soil boring samples showed phosphate, (63,725 mg/kg), at the site, (Ref. 6, p. 3-30).

Site 17 is the location of the furnace department, and has been since the plant opened. Analysis of unconsolidated soils showed phosphate (109,000 mg/kg) and fluoride (311 mg/kg), but relatively low levels of other measured parameters, (Ref. 6, p. 3-21-25).

Site 18 was a disposal area for solids from Pond Number 3 between 1956 and 1973. Coke, coal, and miscellaneous kiln feed materials have been stored in the area since 1973. Composite soil boring samples showed phosphate (62,091 mg.kg), fluoride (2,052 mg/kg), lead (92 mg/kg), and chromium (91 mg/kg), (Ref. 6, p. 3-30, 31).

Site 19 is directly east of the furnace department (site 17), and has been used as a storage area for ferrophos, slag, coke, tanks of diesel oil, and treater dust. The area has also been used as a sanitary landfill, and lead-lined, concrete underground storage tanks may be in the area. Composite soil boring samples showed elemental phosphorus (1300 mg/kg), phosphates (63,637 mg/kg), and fluoride (465 mg/kg), (Ref. 6, p. 3-25).

Site 20 is a former mine site that possibly received phosphorus contaminated material, scrap structural steel, and treater oil wastes. Composite soil boring analysis showed phosphate (40,850 mg/kg), fluoride (1,706 mg/kg), and lead (479 mg/kg), (Ref. 6, p. 3-31).

The site investigation conducted in 1985 focused on five of these 15 sites as the most important: Sites 4, 9, 12, 17, and 19. Inorganic analyses of groundwater at these sites for the 1985 study are shown in Tables 2 and 3. No organic analyses were performed during the study. Although the monitoring wells at Site 12 show significant contamination, they serve as background for Sites 17 and 19, because they are upgradient of these sites. No samples were taken that could serve as background for Sites 4 and 9. Five monitoring wells were dug at Site 4, and the study found elevated levels of soluble phosphate (119.9 mg/L), arsenic (0.047 mg/L), chromium (0.2 mg/L), soluble fluoride (6.3 mg/L), lead (0.72 mg/L), and phosphorus (0.086 μg/L) in some of the wells (Ref. 6, Table G.2). Six monitoring wells were installed at Site 9. These wells showed elevated levels of soluble phosphate (229.7 mg/L), arsenic (0.86 mg/L), cadmium (0.05 mg/L), chromium (0.753 mg/L), soluble fluoride (5.7 mg/L), and lead (1.78 mg/L). Sites 12, 17, and 19 are very close together and were analyzed as a unit;

# TABLE 2
## Monsanto Company
### Columbia, Maury County, Tennessee
### GROUNDWATER SAMPLES
### Summer 1985

| | Background | | | | On-Site Samples | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well | 12-1W | 12-2W | 12-3AW | 12-4W | 17-5W | 19-1W | 19-2W | 19-3W | 19-4W | 19-5W | 19-6AW | 19-7W | 19-8W |
| Phosphorus | 0.07 | 1.43 | 0.00127 | 0.00818 | 0.0007 | 0.000001 | 0.000001 | 0.000001 | 0.000002 | 0.000002 | 0.000018 | 0.000006 | 0.000001 |
| Soluble Phosphate | 2.8 | 4.6 | 0.9 | 6.2 | 4.6 | 1.3 | 1.4 | 2.5 | 1.5 | 0.7 | - | 1.3 | 0.7 |
| Soluble Fluorine | 2.4 | 1.3 | 1.6 | 2 | 44 | 10 | 2 | 14 | 4.4 | 7.2 | 7.5 | 6.2 | 5.1 |
| Cadmium | <0.0002 | <0.0002 | <0.0002 | <0.0002 | - | 0.007 | 0.01 | 0.035 | 0.015 | 0.015 | 0.002 | 0.007 | - |
| Chromium | <0.030 | 0.21 | 0.25 | 0.32 | 0.123 | - | - | 0.32 | 0.24 | 0.19 | - | - | - |
| Lead | <0.005 | 0.13 | <0.005 | <0.005 | 0.006 | 0.016 | 0.005 | 0.68 | 0.74 | 0.3 | - | - | 0.05 |
| Arsenic | 0.007 | 0.004 | <0.001 | 0.003 | 0.008 | 0.002 | 0.002 | 0.07 | 0.07 | 0.014 | 0.005 | 0.005 | 0.01 |
| Cyanide | 0.005 | <0.005 | <0.005 | 0.015 | 0.013 | - | 0.01 | - | - | - | - | 0.009 | 0.007 |

*All concentrations are in mg/L.*

The first number (e.g. 12, 17, or 19) in a sample label identifies the site where the well is located. The second number identifies an individual monitoring well at the site. W following the numbers signifies a monitoring well.

Shading signifies a sample concentration three times the background concentration, or above sample quantitation limit (SQL).

# TABLE 3
## Monsanto Company
### Columbia, Maury County, Tennessee
### GROUNDWATER SAMPLES
### Summer 1985

| | On-Site Samples | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Sampled | 4-5W | 4-6W | 4-7W | 4-8W | 4-9W | 9-1W | 9-2W | 9-3W | 9-4W | 9-5W | 9-6W |
| Phosphorus | 0.000002 | 0.000002 | 0.000086 | 0.000042 | 0.000003 | 0.000001 | 0.000002 | 0.000001 | 0.000001 | 0.000001 | 0.000001 |
| Soluble Phosphate | 1 | 1.4 | 15.3 | 119.9 | 1.1 | 40.2 | 1 | 1.2 | 229.7 | 3.2 | 0.6 |
| Soluble Fluorine | 0.6 | 0.4 | 0.6 | 0.7 | 6.3 | 3.9 | 1 | 1 | 5.7 | 0.5 | 1.6 |
| Cadmium | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | <0.0002 | 0.05 | <0.0002 | <0.0002 |
| Chromium | <0.010 | <0.010 | 0.2 | <0.010 | 0.126 | 0.094 | 0.012 | <0.010 | 0.753 | 0.011 | <0.010 |
| Lead | 0.026 | 0.042 | 0.72 | 0.125 | 0.145 | 0.022 | 0.005 | 0.016 | 1.78 | 0.022 | 0.015 |
| Arsenic | 0.001 | 0.015 | 0.023 | 0.047 | 0.003 | 0.035 | 0.001 | 0.006 | 0.86 | 0.006 | <0.001 |
| Cyanide | <0.005 | 0.005 | 0.006 | <0.005 | 0.003 | <0.005 | <0.005 | <0.005 | <0.005 | 0.005 | <0.005 |

All concentrations are in mg/L.

The first number (e.g. 12, 17, or 19) in a sample label identifies the site where the well is located. The second number identifies an individual monitoring well at the site. W following the numbers signifies a monitoring well.

There were no background samples taken for these sites.

thirteen wells were constructed at the sites. Excess chromium (0.32 mg/L), lead (0.13 mg/L), and phosphorus (1.43 mg/L), were found in wells sampled at Site 12. Excess chromium (0.123 mg/L) and soluble fluoride (44 mg/L) were found in wells sampled at Site 17. Excess chromium (0.32 mg/L), fluoride (10 mg/L), and lead (0.74 mg/L) were found in wells at Site 19. The site investigation also found high levels of phosphate, cyanide, fluoride, and lead in wells at Site 3, and chromium and lead in wells at Site 5 (Ref. 6, pp 3-26, 27, 28).

Surface water and sediment samples were also taken during the site investigation of 1985. Table 4 shows that elemental phosphorus was found at levels significantly above background in the water of Greenlick Creek, and phosphate and fluoride were found significantly above background in the sediments of Greenlick Creek.

After the completion of the site investigation in 1985, Sites 3, 4, 5, and 12 were placed on the Tennessee Superfund Promulgated List (Ref. 8, p. 1-1). The Promulgated List includes those sites within Tennessee that are eligible under the Hazardous Waste Remedial Action Fund for investigation, identification, containment, and clean-up, including monitoring and maintenance.

Sites 3, 4, and 5 were closed in 1978, and have since been covered with three-foot thick clay caps. Site 12 is still used in the drumming operation mentioned previously. Monsanto's remediation plan called for capping Site 12, along with Sites 17 and 19, with a clay cap and covering a large part of the area with concrete and asphalt. The plan further called for installation of a concrete trough upgradient of the area to divert uncontaminated surface runoff from the site. This trough has since been installed. A retaining wall was constructed downgradient of the site to intercept phosphorus migration in the groundwater. Seepage from the retaining wall is collected in sumps and treated in the on-site wastewater treatment plant (Ref. 9, p. 2).

The State of Tennessee Division of Superfund accepted the proposed remediation, with the addition of long term quarterly monitoring of groundwater and surface water at the sites (Ref. 9). Selected results of quarterly monitoring are shown on Tables 5, 6, and 7. On these tables, Site 12 is used as background. Although the monitoring

# TABLE 4
## Monsanto Company
### Columbia, Maury County, Tennessee
### SURFACE WATER AND SEDIMENT SAMPLES
### Summer 1985

| | Surface Water Samples | | | | | Sediment Samples | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Background | | On-Site Samples | | | Background | | On-Site Samples | | |
| Sample | STA 12 | STA 13 | STA 5 | STA 6 | STA 11 | STA 12 | STA 13 | STA 5 | STA 6 | STA 11 |
| Phosphorus | 0.000002 | 0.000001 | 0.000086 | 0.000086 | 0.00011 | N/A | N/A | N/A | N/A | N/A |
| Soluble Phosphate | 1.3 | 0.9 | 1.2 | 0.9 | 0.6 | 90 | 119 | 98 | 1149 | 183 |
| Soluble Fluorine | 0.2 | 0.5 | 0.7 | 0.7 | 0.5 | 5 | 6.4 | 4 | 1.5 | 30 |
| Cadmium | 0.0003 | 0.0004 | 0.0004 | 0.0006 | 0.0003 | 1.8 | 1.9 | 2.4 | 2.4 | 2.7 |
| Chromium | <0.010 | <0.010 | - | - | - | 42 | 43 | 27 | 37 | 49 |
| Lead | 0.065 | 0.05 | 0.015 | 0.026 | 0.081 | 24 | 32 | 41 | 38 | 32 |
| Arsenic | 0.003 | 0.002 | 0.004 | 0.003 | - | 2.7 | 2.1 | 2.6 | 3.4 | 3.8 |
| Cyanide | 0.005 | <0.005 | - | - | - | <0.1 | <0.1 | - | - | - |

All surface water concentrations are in mg/L. All sediment concentrations are in mg/kg.

The number (e.g. 12, 13, 5, 6, or 11) in a sample label identifies the point on Greenlick Creek where the sample was taken. STA preceding the number signifies a sampling location on a surface water body.

Shading signifies a sample concentration three times the background concentration, or above sample quantitation limit (SQL).

# TABLE 5
## Monsanto Company
### Columbia, Maury County, Tennessee
### GROUNDWATER SAMPLES
### Fourth Quarter 1990

| | Background | | | On-Site Samples | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Sampled | MW-12-1 | MW-12-2 | MW-12-4 | MW-6-2 | MW-17-5 | MW-19-1 | MW-19-3 | MW-19-4 | MW-19-5 | MW-19-7 |
| Soluble Phosphate | 3.910 | 30.400 | 0.950 | 444.00 | 1.310 | 0.054 | 0.071 | 0.109 | 0.109 | 0.403 |
| Soluble Fluorine | 1.11 | 0.91 | 0.22 | 6.04 | 25.70 | 9.52 | 12.70 | 10.60 | 10.60 | 5.97 |
| Soluble Lead | <0.003 | <0.003 | <0.003 | - | - | - | - | - | - | 0.011 |
| Chromium | <0.010 | <0.010 | <0.010 | - | - | - | - | - | - | - |
| Arsenic | <0.010 | <0.010 | <0.010 | - | - | - | 0.020 | - | - | - |
| Cyanide | 5.1 | 8.8 | <5.0 | 245.0 | 71.8 | 8.0 | 47.0 | 100.00 | - | 6.0 |
| Phosphorus | 0.320 | 350.00 | 90.000 | 92.000 | 112.00 | 0.002 | 0.002 | 0.010 | 0.002 | 0.004 |

*All concentrations are in mg/L.*

MW signifies a monitoring well. The first number (e.g. 12, 6, 17, or 19) identifies the site where the well is located. The second number identifies an individual monitoring well at the site.

Shading signifies a sample concentration three times the background concentration, or above sample quantitation limit (SQL).

# TABLE 6
## Monsanto Company
### Columbia, Maury County, Tennessee
### GROUNDWATER SAMPLES
### Fourth Quarter 1991

| | Background | | | On-Site Samples | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Sampled | MW-12-1 | MW-12-2 | MW-12-4 | MW-6-2 | MW-17-5 | MW-19-1 | MW-19-3 | MW-19-4 | MW-19-5 | MW-19-7 |
| Soluble Phosphate | 2.800 | 39.300 | 3.630 | 447.00 | 44.900 | 0.063 | 0.203 | 0.202 | 0.317 | 0.285 |
| Soluble Fluorine | 0.17 | 0.21 | 1.33 | 9.65 | 56.60 | 12.20 | 12.20 | 3.68 | 5.58 | 4.51 |
| Soluble Lead | <0.003 | <0.003 | <0.003 | - | - | - | - | - | - | - |
| Chromium | <0.010 | <0.010 | <0.010 | 0.016 | - | - | 0.011 | - | 0.294 | - |
| Arsenic | <0.010 | <0.010 | <0.010 | - | - | - | 0.015 | - | - | - |
| Cyanide | 8.2 | 6.2 | 6.9 | 237.0 | 19.7 | 6.4 | 28.9 | 35.4 | - | - |
| Phosphorus | 27.000 | 80.00 | 0.003 | 27.000 | 0.195 | 0.002 | 0.002 | 0.007 | 0.002 | 0.002 |

All concentrations are in mg/L.

MW signifies a monitoring well. The first number (e.g. 12, 6, 17, or 19) identifies the site where the well is located. The second number identifies an individual monitoring well at the site.

Shading signifies a sample concentration three times the background concentration, or above sample quantitation limit (SQL).

# TABLE 7
## Monsanto Company
### Columbia, Maury County, Tennessee
### GROUNDWATER SAMPLES
### Second Quarter 1992

| | Background | | | On-Site Samples | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Monitoring Well Sampled | MW-12-1 | MW-12-2 | MW-12-4 | MW-6-2 | MW-17-5 | MW-19-1 | MW-19-3 | MW-19-4 | MW-19-5 | MW-19-7 |
| Soluble Phosphate | 1.270 | 11.600 | 12.000 | 459.00 | 7.290 | 0.040 | 0.100 | 0.080 | 0.180 | 0.340 |
| Soluble Fluorine | 1.20 | 0.07 | 0.05 | 9.57 | 26.20 | 13.20 | 16.70 | 2.28 | 6.11 | 5.28 |
| Soluble Lead | <0.003 | <0.003 | <0.003 | - | - | - | - | - | - | - |
| Chromium | <0.010 | <0.010 | <0.010 | - | - | - | - | - | - | - |
| Arsenic | <0.010 | <0.010 | <0.010 | - | - | - | 0.023 | - | - | - |
| Cyanide | <5.0 | <5.0 | 6.9 | 134.0 | - | - | 28.6 | 31.2 | - | 8.2 |
| Phosphorus | 0.047 | 450.00 | 219.00 | 144.00 | 680.00 | 0.002 | 0.002 | 0.002 | 0.002 | 0.002 |

All concentrations are in mg/L.

MW signifies a monitoring well. The first number (e.g. 12, 6, 17, or 19) identifies the site where the well is located. The second number identifies an individual monitoring well at the site.

Shading signifies a sample concentration three times the background concentration, or above sample quantitation limit (SQL).

wells at Site 12 show significant contamination, they serve as background for Sites 6, 17, and 19, because they are upgradient of these sites.

A review of RCRA files at the Nashville Field Office of the Tennessee Department of Solid Waste Management showed that Monsanto is complying with all regulations applicable to its permitted landfills. No RCRA Facility Assessment report has been filed concerning Monsanto.

# 3.0 Groundwater Pathway

## 3.1 Hydrogeologic Setting

The Monsanto Company lies in the Central Basin region of Tennessee, an area characterized by rolling topography, a temperate climate, and an average elevation of 700 feet above mean sea level (amsl) (Ref. 10, p. 3). The site lies between 540 feet and 620 feet amsl, and within the floodplain and terraces of the Duck River (Ref. 1).

Soils beneath the site are of the Huntington-Lindside-Armour (Terrace Phases)-Egam association which occupy low stream terraces and along the Duck River and its tributaries (Ref. 3, p. 14). The Huntington and Lindside soils occupy bottom lands and depressed areas while the Egam soils occur on the higher bottoms and are better drained. The well-drained Armour terrace phase soils occupy the broad smooth terraces and develop from streamwash of upstream limestones (Ref. 3, p. 14). Etowah soils develop on high terraces of the Duck River and in the lower reaches of its major tributaries. These soils are well-drained, up to 40 inches thick, and are derived from phosphatic limestone parent material (Ref. 3, p. 31). Under the soilcover in low-lying areas in close proximity to the Duck River lie unconsolidated alluvial sands and gravels with minor silt and clays of the Quaternary Age (Ref. 11, p. 5). The unconsolidated deposits average around 30 feet in thickness within the valleys of the Duck River (Ref. 11, p. 6).

The site is underlain by rocks of the Ordovician Age. In descending order, these rocks consist of the following: the Hermitage formation, the Carters Limestone, the Lebanon Limestone, and the Ridley Limestone. In the vicinity of Columbia, the

Hermitage is approximately 70 feet thick and consists of thin-bedded, argillaceous limestone and shale partings (Ref. 11, p. 6). The Carters Limestone lies unconformably below and consists of approximately 65 feet of fine to coarse-grained massive-bedded limestone (Ref. 11, pp. 16, 17). Beneath lies the thin-bedded shaly limestone of the Lebanon Limestone which averages 105 feet in thickness (Ref. 11, p. 7). The lowest unit of concern is the Ridley Limestone, which is approximately 90 feet thick. The lithology consists of coarse-grained, massive limestones and thin shale partings (Ref. 11, p. 8). The topography of the area is karst.

Groundwater in the Columbia area occurs within the unconfined alluvial/colluvial deposits as well as in the underlying, confined limestone units. The Ordovician carbonates are highly fractured and porous due to solution activity (Ref. 10, p. 7). Most of the wells in the area obtain water from the Hermitage formation despite its shaly nature. However, good quality water occurs in moderate quantities where depth to the formation is less than 100 feet (Ref. 10, p. 19). The underlying Carters and Lebanon limestones are restricted somewhat as water-bearing formations by the fine-grained clayey nature of the Hermitage formation which can act as a confining layer (Ref 10, p. 17). However, the fractured nature of the formation allows groundwater flow to occur. As a result, the 260 feet of massive, coarse to fine-grained carbonates of the Carters, Lebanon, and Ripley limestones produce small to moderate quantities of water (Ref. 10, pp. 13-19). The Ripley, however, is the most reliable source because of its relatively pure nature allowing more favorable conditions for solution-channel development, and the Ripley limestone is largely responsible for the karst topography in the area (Ref. 10, p. 13). Depth to groundwater in the area is approximately 40 feet below land surface (bls) and flows toward the Duck River (Refs. 10, p. 58; 11). Hydraulic conductivities from limestones of similar composition range between $1 \times 10^{-4}$ to $1 \times 10^{-2}$ cm/sec (Ref. 12, p. 29).

## 3.2 Groundwater Targets

Most of the drinking water within the 4-mile radius is supplied by the Columbia Water Department, which gets its water from an intake on the Duck River, more than four miles upstream of the Monsanto site (Refs. 13, 14, 15). A significant number of houses within the 4-mile radius of Monsanto use groundwater wells, including approximately 34 within 0.25 miles, 22 more within 0.5 miles, 21 more within 1 mile, 138 more within 2 miles, 195 more within 3 miles, and 368 more within

4 miles. Using the Maury County average of 2.62 people per household, the number of people near Monsanto is approximately 63 within 0.25 miles, 58 more within 0.5 miles, 55 more within 1 mile, 362 more within 2 miles, 511 more within 3 miles, and 964 more within 4 miles (Ref. 16). Two of the wells within 0.25 miles are at a Girl Scout camp on Monsanto property. One of these wells was found to contain a small amount of phosphorus, but neither well is used for drinking water at the camp (Ref. 17).

## 4.0 Surface Water Pathway

### 4.1 Hydrologic Setting

Surface water runoff from the site flows into either Greenlick Creek or the Duck River. Greenlick Creek empties into the Duck River at the Monsanto property line after flowing through the property for four miles (Ref. 1). Greenlick Creek has a flowrate of 38.2 cubic feet per second (cfs) where it enters the Duck River (Ref. 18). The Duck River has an annual mean flow rate of 2091 cfs at the measuring station at river mile 132.8 in Columbia (Ref. 19). The sites of interest at Monsanto are all outside of the 100-year floodplains of the Duck River and Greenlick Creek (Ref. 20).

### 4.2 Surface Water Targets

The Columbia Water System has an intake on the Duck River at mile marker 134, and this is the only intake that they use. This intake is 7.5 miles upstream of Monsanto property. There are no surface water intakes within 15 miles downstream of Monsanto property, along either Greenlick Creek or the Duck River, with the exception of Monsanto's water system. The Monsanto water system has its intake on Greenlick Creek, and it serves the 35 employees on site (Ref. 21). The intake is upgradient of the probable points of entry from most of the areas on the site. However, the intake is on Monsanto property, and the possibility exists that the intake is contaminated.

There is a moderate amount of fishing on the Duck River in the 15-mile surface water pathway (Ref. 22). The release of phossy water caused occasional fish kills on Greenlick Creek when Monsanto was open, but the Duck River was never affected (Ref. 22). There are four miles of wetlands along the 15-mile surface water pathway

(Ref. 23). Although there are a significant number of endangered species in Maury County, none are known to inhabit the 15-mile surface water pathway (Refs. 24, 25).

## 5.0 Soil Exposure and Air Pathways

### 5.1 Physical Conditions

All of Monsanto's current operations are confined to a small industrial area that consists of roads, railroad tracks, and several buildings, and is adjacent to Greenlick Creek. The area, which is less than 50 acres, is fenced and is not open to the public. Vines, grass, and trees have been allowed to grow in the surrounding area, and they form a 5000 acre green belt around the facility. The old tailings ponds are popular with bird watchers, and deer and other animals inhabit the entire area (Ref. 21). An area in the eastern part of the Monsanto property is used as a Girl Scout camp in the summer months.

### 5.2 Soil and Air Targets

Thirty-five employees still work at the Monsanto plant, and they, along with occasional visitors, are the only people that have access to the industrial area (Ref. 26). The nearest residence is 0.13 miles south of the Monsanto property line, but a full mile away from the industrial area (Ref. 1). Whitthorne Junior High School is the nearest school, and it is 1.7 miles away from the property line (Ref. 1). Surface soil samples have not been taken in either the area around the Girl Scout camp or the areas that bird watchers frequent. However, the most likely contaminant for the surface soils in those areas is phosphate, and phosphate is a larger threat to the environment than it is to people. The unstressed nature of the environment in these areas suggests that phosphate contamination is not a problem there. Several endangered species live in Maury County, but they inhabit the eastern part of the county, more than four miles from Monsanto (Ref. 24).

## 6.0 Summary and Conclusions

The Monsanto Company site was evaluated to assess the threat posed to human health and the environment and to determine the need for additional investigation.

Fifteen areas on the 6400 acre property were examined. Although samples were only tested for inorganic contaminants, phosphorus, phosphate, fluoride, cyanide, lead, chromium, and arsenic were found in wells on site. Four of the worst areas were placed on the Tennessee Superfund Promulgated List, and have since been remediated.

The groundwater pathway is of concern because there is significant inorganic groundwater contamination. However, there are not very many people using private wells within four miles of the site, and the public system uses surface water.

Because of the 35 people using the Monsanto water system and fishing on the Duck River and wetlands along the Duck River, the surface water pathway is of significant importance. However, only one recent surface water sample showed contamination attributable to Monsanto, and this was well within their NPDES discharge limits (Refs. 18, 27). Samples taken from the Duck River downstream have shown no contamination. Subsequent samples taken from both locations have also shown no contamination (Ref. 28). No samples from the Monsanto water system have been analyzed.

Neither the soil exposure pathway nor the air pathway are of significant concern in this case. Nearly all of the contaminated soils are in areas locked within a fence, and this protects the general public from exposure. Furthermore, most of these areas have also been capped with several feet of clay, which protects the workers at the plant. The air pathway is not a major concern because the contaminants of interest are not easily volatilized, and, therefore, are unlikely to be carried through the air. The clay caps make this possibility even more remote.

From the information gathered in this study, it is recommended that further action be planned for the site.

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**CONFIDENTIAL**

# HAZARD RANKING SYSTEM PRELIMINARY SCORE FOR

## MONSANTO COMPANY INC.
## COLUMBIA, MAURY COUNTY, TENNESSEE
## EPA ID NO. TND004048104

This preliminary score was calculated using the June 18, 1992 draft SI worksheets. Pathways evaluated include groundwater, surface water, soil exposure, and air. The following score reflects a hazardous waste quantity score of 10,000 based upon the volume and surface area of fourteen areas on Monsanto property. The hazardous waste quantity score was determined primarily by site 9, which is a tailings pond. The main contaminants found onsite were elemental phosphorus, phosphate, lead, chromium, fluoride, and arsenic.

The groundwater pathway is of concern because there is significant groundwater contamination. The site was scored based on an observed release of lead. Samples taken during the site investigation conducted in 1985 show lead contamination far in excess of the MCL. More recent samples show lead contamination below the MCL, but the more recent sampling was not as extensive. There are 2000 people using private wells in the four-mile radius.

The surface water pathway is of concern because of the Monsanto drinking water intake on Greenlick Creek. Although the intake is upgradient of the probable points of entry for most of the areas on the site, the water has not been analyzed, and it may be contaminated. There are no other drinking water intakes or endangered species along the fifteen-mile surface water pathway, but there are fishing and wetlands. The tailings ponds near the Girl Scout camp were not sampled, and it is not known whether they are contaminated. However, the Girl Scouts do not use these ponds, so any possible contamination will probably have little effect on the score. Two worst case surface water pathway scores are attained by assuming Level I contamination and Level II contamination of the Monsanto intake.

The air pathway is not of serious concern because the contaminants that have been detected on site are metals, and they have very low air mobilities.

The soil exposure pathway is of concern because there are 35 workers on-site, and there are soil contaminants. The central area is fenced, so there is little risk of non-workers being exposed there, but the vast majority of the property is accessible to the public. The unfenced area draws moderate numbers of people because it is a bird sanctuary, so this will provide a possible pathway for contamination. The Girl Scout camp is again of interest because the Girl Scouts will have significant contact with potentially contaminated soils. Only composite soil boring samples were analyzed at Monsanto, but a worst case for this pathway was scored as if surface soil samples were taken and contamination was found.

Based on these preliminary scores, further action is recommended for Monsanto Company.

**Score based on current information:**

$S_{gw}$ = 76.30
$S_{sw}$ = 3.94
$S_s$ = 0.00
$S_a$ = 1.24

**Overall Score** = 38.2

**Worst case score I:**

$S_{gw}$ = 76.30
$S_{sw}$ = 100.00
$S_s$ = 3.69
$S_a$ = 1.24

**Overall Score** = 62.9

**Worst case score II:**

$S_{gw}$ = 76.30
$S_{sw}$ = 56.70
$S_s$ = 3.69
$S_a$ = 1.24

**Overall Score** = 47.6

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | - | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | 10 | |
| 2b. Runoff | 25 | 25 | |
| 2c. Distance to Surface Water | 25 | 25 | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | 500 | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 500 |
| Waste Characteristics | | | |
| 6. Toxicity/Persistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 2 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 0 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0.5 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 7.5 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 4.55 |

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 0 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 0 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 0 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 500 |

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 0.91 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 5.46 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 5.46 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (continued)** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | - | |
| 2. Potential to Release | | | |
| 2a. Gas Potential to Release | 500 | - | |
| 2b. Particulate Potential to Release | 500 | 500 | |
| 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 0.8 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 6 |
| **Targets** | | | |
| 7. Nearest Individual | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 5.7 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. Resources | 5 | 5 | |
| 10. Sensitive Environments | | | |
| 10a. Actual Contamination | c | 0 | |
| 10b. Potential Contamination | c | 3.386 | |
| 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| **Air Migration Pathway Score** | | | |
| 12. Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | 550 | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | - | |
| 2b. Runoff | 25 | - | |
| 2c. Distance to Surface Water | 25 | - | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | - | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 550 |
| Waste Characteristics | | | |
| 6. Toxicity/Presistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 0 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 0 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 5 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 3.33 |

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 550 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 20 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 20 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 13.33 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 550 |

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 1.00 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 17.66 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 17.66 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (continued)** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 + 19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

a Maximum value applies to waste characteristics category.
b Maximum value not applicable.
c No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
d Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | - | |
| 2. Potential to Release | | | |
| 2a. Gas Potential to Release | 500 | - | |
| 2b. Particulate Potential to Release | 500 | 500 | |
| 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 0.8 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 6 |
| **Targets** | | | |
| 7. Nearest Individual | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 5.7 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. Resources | 5 | 5 | |
| 10. Sensitive Environments | | | |
| 10a. Actual Contamination | c | 0 | |
| 10b. Potential Contamination | c | 3.386 | |
| 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| **Air Migration Pathway Score** | | | |
| 12. Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500]$^{F}$ | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)$^{c}$ | 100 | | 76.3 |

a Maximum value applies to waste characteristics category.
b Maximum value not applicable.
c Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | 550 | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | - | |
| 2b. Runoff | 25 | - | |
| 2c. Distance to Surface Water | 25 | - | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | - | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 550 |
| Waste Characteristics | | | |
| 6. Toxicity/Presistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 50 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 350 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 405 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 550 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 20 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 20 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 13.33 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 550 |

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 1.00 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 100 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 100 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (contin** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

a Maximum value applies to waste characteristics category.
b Maximum value not applicable.
c No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
d Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | - | |
| 2. Potential to Release | | | |
| 2a. Gas Potential to Release | 500 | - | |
| 2b. Particulate Potential to Release | 500 | 500 | |
| 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 0.8 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 6 |
| **Targets** | | | |
| 7. Nearest Individual | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 5.7 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. Resources | 5 | 5 | |
| 10. Sensitive Environments | | | |
| 10a. Actual Contamination | c | 0 | |
| 10b. Potential Contamination | c | 3.386 | |
| 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| **Air Migration Pathway Score** | | | |
| 12. Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | 550 | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | - | |
| 2b. Runoff | 25 | - | |
| 2c. Distance to Surface Water | 25 | - | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | - | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 550 |
| Waste Characteristics | | | |
| 6. Toxicity/Persistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 45 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 35 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 85 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 56.7 |

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 550 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 20 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 20 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 13.33 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 550 |

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 1.00 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 57.7 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 57.7 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (contin** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

a Maximum value applies to waste characteristics category.
b Maximum value not applicable.
c No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
d Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | - | |
| 2. Potential to Release | | | |
| 2a. Gas Potential to Release | 500 | - | |
| 2b. Particulate Potential to Release | 500 | 500 | |
| 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 0.8 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 6 |
| **Targets** | | | |
| 7. Nearest Individual | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 5.7 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. Resources | 5 | 5 | |
| 10. Sensitive Environments | | | |
| 10a. Actual Contamination | c | 0 | |
| 10b. Potential Contamination | c | 3.386 | |
| 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| **Air Migration Pathway Score** | | | |
| 12. Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

# EPA Notification of Hazardous Waste Site

R

United States Environmental Protection Agency Washington DC 20460

This initial notification information is required by Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 and must be mailed by June 9, 1981.

Please type or print in ink. If you need additional space, use separate sheets of paper. Indicate the letter of the item which applies.

810609

TNS000001096

**A Person Required to Notify:**

Enter the name and address of the person or organization required to notify.

Name: Monsanto Company

Street: Monsanto Road

City: Columbia State: TN Zip Code: 38401

**B Site Location:**

Enter the common name (if known) and actual location of the site.

TND004048104

Name of Site: Monsanto Company

Street: Monsanto Road

City: Columbia County: Maury State: TN Zip Code: 38401

**C Person to Contact:**

Enter the name, title (if applicable), and business telephone number of the person to contact regarding information submitted on this form.

Name (Last, First and Title): Smith, Steve, Environmental Engineer

Phone: 615-388-3431 Extension 300

**D Dates of Waste Handling:**

Enter the years that you estimate waste treatment, storage, or disposal began and ended at the site.

From (Year): 1937 To (Year): 1979

**E Waste Type:** Choose the option you prefer to complete

**Option 1:** Select general waste types and source categories. If you do not know the general waste types or sources, you are encouraged to describe the site in Item I—Description of Site.

**General Type of Waste:**
Place an X in the appropriate boxes. The categories listed overlap. Check each applicable category.

1. ☐ Organics
2. XX Inorganics
3. ☐ Solvents
4. ☐ Pesticides
5. ☐ Heavy metals
6. ☐ Acids
7. ☐ Bases
8. ☐ PCBs
9. ☐ Mixed Municipal Waste
10. ☐ Unknown
11. ☐ Other (Specify)

**Source of Waste:**
Place an X in the appropriate boxes.

1. ☐ Mining
2. ☐ Construction
3. ☐ Textiles
4. ☐ Fertilizer
5. ☐ Paper/Printing
6. ☐ Leather Tanning
7. ☐ Iron/Steel Foundry
8. XX Chemical, General
9. ☐ Plating/Polishing
10. ☐ Military/Ammunition
11. ☐ Electrical Conductors
12. ☐ Transformers
13. ☐ Utility Companies
14. ☐ Sanitary/Refuse
15. ☐ Photofinish
16. ☐ Lab/Hospital
17. ☐ Unknown
18. ☐ Other (Specify)

**Option 2:** This option is available to persons familiar with the Resource Conservation and Recovery Act (RCRA) Section 3001 regulations (40 CFR Part 261).

**Specific Type of Waste:**
EPA has assigned a four-digit number to each hazardous waste listed in the regulations under Section 3001 of RCRA. Enter the appropriate four-digit number in the boxes provided. A copy of the list of hazardous wastes and codes can be obtained by contacting the EPA Region serving the State in which the site is located.

RECEIVED EPA/REGION IV JUN 9 3 15 PM '81 ENFORCEMENT DIVISION

0004 25

Form Approved OMB No. 2000-0138

EPA Form 8900-1

Notification of Hazardous Waste Site — Side Two

**F Waste Quantity:**

Place an X in the appropriate boxes to indicate the facility types found at the site.

In the "total facility waste amount" space give the estimated combined quantity (volume) of hazardous wastes at the site using cubic feet or gallons.

In the "total facility area" space, give the estimated area size which the facilities occupy using square feet or acres.

**Facility Type**

1. ☐ Piles
2. ☐ Land Treatment
3. XX Landfill
4. ☐ Tanks
5. ☐ Impoundment
6. ☐ Underground Injection
7. ☐ Drums, Above Ground
8. XX Drums, Below Ground
9. ☐ Other (Specify) _____

**Total Facility Waste Amount**

cubic feet 274,205

gallons _____

**Total Facility Area**

square feet _____

acres 11

**G Known, Suspected or Likely Releases to the Environment:**

Place an X in the appropriate boxes to indicate any known, suspected, or likely releases of wastes to the environment.

[XX] not known ☐ Known ☐ Suspected ☐ Likely ☐ None

Note: Items H and I are optional. Completing these items will assist EPA and State and local governments in locating and assessing hazardous waste sites. Although completing the items is not required, you are encouraged to do so.

**H Sketch Map of Site Location: (Optional)**

Sketch a map showing streets, highways, routes or other prominent landmarks near the site. Place an X on the map to indicate the site location. Draw an arrow showing the direction north. You may substitute a publishing map showing the site location.

A copy of a U.S. Geologic Survey topographic map showing the plant site and the inactive landfill sites is attached. This is a copy of the information attached with the November RCRA notification.

**I Description of Site: (Optional)**

Describe the history and present conditions of the site. Give directions to the site and describe any nearby wells, springs, lakes, or housing. Include such information as how waste was disposed and where the waste came from. Provide any other information or comments which may help describe the site conditions.

**J Signature and Title:**

The person or authorized representative (such as plant managers, superintendents, trustees or attorneys) of persons required to notify must sign the form and provide a mailing address (if different than address in item A). For other persons providing notification, the signature is optional. Check the boxes which best describe the relationship to the site of the person required to notify. If you are not required

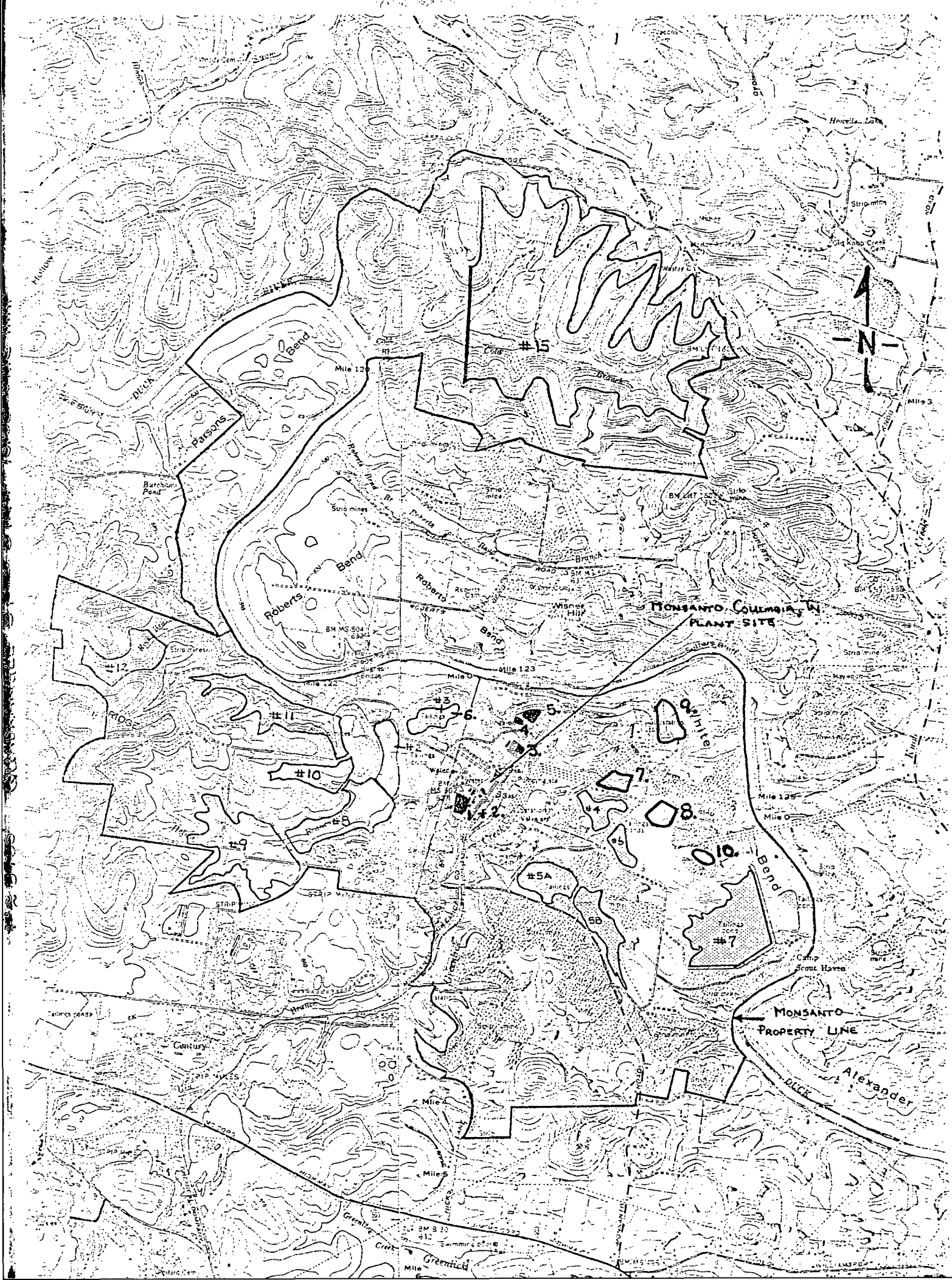
Name Needham Coppedge, Plant Manager

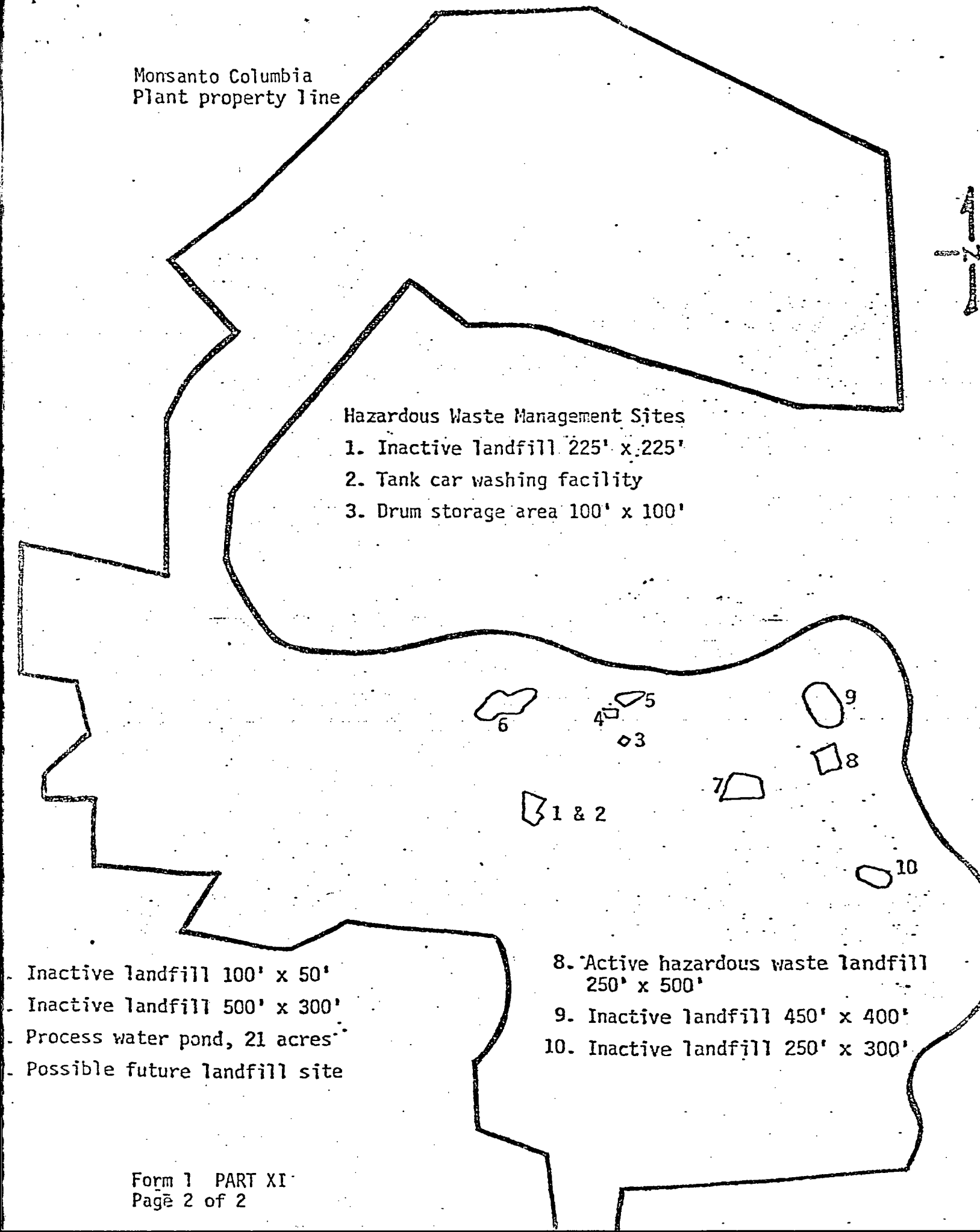
Street Monsanto Road

City Columbia State TN Zip Code 38401

Signature Needham Coppedge Date 6-3-81

☒ Owner, Present
☐ Owner, Past
☐ Transporter
☒ Operator, Present
☐ Operator, Past
☐ Other


N
#15
Roberts Bend
Parsons
Burchum Pond
Strip mines
Mile 120
Mile 123
Mile 125
Mile 0
Mile 3
Mile 4
Mile 5
Mile 6
Wisner Hill
MONSANTO, COLUMBIA, TN
PLANT SITE
#12
#11
#10
#9
#8
#3
#2
#4
#5
#5A
#5B
#7
1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
White Bend
Camp Scout Haven
MONSANTO
PROPERTY LINE
Alexander
Century
Greenfield
Greenfield Creek
Cold Branch
Dutch Hollow
Roberts Bend Br.
Hicks Creek
Hicks Branch
Hanner Branch
Wisner Branch
Strip mines
Old Knob Creek
Hoicelle Lake


Monsanto Columbia
Plant property line
N
Hazardous Waste Management Sites
1. Inactive landfill 225' x 225'
2. Tank car washing facility
3. Drum storage area 100' x 100'
6
4
5
3
9
8
7
1 & 2
10
. Inactive landfill 100' x 50'
. Inactive landfill 500' x 300'
. Process water pond, 21 acres
. Possible future landfill site
8. Active hazardous waste landfill 250' x 500'
9. Inactive landfill 450' x 400'
10. Inactive landfill 250' x 300'

Monsanto

**MONSANTO CHEMICAL INTERMEDIATES CO.**
800 N. Lindbergh Boulevard
St. Louis, Missouri 63166
Phone: (314) 694-1000

June 4, 1981

U.S. Environmental Protection Agency
Region IV
Sites Notification
Atlanta, GA 30308

Gentlemen:

In accordance with the requirements of Section 103(c) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, the enclosed Notification of Hazardous Waste Site is submitted.

The notification has been signed on behalf of Monsanto Company by the Columbia Plant Manager. Please note, however, that any communication with Monsanto Company in connection with this notification should be addressed (and will move much more rapidly if so addressed) as follows:

Mr. J. S. Smith
Monsanto Company
Monsanto Road
Columbia, Tennessee 38401

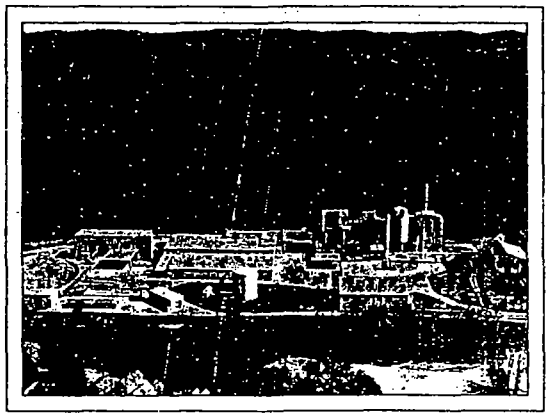
Phone: (615) 388-3431

Sincerely,

Michael R. Foresman

Michael R. Foresman
Environmental Affairs Manager

MRF:ku
Enclosure



**Not a place to burn waste, protesters say.**

Humphreys says he feels completely comfortable with the safety of the project. "This place is under the tightest scrutiny you can imagine, and we like that," he says. He also says he and the other members of the Citizens Advisory Committee are allowed to arrive at the facility whenever they like, without advance warning. "People there are instructed to show us what's going on whenever we turn up," he says.

**DIFFERENT STORY.** For the incinerator's opponents, the story is entirely different. "I'll sum it up for you," says Swearingen. "Incineration of hazardous waste is not safe, it's not needed, it's not wanted, and in this case it's illegal." Swearingen points out that the facility will be allowed to release 4.5 tons of lead, 1.5 tons of mercury, and 100 tons of sulfur dioxide into the atmosphere each year. She also says a preliminary EPA study indicates that indirect risks—contamination of the food chain in the area—could be as much as 100 times greater than risk suffered by simple inhalation of emissions.

In addition, Swearingen and other like-minded citizens find the location of the facility completely unacceptable. They say that East Liverpool is located in an atmospheric inversion area, further increasing health risks related to emissions, and that, despite the company's claims to the contrary, the plant is in a flood hazard area. It is also a few hundred feet from the nearest homes. Even more disturbing to some of the protesters is the location of an elementary school about 300 yards in a direct line from the top of the facility's incinerator stack.

Should WTI be allowed to proceed with plans to add a second kiln to the plant, says Swearingen, Ohio will be home to 21% of national hazardous waste incineration capacity, an amount considerably above the state's own production of hazardous waste.

In addition, says Swearingen, while some residents of the area are in favor of the project, a majority are not. She points to telephone surveys conducted by the Steubenville *Herald-Star* in November of last year that indicate 72% of area residents surveyed thought civil disobedience should be used to protest the plant; in December 1992, 63% thought Clinton should intervene in the testing of the facility.

As for its illegal aspect, Swearingen says that while Von Roll America, a subsidiary of Von Roll, has wholly owned the project since 1990, during the 10 previous years the composition of the partners and ownership of the facility underwent a number of changes and violated the terms of the Resource Conservation and Recovery Act, which requires advance approval for any change in permit holders.

WTI management says it believes Swearingen is an employee of Greenpeace. Greenpeace has been actively involved in opposing the facility and helped to organize a protest in November 1992, during which actor Sheen—whose mother-in-law lives in the area—joined local opponents who climbed over a fence to gain access to the grounds. Swearingen denies that she has ever worked for Greenpeace and says that, far from receiving remuneration for her work, she has poured considerable personal assets into the effort to stop the plant. "We just want our lives back as they were before WTI," she says. "There's no other reason for doing this than that we care."

Larry Rosen, CEO and chairman of Pressure Chemical in nearby Pittsburgh, says he believe WTI has been unmercifully hounded by the public and the various regulatory agencies. "A burden has been imposed on them that shouldn't be imposed," Rosen says. He calls WTI "a symbol of the ills of our times."

It is a statement that perhaps both sides of the question would agree on—although each side would claim to see evil lurking in the opposite corner.

*MARJORIE COEYMAN*
*in East Liverpool, OH*

# PHOSPHORUS CLEANUP BENEFITS WILDLIFE IN TENNESSEE

## *The community birdwatchers give guidance*

When the phosphorus mining and processing industry began winding down operations in Maury County, Tennessee in the late 1980s after about 50 years of activity, a key concern for state officials and environmentalists became how the companies would handle the cleanup and restoration of manufacturing sites.

While Monsanto (St. Louis), Rhône-Poulenc (Princeton, NJ), and OxyChem (Dallas) all had large phosphorus units, the initial interest was focused on Monsanto, which stopped manufacturing operations in 1986 and began immediate steps to reclaim and clean up its 5,300-acre tract near Columbia.

Monsanto faced an approximately $80-million remediation job and also had to lay off or find new work for 403 employees. Although the Responsible Care program had not yet been introduced in the industry, Monsanto had traditionally maintained good community relations in Columbia and also had a good reputation with local environmental groups, which considered that the company's processing plant was operated with attention to environmental impacts.

The result has been a fairly successful cleanup and wind down to date. The environmental remediation plan and follow through has received good reviews from the state Department of Environment and Conservation, according to officials in Nashville, and Monsanto's work on wildlife protection won national attention.

At the same time Monsanto was able to relocate about 100 workers to other plants, offer another 100 early retirement, and provide work for about 100 others in the cleanup effort.

For Monsanto, a key issue was what to do with about 1,000 acres of tailings ponds that had been used in ore washing operations and were filled with clay deposits but not toxic chemicals. According to Nelson Lyles, current site manager in Columbia for Monsanto, the original idea was to drain the ponds and plant cypress trees to stabilize the clay soil. But as this idea was being consid-

ered, a totally different solution arose because of interest by local bird watching groups. Members of the Tennessee Ornithological Society (TOS), led by naturalist Stephen Stedman, had discovered that the tailing ponds had evolved into a prime wetland area in the region and housed up to 160 different species of birds. Stedman had determined that because other wetlands were rare in that part of the state, the Monsanto Ponds attracted species not normally seen elsewhere.

TOS members had shown over several years that the ponds were being used for breeding by rare species, including Virginia Rails, Common Moorhens, Greenback Herons, and Tundra Swans. Stedman said that the forestation project would probably eliminate these species from the Middle Tennessee area and his group won agreement from Monsanto to maintain three ponds with about 200 acres of area as a bird preserve.

**Sunset for phosphorus processing in Maury County.**

**REFUGE.** Monsanto designed the refuge in cooperation with the Tennessee Wildlife Resources Agency and officially opened it in 1990. The company set up two observation platforms near a public road, a visitor's center, nesting boxes, and is now considering creating nature trails and more blinds, says Lyles. Eventually, Monsanto says it will make its entire 5,000-acre site a wildlife habitat enhancement area with mineral licks for deer and plantings of special trees and grasses for wildlife food and protection. Monsanto will also plant 4 million cypress trees at the site and has arranged with farmers to leave wooded sites along the area's boundaries.

Besides the ponds, Monsanto carried out a distillation process on the site between 1987 and 1990 to remove elemental phosphorus from sludges remaining in storage on the site. It recovered more than 2 million lbs of phosphorus and reduced sludge volume by 90%.

Currently, says Lyles, Monsanto is operating a $10-million groundwater treatment plant on the site that is removing pollution that leaked into the ground from tanks. The company also has environmental monitoring equipment and employs a staff of 18 to maintain the site. It also has a small phosphorus drumming operation using raw materials brought in from plants in Idaho. Lyles says that Monsanto now believes that a constructed wetland may be a better long term means to treat groundwater and is looking into that option but has not yet made a decision.

Lyles also said that Monsanto had kept down its final cleanup costs by carrying out reclamation of mining areas as it closed mines. It also has persuaded state officials that in some cases full reclamation, which would leave open fields, was less preferrable for wildlife ehancement than leaving sites alone with existing dense cover.

To help employees find jobs, Monsanto had hired a placement consultant to help with retraining, independent business startups, and resumé writing. It also agreed to allow early departures using contract workers to fill jobs.

For placement inside the company, Monsanto maintained an office in Columbia for a year and eventually relocated employees in 13 different locations.

Monsanto also offered an early retirement plan for workers who reached 55 with an incentive of one week's pay per year of service. This benefit usually amounted to more than a half-year's pay.

Also once it gained experience with the plant dismantling, including recovery of 20 million lbs of carbon steel for scrap, it determined that retrained Monsanto workers could do most of the work. This allowed it to keep many extra workers on until the 55-year retirement age and saved an estimated $3 million in contracting costs.

While Monsanto is well ahead in its cleanup in the Columbia area, Rhône-Poulenc and OxyChem are still in earlier stages. OxyChem is believed to face a $75 million-$100 million cleanup effort, and cost for the Rhône-Poulenc job appear to be similar.

Officials of the Tennessee Environmental Council, a state-wide activist group, say they believe the OxyChem and Rhône-Poulenc properties are in worse shape than what Monsanto started with in 1986 because the plants used different processes that discharged more wastes into ponds. At present, however, the group is waiting to see how what remediation plans are presented.

Rhône-Poulenc inherited phosphorus production and a 4,000-acre site near Mt. Pleasant, TN when it bought Stauffer Chemicals in 1987. According to John Sheehan, director of regulation for Rhône-Poulenc Basic Chemicals in Shelton, CT, the company has ended all mining and has shut down half its phosphorus processing capacity in the Mt. Pleasant area. It is now using the other half to reprocess waste from tanks and ponds and recover remaining phosphorus.

**EVALUATING.** "Once we have finished the reprocessing we will evaluate how much material is left and develop a site remediation plan," says Sheehan. This will be reported to the state Department of Health and Environment for final approval.

Rhône-Poulenc is not yet sure what shape its ponds will be in once the reprocessing is done and what will be the best solution for them. It is considering a constructed wetlands approach for groundwater treatment, and is looking at the way Monsanto has handled its tailing ponds.

OxyChem had sold off its phosphorus business in 1991 and stopped all mining and processing at the site in June of that year. It is still in the first stages of determining its cleanup plan, says Ken Haseley, company spokesman in Dallas. It expects to dismantle and remove all production equipment by 1994 and also to complete initial sampling of ponds and groundwater by that time.

OxyChem had used its ponds to collect phosphorus wastes and now must reclaim the material from the ponds as a key step in its cleanup effort. Haseley says the company is evaluating processes for recovering the phosphorus and will later make a determination on the long-term use of the site. It will also submit a remediation plan to the state.

The OxyChem shutdown in 1991 forced the layoff of 280 workers. The workers were given normal company severance packages.

*PAUL KEMEZIS*

* Update

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# IDENTIFICATION AND PRELIMINARY ASSESSMENT

REGION:

SITE NUMBER (to be assigned by Hq): TND004048104

**NOTE:** This form is completed for each potential hazardous waste site to help set priorities for site inspection. The information submitted on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

**GENERAL INSTRUCTIONS:** Complete Sections I and III through X as completely as possible before Section II (*Preliminary Assessment*). File this form in the Regional Hazardous Waste Log File and submit a copy to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force (*EN-335*); 401 M St., SW; Washington, DC 20460.

## I. SITE IDENTIFICATION

A. SITE NAME: Monsanto Chemical Company Inc

B. STREET (or other identifier): Monsanto Road

C. CITY: Columbia

D. STATE: TN

E. ZIP CODE: 38401

F. COUNTY NAME: Maury

G. OWNER/OPERATOR (If known)

1. NAME: John Smith, Environmental Engineer

2. TELEPHONE NUMBER: 615-388-3431

H. TYPE OF OWNERSHIP

☐ 1. FEDERAL ☐ 2. STATE ☐ 3. COUNTY ☐ 4. MUNICIPAL ☑ 5. PRIVATE ☐ 6. UNKNOWN

I. SITE DESCRIPTION: Hwy. 50 West

J. HOW IDENTIFIED (i.e., citizen's complaints, OSHA citations, etc.): ERRS LIST

K. DATE IDENTIFIED (mo., day, & yr.):

L. PRINCIPAL STATE CONTACT

1. NAME: Rebecca Harris, Environmental Engineer

2. TELEPHONE NUMBER: 615-741-3424

## II. PRELIMINARY ASSESSMENT (complete this section last)

A. APPARENT SERIOUSNESS OF PROBLEM

☐ 1. HIGH ☐ 2. MEDIUM ☒ 3. LOW ☐ 4. NONE ☐ 5. UNKNOWN

B. RECOMMENDATION

☐ 1. NO ACTION NEEDED (no hazard)

☐ 2. IMMEDIATE SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

☐ 3. SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

☑ 4. SITE INSPECTION NEEDED (low priority)

C. PREPARER INFORMATION

1. NAME: Karen Bonner

2. TELEPHONE NUMBER: 615-741-6287

3. DATE (mo., day, & yr.): 11-23-83

## III. SITE INFORMATION

A. SITE STATUS

☑ 1. ACTIVE (Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if intermittently.)

☐ 2. INACTIVE (Those sites which no longer receive wastes.)

☐ 3. OTHER (specify): (Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.)

B. IS GENERATOR ON SITE?

☐ 1. NO ☐ 2. YES (specify generator's four-digit SIC Code):

C. AREA OF SITE (in acres):

D. IF APPARENT SERIOUSNESS OF SITE IS HIGH, SPECIFY COORDINATES

1. LATITUDE (deg.-min.-sec.):

2. LONGITUDE (deg.-min.-sec.):

E. ARE THERE BUILDINGS ON THE SITE?

☐ 1. NO ☑ 2. YES (specify):

Continued From Front

## IV. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in the appropriate boxes.

| 'X' | A. TRANSPORTER | 'X' | B. STORER | 'X' | C. TREATER | 'X' | D. DISPOSER |
|---|---|---|---|---|---|---|---|
| | 1. RAIL | | 1. PILE | | 1. FILTRATION | | 1. LANDFILL |
| | 2. SHIP | | 2. SURFACE IMPOUNDMENT | | 2. INCINERATION | | 2. LANDFARM |
| | 3. BARGE | | 3. DRUMS | | 3. VOLUME REDUCTION | | 3. OPEN DUMP |
| | 4. TRUCK | | 4. TANK, ABOVE GROUND | | 4. RECYCLING/RECOVERY | | 4. SURFACE IMPOUNDMENT |
| | 5. PIPELINE | | 5. TANK, BELOW GROUND | | 5. CHEM./PHYS. TREATMENT | | 5. MIDNIGHT DUMPING |
| | 6. OTHER (specify): | | 6. OTHER (specify): | | 6. BIOLOGICAL TREATMENT | | 6. INCINERATION |
| | | | | | 7. WASTE OIL REPROCESSING | | 7. UNDERGROUND INJECTION |
| | | | | | 8. SOLVENT RECOVERY | | 8. OTHER (specify): |
| | | | | | 9. OTHER (specify): | | |

E. SPECIFY DETAILS OF SITE ACTIVITIES AS NEEDED

they produce elemental phosphorus from ore through a process of washing, concentrating, blending, nodulizing, and firing in an electric furnace. There are 3 general waste categories considered at this plant: 1) Phos. processing waste 2) laboratory chemical waste 3) PCB contaminated transformer oil

## V. WASTE RELATED INFORMATION

A. WASTE TYPE

[X] 1 UNKNOWN [ ] 2. LIQUID [ ] 3. SOLID [ ] 4. SLUDGE [ ] 5. GAS

B. WASTE CHARACTERISTICS

[X] 1. UNKNOWN [ ] 2. CORROSIVE [ ] 3. IGNITABLE [ ] 4 RADIOACTIVE [ ] 5 HIGHLY VOLATILE
[ ] 6. TOXIC [ ] 7 REACTIVE [ ] 8 INERT [ ] 9 FLAMMABLE

[ ] 10. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

EPA - 5IA

2. Estimate the amount (specify unit of measure) of waste by category; mark 'X' to indicate which wastes are present.

| a. SLUDGE | b. OIL | c. SOLVENTS | d. CHEMICALS | e. SOLIDS | f. OTHER |
|---|---|---|---|---|---|
| AMOUNT | AMOUNT | AMOUNT | AMOUNT 31918 | AMOUNT | AMOUNT |
| UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE KG | UNIT OF MEASURE | UNIT OF MEASURE |
| 'X' (1) PAINT, PIGMENTS | 'X' (1) OILY WASTES | 'X' (1) HALOGENATED SOLVENTS | 'X' (1) ACIDS | 'X' (1) FLYASH | 'X' (1) LABORATORY PHARMACEUT. |
| (2) METALS SLUDGES | (2) OTHER (specify): | (2) NON-HALOGNTD. SOLVENTS | (2) PICKLING LIQUORS | (2) ASBESTOS | (2) HOSPITAL |
| (3) POTW | | (3) OTHER (specify): | (3) CAUSTICS | (3) MILLING/ MINE TAILINGS | (3) RADIOACTIVE |
| (4) ALUMINUM SLUDGE | | | (4) PESTICIDES | (4) FERROUS SMLTG. WASTES | (4) MUNICIPAL |
| (5) OTHER (specify): | | | (5) DYES/INKS | (5) NON-FERROUS SMLTG. WASTES | (6) OTHER (specify): |
| | | | (6) CYANIDE | (6) OTHER (specify): | |
| | | | (7) PHENOLS | | |
| | | | (8) HALOGENS | | |
| | | | (9) PCB | | |
| | | | (10) METALS | | |
| | | | X (11) OTHER (specify) Scrap phosphorus | | |



Continue On Page 3

*Continued From Page 2*

## V. WASTE RELATED INFORMATION *(continued)*

3. LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE *(place in descending order of hazard)*.

4. ADDITIONAL COMMENTS OR NARRATIVE DESCRIPTION OF SITUATION KNOWN OR REPORTED TO EXIST AT THE SITE.

## VI. HAZARD DESCRIPTION

| A. TYPE OF HAZARD | B. POTENTIAL HAZARD *(mark 'X')* | C. ALLEGED INCIDENT *(mark 'X')* | D. DATE OF INCIDENT *(mo., day, yr.)* | E. REMARKS |
|---|---|---|---|---|
| 1. NO HAZARD | | | | |
| 2. HUMAN HEALTH | X | | | |
| 3. NON-WORKER INJURY/EXPOSURE | | | | |
| 4. WORKER INJURY | X | | | |
| 5. CONTAMINATION OF WATER SUPPLY | | | | |
| 6. CONTAMINATION OF FOOD CHAIN | | | | |
| 7. CONTAMINATION OF GROUND WATER | | | | |
| 8. CONTAMINATION OF SURFACE WATER | | | | |
| 9. DAMAGE TO FLORA/FAUNA | | | | |
| 10. FISH KILL | | | | |
| 11. CONTAMINATION OF AIR | | | | |
| 12. NOTICEABLE ODORS | | | | |
| 13. CONTAMINATION OF SOIL | | | | |
| 14. PROPERTY DAMAGE | | | | |
| 15. FIRE OR EXPLOSION | | | | |
| 16. SPILLS/LEAKING CONTAINERS/ RUNOFF/STANDING LIQUIDS | | | | |
| 17. SEWER, STORM DRAIN PROBLEMS | | | | |
| 18. EROSION PROBLEMS | | | | |
| 19. INADEQUATE SECURITY | | | | |
| 20. INCOMPATIBLE WASTES | | | | |
| 21. MIDNIGHT DUMPING | | | | |
| 22. OTHER *(specify)*: | | | | |



*Continue On Reverse*

Continued From Front

## VII. PERMIT INFORMATION

A. INDICATE ALL APPLICABLE PERMITS HELD BY THE SITE.

- [ ] 1. NPDES PERMIT
- [ ] 2. SPCC PLAN
- [ ] 3. STATE PERMIT (specify): _____
- [ ] 4. AIR PERMITS
- [ ] 5. LOCAL PERMIT
- [ ] 6. RCRA TRANSPORTER
- [ ] 7 RCRA STORER
- [ ] 8 RCRA TREATER
- [ ] 9 RCRA DISPOSER
- [ ] 10. OTHER (specify): _____

B. IN COMPLIANCE?

- [x] 1. YES
- [ ] 2. NO
- [ ] 3. UNKNOWN
- 4. WITH RESPECT TO (list regulation name & number): _____

## VIII. PAST REGULATORY ACTIONS

- [x] A. NONE
- [ ] B. YES (summarize below)

## IX. INSPECTION ACTIVITY (past or on-going)

- [ ] A NONE
- [x] B. YES (complete items 1,2,3, & 4 below)

| 1 TYPE OF ACTIVITY | 2 DATE OF PAST ACTION (mo., day, & yr.) | 3 PERFORMED BY: (EPA/State) | 4. DESCRIPTION |
|---|---|---|---|
| compliance inspection | 9-28-83 | state | no violations were found |
| | | | |
| | | | |

## X. REMEDIAL ACTIVITY (past or on-going)

- [x] A. NONE
- [ ] B. YES (complete items 1, 2, 3, & 4 below)

| 1. TYPE OF ACTIVITY | 2. DATE OF PAST ACTION (mo., day, & yr.) | 3. PERFORMED BY: (EPA/State) | 4. DESCRIPTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

NOTE: Based on the information in Sections III through X, fill out the Preliminary Assessment (Section II) information on the first page of this form.



Monsanto is subject to testing and notification hazardous waste regulations only the 3 waste types listed are exempt from compliance with other hazardous waste requirements. The phosphorus processing waste is exempt under Rule 1200-1-11-.02(1)(d)3(ii)(III). Lab wastes, due to the small quantity produced, are exempt under Rule 1200-1-11-.02(1)(c)1. PCB transformer oil is not a waste because it is still being used as a valuable material in the transformer. The Tenn. Regional SWM office should be informed before contaminated oil is removed. At that time, proper removal, transport, and disposal of the material will be coordinated between Stauffer, TN-SWM, and the EPA.

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## IDENTIFICATION AND PRELIMINARY ASSESSMENT

| REGION | SITE NUMBER (to be assigned by HQ) |
|---|---|
| | |

NOTE: This form is completed for each potential hazardous waste site to help set priorities for site inspection. The information submitted on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

GENERAL INSTRUCTIONS: Complete Sections I and III through X as completely as possible before Section II (*Preliminary Assessment*). File this form in the Regional Hazardous Waste Log File and submit a copy to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force (*EN-335*); 401 M St., SW; Washington, DC 20460.

## I. SITE IDENTIFICATION

A. SITE NAME: Monsanto Chemical

B. STREET (or other identifier):

C. CITY: Columbia

D. STATE: TN

E. ZIP CODE: 38401

F. COUNTY NAME: Maury

G. OWNER/OPERATOR (If known)

1. NAME: SAME

2. TELEPHONE NUMBER:

H. TYPE OF OWNERSHIP

☐ 1. FEDERAL ☐ 2. STATE ☐ 3. COUNTY ☐ 4. MUNICIPAL ☑ 5. PRIVATE ☐ 6. UNKNOWN

I. SITE DESCRIPTION

Chemical, Inorganics + Misc. Dump

J. HOW IDENTIFIED (*i.e., citizen's complaints, OSHA citations, etc.*)

Eckhart

K. DATE IDENTIFIED (mo., day, & yr.): 11-21-79

L. PRINCIPAL STATE CONTACT

1. NAME: SHM

2. TELEPHONE NUMBER: 7413424

## II. PRELIMINARY ASSESSMENT (*complete this section last*)

A. APPARENT SERIOUSNESS OF PROBLEM

☐ 1. HIGH ☐ 2. MEDIUM ☐ 3. LOW ☐ 4. NONE ☑ 5. UNKNOWN

B. RECOMMENDATION

☐ 1. NO ACTION NEEDED (*no hazard*)

☐ 2. IMMEDIATE SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

☐ 3. SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR: 1980
b. WILL BE PERFORMED BY:

☐ 4. SITE INSPECTION NEEDED (*low priority*)

C. PREPARER INFORMATION

1. NAME: [illegible]

2. TELEPHONE NUMBER: 7413424

3. DATE (mo., day, & yr.): 2-4-80

## III. SITE INFORMATION

A. SITE STATUS

☐ 1. ACTIVE (*Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.*)

☑ 2. INACTIVE (*Those sites which no longer receive wastes.*)

☐ 3. OTHER (*specify*) (*Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.*)

B. IS GENERATOR ON SITE?

☐ 1. NO ☑ 2. YES (*specify generator's four-digit SIC Code*):

C. AREA OF SITE (*in acres*)

D. IF APPARENT SERIOUSNESS OF SITE IS HIGH, SPECIFY COORDINATES
1. LATITUDE (*deg.—min.—sec.*)
2. LONGITUDE (*deg.—min.—sec.*)

E. ARE THERE BUILDINGS ON THE SITE?

☐ 1. NO ☑ 2. YES (*specify*):

## IV. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major waste activity(ies) and details relating to each activity by marking "X" in the appropriate boxes.

| X | A. TRANSPORTER | X | B. STORER | X | C. TREATER | X | D. DISPOSER |
|---|---|---|---|---|---|---|---|
| | 1. RAIL | | 1. PILE | | 1. FILTRATION | | 1. LANDFILL |
| | 2. SHIP | | 2. SURFACE IMPOUNDMENT | | 2. INCINERATION | | 2. LANDFARM |
| | 3. BARGE | | 3. DRUMS | | 3. VOLUME REDUCTION | X | 3. OPEN DUMP |
| | 4. TRUCK | | 4. TANK, ABOVE GROUND | | 4. RECYCLING/RECOVERY | | 4. SURFACE IMPOUNDMENT |
| | 5. PIPELINE | | 5. TANK, BELOW GROUND | | 5. CHEM./PHYS. TREATMENT | | 5. MIDNIGHT DUMPING |
| | 6. OTHER (specify): | | 6. OTHER (specify): | | 6. BIOLOGICAL TREATMENT | | 6. INCINERATION |
| | | | | | 7. WASTE OIL REPROCESSING | | 7. UNDERGROUND INJECTION |
| | | | | | 8. SOLVENT RECOVERY | | 8. OTHER (specify): |
| | | | | | 9. OTHER (specify): | | |

E. SPECIFY DETAILS OF SITE ACTIVITIES AS NEEDED

## V. WASTE RELATED INFORMATION

A. WASTE TYPE

[ ] 1 UNKNOWN [ ] 2 LIQUID [ ] 3. SOLID [ ] 4. SLUDGE [ ] 5. GAS

B. WASTE CHARACTERISTICS

[X] 1 UNKNOWN [ ] 2. CORROSIVE [ ] 3. IGNITABLE [ ] 4 RADIOACTIVE [ ] 5 HIGHLY VOLATILE
[ ] 6. TOXIC [ ] 7 REACTIVE [ ] 8 INERT [ ] 9 FLAMMABLE

[ ] 10. OTHER (specify):

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

EPA STA

2. Estimate the amount (specify unit of measure) of waste by category; mark 'X' to indicate which wastes are present.

| a. SLUDGE | b. OIL | c. SOLVENTS | d. CHEMICALS | e. SOLIDS | f. OTHER |
|---|---|---|---|---|---|
| AMOUNT | AMOUNT | AMOUNT | AMOUNT | AMOUNT | AMOUNT |
| UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE |
| X (1) PAINT, PIGMENTS | X (1) OILY WASTES | X (1) HALOGENATED SOLVENTS | X (1) ACIDS | X (1) FLYASH | X (1) LABORATORY PHARMACEUT. |
| (2) METALS SLUDGES | (2) OTHER (specify): | (2) NON-HALOGNTD. SOLVENTS | (2) PICKLING LIQUORS | (2) ASBESTOS | (2) HOSPITAL |
| (3) POTW | | (3) OTHER (specify): | (3) CAUSTICS | (3) MILLING/ MINE TAILINGS | (3) RADIOACTIVE |
| (4) ALUMINUM SLUDGE | | | (4) PESTICIDES | (4) FERROUS SMLTG. WASTES | (4) MUNICIPAL |
| (5) OTHER (specify): | | | (5) DYES/INKS | (5) NON-FERROUS SMLTG. WASTES | (5) OTHER (specify): |
| | | | (6) CYANIDE | (6) OTHER (specify): | |
| | | | (7) PHENOLS | | |
| | | | (8) HALOGENS | | |
| | | | (9) PCB | | |
| | | | (10) METALS | | |
| | | | (11) OTHER (specify) | | |


Continue On Page 3

Continued From Page 2

## V. WASTE RELATED INFORMATION (continued)

3. LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE (place in descending order of hazard).

Salts

air / water Reactive waste

4. ADDITIONAL COMMENTS OR NARRATIVE DESCRIPTION OF SITUATION KNOWN OR REPORTED TO EXIST AT THE SITE.

## VI. HAZARD DESCRIPTION

| A. TYPE OF HAZARD | B. POTENTIAL HAZARD (mark 'X') | C. ALLEGED INCIDENT (mark 'X') | D. DATE OF INCIDENT (mo., day, yr.) | E. REMARKS |
|---|---|---|---|---|
| 1. NO HAZARD | | | | |
| 2. HUMAN HEALTH | | | | No Evaluation |
| 3. NON-WORKER INJURY/EXPOSURE | | | | |
| 4. WORKER INJURY | | | | |
| 5. CONTAMINATION OF WATER SUPPLY | | | | |
| 6. CONTAMINATION OF FOOD CHAIN | | | | |
| 7. CONTAMINATION OF GROUND WATER | | | | |
| 8. CONTAMINATION OF SURFACE WATER | | | | |
| 9. DAMAGE TO FLORA/FAUNA | | | | |
| 10. FISH KILL | | | | |
| 11. CONTAMINATION OF AIR | | | | |
| 12. NOTICEABLE ODORS | | | | |
| 13. CONTAMINATION OF SOIL | | | | |
| 14. PROPERTY DAMAGE | | | | |
| 15. FIRE OR EXPLOSION | | | | |
| 16. SPILLS/LEAKING CONTAINERS/ RUNOFF/STANDING LIQUIDS | | | | |
| 17. SEWER, STORM DRAIN PROBLEMS | | | | |
| 18. EROSION PROBLEMS | | | | |
| 19. INADEQUATE SECURITY | | | | |
| 20. INCOMPATIBLE WASTES | | | | |
| 21. MIDNIGHT DUMPING | | | | |
| 22. OTHER (specify): | | | | |

 Continue On Reverse

## VII. PERMIT INFORMATION

A. INDICATE ALL APPLICABLE PERMITS HELD BY THE SITE.

- [ ] 1. NPDES PERMIT
- [ ] 2. SPCC PLAN
- [ ] 3. STATE PERMIT *(specify)* _____
- [ ] 4. AIR PERMITS
- [ ] 5. LOCAL PERMIT
- [ ] 6. RCRA TRANSPORTER
- [ ] 7. RCRA STORER
- [ ] 8. RCRA TREATER
- [ ] 9. RCRA DISPOSER
- [ ] 10. OTHER *(specify)*: _____

B. IN COMPLIANCE?

- [ ] 1. YES
- [ ] 2. NO
- [x] 3. UNKNOWN

4. WITH RESPECT TO *(list regulation name & number)*: _____

## VIII. PAST REGULATORY ACTIONS

- [x] A. NONE
- [ ] B. YES *(summarize below)*

## IX. INSPECTION ACTIVITY *(past or on-going)*

- [x] A. NONE
- [ ] B. YES *(complete items 1,2,3, & 4 below)*

| 1. TYPE OF ACTIVITY | 2. DATE OF PAST ACTION *(mo., day, & yr.)* | 3. PERFORMED BY: *(EPA/State)* | 4. DESCRIPTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

## X. REMEDIAL ACTIVITY *(past or on-going)*

- [ ] A. NONE
- [ ] B. YES *(complete items 1, 2, 3, & 4 below)*

| 1. TYPE OF ACTIVITY | 2. DATE OF PAST ACTION *(mo., day, & yr.)* | 3. PERFORMED BY: *(EPA/State)* | 4. DESCRIPTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

NOTE: Based on the information in Sections III through X, fill out the Preliminary Assessment *(Section II)* information on the first page of this form.

# POTENTIAL HAZARDOUS WASTE SITE
## IDENTIFICATION AND PRELIMINARY ASSESSMENT

| REGION | SITE NUMBER (to be assigned by HQ) |
|---|---|
| | |

NOTE: This form is completed for each potential hazardous waste site to help set priorities for site inspection. The information submitted on this form is based on available records and may be updated on subsequent forms as a result of additional inquiries and on-site inspections.

GENERAL INSTRUCTIONS: Complete Sections I and III through X as completely as possible before Section II (*Preliminary Assessment*). File this form in the Regional Hazardous Waste Log File and submit a copy to: U.S. Environmental Protection Agency; Site Tracking System; Hazardous Waste Enforcement Task Force (*EN-335*); 401 M St., SW; Washington, DC 20460.

## I. SITE IDENTIFICATION

A. SITE NAME: Monsanto Chemical

B. STREET (*or other identifier*):

C. CITY: Columbia

D. STATE: TN

E. ZIP CODE: 38401

F. COUNTY NAME: Maury

G. OWNER/OPERATOR (*if known*)

1. NAME: SAME

2. TELEPHONE NUMBER:

H. TYPE OF OWNERSHIP

☐ 1. FEDERAL ☐ 2. STATE ☐ 3. COUNTY ☐ 4. MUNICIPAL ☑ 5. PRIVATE ☐ 6. UNKNOWN

I. SITE DESCRIPTION

Chemical, Inorganics + Misc. Dump

J. HOW IDENTIFIED (*i.e., citizen's complaints, OSHA citations, etc.*)

Eckhart

K. DATE IDENTIFIED (*mo., day, & yr.*): 11-21-79

L. PRINCIPAL STATE CONTACT

1. NAME: SHM

2. TELEPHONE NUMBER: 7413420

## II. PRELIMINARY ASSESSMENT (*complete this section last*)

A. APPARENT SERIOUSNESS OF PROBLEM

☐ 1. HIGH ☐ 2. MEDIUM ☐ 3. LOW ☐ 4. NONE ☑ 5. UNKNOWN

B. RECOMMENDATION

☐ 1. NO ACTION NEEDED (*no hazard*)

☐ 2. IMMEDIATE SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR:
b. WILL BE PERFORMED BY:

☐ 3. SITE INSPECTION NEEDED
a. TENTATIVELY SCHEDULED FOR: 1980
b. WILL BE PERFORMED BY:

☐ 4. SITE INSPECTION NEEDED (*low priority*)

C. PREPARER INFORMATION

1. NAME: [illegible]

2. TELEPHONE NUMBER: 7413020

3. DATE (*mo., day, & yr.*): 2-4-80

## III. SITE INFORMATION

A. SITE STATUS

☐ 1. ACTIVE (*Those industrial or municipal sites which are being used for waste treatment, storage, or disposal on a continuing basis, even if infrequently.*)

☑ 2. INACTIVE (*Those sites which no longer receive wastes.*)

☐ 3. OTHER (*specify*): (*Those sites that include such incidents like "midnight dumping" where no regular or continuing use of the site for waste disposal has occurred.*)

B. IS GENERATOR ON SITE?

☐ 1. NO ☑ 2. YES (*specify generator's four-digit SIC Code*):

C. AREA OF SITE (*in acres*)

D. IF APPARENT SERIOUSNESS OF SITE IS HIGH, SPECIFY COORDINATES

1. LATITUDE (*deg.—min.—sec.*)

2. LONGITUDE (*deg.—min.—sec.*)

E. ARE THERE BUILDINGS ON THE SITE?

☐ 1. NO ☑ 2. YES (*specify*):

## IV. CHARACTERIZATION OF SITE ACTIVITY

Indicate the major site activity(ies) and details relating to each activity by marking 'X' in appropriate boxes.

| X | A. TRANSPORTER | X | B. STORER | X | C. TREATER | X | D. DISPOSER |
|---|---|---|---|---|---|---|---|
| | 1. RAIL | | 1. PILE | | 1. FILTRATION | | 1. LANDFILL |
| | 2. SHIP | | 2. SURFACE IMPOUNDMENT | | 2. INCINERATION | | 2. LANDFARM |
| | 3. BARGE | | 3. DRUMS | | 3. VOLUME REDUCTION | X | 3. ~~OPEN~~ DUMP |
| | 4. TRUCK | | 4. TANK, ABOVE GROUND | | 4. RECYCLING/RECOVERY | | 4. SURFACE IMPOUNDMENT |
| | 5. PIPELINE | | 5. TANK, BELOW GROUND | | 5. CHEM./PHYS. TREATMENT | | 5. MIDNIGHT DUMPING |
| | 6. OTHER *(specify)*: | | 6. OTHER *(specify)*: | | 6. BIOLOGICAL TREATMENT | | 6. INCINERATION |
| | | | | | 7. WASTE OIL REPROCESSING | | 7. UNDERGROUND INJECTION |
| | | | | | 8. SOLVENT RECOVERY | | 8. OTHER *(specify)*: |
| | | | | | 9. OTHER *(specify)*: | | |

E. SPECIFY DETAILS OF SITE ACTIVITIES AS NEEDED

## V. WASTE RELATED INFORMATION

A. WASTE TYPE

[ ] 1 UNKNOWN [ ] 2 LIQUID [ ] 3. SOLID [ ] 4. SLUDGE [ ] 5. GAS

B. WASTE CHARACTERISTICS

[ ] 1 UNKNOWN [ ] 2. CORROSIVE [ ] 3. IGNITABLE [ ] 4 RADIOACTIVE [ ] 5 HIGHLY VOLATILE
[ ] 6. TOXIC [ ] 7 REACTIVE [ ] 8 INERT [ ] 9 FLAMMABLE

[ ] 10. OTHER *(specify)*:

C. WASTE CATEGORIES

1. Are records of wastes available? Specify items such as manifests, inventories, etc. below.

EPA STA

2. Estimate the amount *(specify unit of measure)* of waste by category; mark 'X' to indicate which wastes are present.

| a. SLUDGE | b. OIL | c. SOLVENTS | d. CHEMICALS | e. SOLIDS | f. OTHER |
|---|---|---|---|---|---|
| AMOUNT | AMOUNT | AMOUNT | AMOUNT | AMOUNT | AMOUNT |
| UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE | UNIT OF MEASURE |
| X (1) PAINT, PIGMENTS | X (1) OILY WASTES | X (1) HALOGENATED SOLVENTS | X (1) ACIDS | X (1) FLYASH | X (1) LABORATORY PHARMACEUT. |
| (2) METALS SLUDGES | (2) OTHER *(specify)*: | (2) NON-HALOGNTD. SOLVENTS | (2) PICKLING LIQUORS | (2) ASBESTOS | (2) HOSPITAL |
| (3) POTW | | (3) OTHER *(specify)*: | (3) CAUSTICS | (3) MILLING/ MINE TAILINGS | (3) RADIOACTIVE |
| (4) ALUMINUM SLUDGE | | | (4) PESTICIDES | (4) FERROUS SMLTG. WASTES | (4) MUNICIPAL |
| (5) OTHER *(specify)*: | | | (5) DYES/INKS | (5) NON-FERROUS SMLTG. WASTES | (5) OTHER *(specify)*: |
| | | | (6) CYANIDE | (6) OTHER *(specify)*: | |
| | | | (7) PHENOLS | | |
| | | | (8) HALOGENS | | |
| | | | (9) PCB | | |
| | | | (10) METALS | | |
| | | | (11) OTHER *(specify)* | | |

 Continue On Page 3

Continued From Page 2

## V. WASTE RELATED INFORMATION (continued)

3. LIST SUBSTANCES OF GREATEST CONCERN WHICH MAY BE ON THE SITE (place in descending order of hazard).

Salts

air/water Reactive waste

4. ADDITIONAL COMMENTS OR NARRATIVE DESCRIPTION OF SITUATION KNOWN OR REPORTED TO EXIST AT THE SITE.

## VI. HAZARD DESCRIPTION

| A. TYPE OF HAZARD | B. POTENTIAL HAZARD (mark 'X') | C. ALLEGED INCIDENT (mark 'X') | D. DATE OF INCIDENT (mo., day, yr.) | E. REMARKS |
|---|---|---|---|---|
| 1. NO HAZARD | | | | |
| 2. HUMAN HEALTH | | | | No Evaluation |
| 3. NON-WORKER INJURY/EXPOSURE | | | | |
| 4. WORKER INJURY | | | | |
| 5. CONTAMINATION OF WATER SUPPLY | | | | |
| 6. CONTAMINATION OF FOOD CHAIN | | | | |
| 7. CONTAMINATION OF GROUND WATER | | | | |
| 8. CONTAMINATION OF SURFACE WATER | | | | |
| 9. DAMAGE TO FLORA/FAUNA | | | | |
| 10. FISH KILL | | | | |
| 11. CONTAMINATION OF AIR | | | | |
| 12. NOTICEABLE ODORS | | | | |
| 13. CONTAMINATION OF SOIL | | | | |
| 14. PROPERTY DAMAGE | | | | |
| 15. FIRE OR EXPLOSION | | | | |
| 16. SPILLS/LEAKING CONTAINERS/ RUNOFF/STANDING LIQUIDS | | | | |
| 17. SEWER, STORM DRAIN PROBLEMS | | | | |
| 18. EROSION PROBLEMS | | | | |
| 19. INADEQUATE SECURITY | | | | |
| 20. INCOMPATIBLE WASTES | | | | |
| 21. MIDNIGHT DUMPING | | | | |
| 22. OTHER (specify): | | | | |



Continue On Reverse

## VII. PERMIT INFORMATION

A. INDICATE ALL APPLICABLE PERMITS HELD BY THE SITE.

- [ ] 1. NPDES PERMIT
- [ ] 2. SPCC PLAN
- [ ] 3. STATE PERMIT (specify): _____
- [ ] 4. AIR PERMITS
- [ ] 5. LOCAL PERMIT
- [ ] 6. RCRA TRANSPORTER
- [ ] 7. RCRA STORER
- [ ] 8. RCRA TREATER
- [ ] 9. RCRA DISPOSER
- [ ] 10. OTHER (specify): _____

B. IN COMPLIANCE?

- [ ] 1. YES
- [ ] 2. NO
- [x] 3. UNKNOWN

4. WITH RESPECT TO (list regulation name & number): _____

## VIII. PAST REGULATORY ACTIONS

- [x] A. NONE
- [ ] B. YES (summarize below)

## IX. INSPECTION ACTIVITY (past or on-going)

- [x] A. NONE
- [ ] B. YES (complete items 1, 2, 3, & 4 below)

| 1. TYPE OF ACTIVITY | 2. DATE OF PAST ACTION (mo., day, & yr.) | 3. PERFORMED BY: (EPA/State) | 4. DESCRIPTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

## X. REMEDIAL ACTIVITY (past or on-going)

- [ ] A. NONE
- [ ] B. YES (complete items 1, 2, 3, & 4 below)

| 1. TYPE OF ACTIVITY | 2. DATE OF PAST ACTION (mo., day, & yr.) | 3. PERFORMED BY: (EPA/State) | 4. DESCRIPTION |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

NOTE: Based on the information in Sections III through X, fill out the Preliminary Assessment *(Section II)* information on the first page of this form.

SITE LOG
(For Site Inspection)

EPA ID TND004048104 DATE 9-17-84

SITE NAME Monsanto Co. Inc. (Columbia)

REFERRED BY _____

REASON FOR INSPECTION _____

SOURCES OF INFORMATION CHECKED State PA ; State SI ; CERCLA file

SUSPECTED HAZARD(S) PCBs ~~[illegible]~~, phosphorous processing wastes, lab chemical waste
phosphorous tailings ponds

OTHER _____

E. Seely _____

SITE SCREENING & INSPECTION COMPLIANCE

(see SI)
How were the landfills closed? How are they maintained and monitored?

2 active LDFL's permitted by SWM.

Closed LDFLs (how many?) GW monitored by SWM; covered with 3-5' of clay

Need to investigate PCB contamination of LDFL'S, leachate potential, and check GW monitoring data

TENNESSEE DEPARTMENT OF HEALTH AND ENVIRONMENT

OFFICE CORRESPONDENCE

| FROM | TO | DATE |
|---|---|---|
| | | |
| | | |
| | | |
| | | |
| | | |

**DATE:** April 10, 1984

**TO:** THE FILE

**FROM:** Karen Bonner

**SUBJECT:** §3012 Superfund Program
Monsanto

**MONSANTO**

On April 6, 1984, at 9;50 a.m., Charles Allen and I, employees of the TN. Division of SWM, visited this site. We talked with Greg DePagter and Jerry Dickerson.

This site has 2 active landfills which are permitted by SWM. All previous landfills are covered with 3-5' of clay and have groundwater wells that are monitored regularly. Most of their hazardous wastes are exempt because of certain rules. Their used PCB oil is shipped off site, but quite a bit is reserved in spare transformers which are housed in a specially built storage facility.

Based on this investigation, we recommend ~~NO FURTHER ACTION.~~

~~Which rules? Who monitors wells?~~
Superfund Site

| FROM | DATE |
|---|---|
| | |

TO

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PH-0001
SR 3/77

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 1 - SITE LOCATION AND INSPECTION INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

**II. SITE NAME AND LOCATION**

| 01 SITE NAME (Legal, common, or descriptive name of site) | 02 STREET, ROUTE NO., OR SPECIFIC LOCATION IDENTIFIER |
|---|---|
| Monsanto Chemical Co., Inc. | Monsanto Rd. |

| 03 CITY | 04 STATE | 05 ZIP CODE | 06 COUNTY | 07 COUNTY CODE | 08 CONG DIST |
|---|---|---|---|---|---|
| Columbia | TN | 38401 | Maury | | |

| 09 COORDINATES LATITUDE | LONGITUDE | 10 TYPE OF OWNERSHIP (Check one) |
|---|---|---|
| 35 39 28.7 | 087 02 40.5 | [X] A. PRIVATE [ ] B. FEDERAL ____ [ ] C. STATE [ ] D. COUNTY [ ] E. MUNICIPAL [ ] F. OTHER ____ [ ] G. UNKNOWN |

**III. INSPECTION INFORMATION**

| 01 DATE OF INSPECTION (Month Day Year) | 02 SITE STATUS | 03 YEARS OF OPERATION |
|---|---|---|
| 4-6-84 | [X] ACTIVE [ ] INACTIVE | 1936 / present (Beginning Year / Ending Year) ____ UNKNOWN |

04 AGENCY PERFORMING INSPECTION (Check all that apply)

[ ] A. EPA [ ] B. EPA CONTRACTOR ____ (Name of firm) [ ] C. MUNICIPAL [ ] D. MUNICIPAL CONTRACTOR ____ (Name of firm)
[X] E. STATE [ ] F. STATE CONTRACTOR ____ (Name of firm) [ ] G. OTHER ____ (Specify)

| 05 CHIEF INSPECTOR | 06 TITLE | 07 ORGANIZATION | 08 TELEPHONE NO. |
|---|---|---|---|
| Karen Bonner | Chemist | SWM | (615) 741-6287 |

| 09 OTHER INSPECTORS | 10 TITLE | 11 ORGANIZATION | 12 TELEPHONE NO. |
|---|---|---|---|
| Charles Allen | Engineer | SWM | (615) 741-6287 |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |

| 13 SITE REPRESENTATIVES INTERVIEWED | 14 TITLE | 15 ADDRESS | 16 TELEPHONE NO |
|---|---|---|---|
| John G. DePagter | Environ. Supr. | Monsanto Columbia, TN 38401 | (615) 388-3431 |
| Jerry Dickerson | Engr. Super | Monsanto Columbia, TN 38401 | (615) 388-3431 |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | ( ) |
| | | | |

| 17 ACCESS GAINED BY (Check one) | 18 TIME OF INSPECTION | 19 WEATHER CONDITIONS |
|---|---|---|
| [X] PERMISSION [ ] WARRANT | 9:50 AM | Sunny, 55°F |

**IV. INFORMATION AVAILABLE FROM**

| 01 CONTACT | 02 OF (Agency/Organization) | 03 TELEPHONE NO |
|---|---|---|
| John G. DePagter | Monsanto | (615) 388-3431 |

| 04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM | 05 AGENCY | 06 ORGANIZATION | 07 TELEPHONE NO. | 08 DATE (Month Day Year) |
|---|---|---|---|---|
| Karen Bonner | SWM | | 615-741-6287 | 4-9-84 |

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 2 - WASTE INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

**II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS**

| 01 PHYSICAL STATES (Check all that apply) | 02 WASTE QUANTITY AT SITE (Measures of waste quantities must be independent) | 03 WASTE CHARACTERISTICS (Check all that apply) |
|---|---|---|
| X A. SOLID<br>B. POWDER, FINES<br>C. SLUDGE<br>X D. OTHER slag (Specify)<br>E. SLURRY<br>F. LIQUID<br>G. GAS | TONS<br>CUBIC YARDS<br>NO. OF DRUMS | A. TOXIC<br>B. CORROSIVE<br>C. RADIOACTIVE<br>D. PERSISTENT<br>E. SOLUBLE<br>F. INFECTIOUS<br>G. FLAMMABLE<br>H. IGNITABLE<br>I. HIGHLY VOLATILE<br>J. EXPLOSIVE<br>K. REACTIVE<br>L. INCOMPATIBLE<br>M. NOT APPLICABLE |

**III. WASTE TYPE**

| CATEGORY | SUBSTANCE NAME | 01 GROSS AMOUNT | 02 UNIT OF MEASURE | 03 COMMENTS |
|---|---|---|---|---|
| SLU | SLUDGE | | | |
| OLW | OILY WASTE | | | |
| SOL | SOLVENTS | | | |
| PSD | PESTICIDES | | | |
| OCC | OTHER ORGANIC CHEMICALS | | | |
| IOC | INORGANIC CHEMICALS | | | |
| ACD | ACIDS | | | |
| BAS | BASES | | | |
| MES | HEAVY METALS | | | |

**IV. HAZARDOUS SUBSTANCES** (See Appendix for most frequently cited CAS Numbers)

| 01 CATEGORY | 02 SUBSTANCE NAME | 03 CAS NUMBER | 04 STORAGE/DISPOSAL METHOD | 05 CONCENTRATION | 06 MEASURE OF CONCENTRATION |
|---|---|---|---|---|---|
| | | | | | |

**V. FEEDSTOCKS** (See Appendix for CAS Numbers)

| CATEGORY | 01 FEEDSTOCK NAME | 02 CAS NUMBER | CATEGORY | 01 FEEDSTOCK NAME | 02 CAS NUMBER |
|---|---|---|---|---|---|
| FDS | | | FDS | | |
| FDS | | | FDS | | |
| FDS | | | FDS | | |
| FDS | | | FDS | | |

**VI. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

3 waste types - 1) phosphorus processing waste 2) small quantity lab wastes 3) PCB transformer oil. The 1st two are exempt under two different rules. The PCB transformer oil is not a waste because it is still being used as a valuable material in the transformers.

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

## II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☐ A. GROUNDWATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ B. SURFACE WATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ C. CONTAMINATION OF AIR
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ E. DIRECT CONTACT
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ F. CONTAMINATION OF SOIL
03 AREA POTENTIALLY AFFECTED: _____ (Acres)
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ G. DRINKING WATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ H. WORKER EXPOSURE/INJURY
03 WORKERS POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ I. POPULATION EXPOSURE/INJURY
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

| I. IDENTIFICATION | |
|---|---|
| 01. STATE | 02. SITE NUMBER |
| TN | TND004048604 |

**II. HAZARDOUS CONDITIONS AND INCIDENTS** (continued)

01 ☐ J. DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ K. DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION (Include name(s) of species)

01 ☐ L. CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ M. UNSTABLE CONTAINMENT OF WASTES (Spills/Runoff/Standing liquids, Leaking drums) — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: _____ 04 NARRATIVE DESCRIPTION

01 ☐ N. DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ O. CONTAMINATION OF SEWERS, STORM DRAINS, WWTPs — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

01 ☐ P. ILLEGAL/UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

**III. TOTAL POPULATION POTENTIALLY AFFECTED:** _____

**IV. COMMENTS**

**V. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION
### PART 4 - PERMIT AND DESCRIPTIVE INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

**II. PERMIT INFORMATION**

| 01 TYPE OF PERMIT ISSUED (Check all that apply) | 02 PERMIT NUMBER | 03 DATE ISSUED | 04 EXPIRATION DATE | 05 COMMENTS |
|---|---|---|---|---|
| [X] A. NPDES | | | | |
| [ ] B. UIC | | | | |
| [ ] C. AIR | | | | |
| [ ] D. RCRA | | | | |
| [ ] E. RCRA INTERIM STATUS | | | | |
| [ ] F. SPCC PLAN | | | | |
| [ ] G. STATE (Specify) | | | | |
| [ ] H. LOCAL (Specify) | | | | |
| [ ] I. OTHER (Specify) | | | | |
| [ ] J. NONE | | | | |

**III. SITE DESCRIPTION**

| 01 STORAGE/DISPOSAL (Check all that apply) | 02 AMOUNT | 03 UNIT OF MEASURE |
|---|---|---|
| [ ] A. SURFACE IMPOUNDMENT | | |
| [ ] B. PILES | | |
| [ ] C. DRUMS, ABOVE GROUND | | |
| [ ] D. TANK, ABOVE GROUND | | |
| [ ] E. TANK, BELOW GROUND | | |
| [X] F. LANDFILL | unknown | |
| [ ] G. LANDFARM | | |
| [ ] H. OPEN DUMP | | |
| [ ] I. OTHER (Specify) | | |

04 TREATMENT (Check all that apply)

- [ ] A. INCENERATION
- [ ] B. UNDERGROUND INJECTION
- [ ] C. CHEMICAL/PHYSICAL
- [ ] D. BIOLOGICAL
- [ ] E. WASTE OIL PROCESSING
- [ ] F. SOLVENT RECOVERY
- [ ] G. OTHER RECYCLING/RECOVERY
- [ ] H. OTHER (Specify)

05 OTHER

- [X] A. BUILDINGS ON SITE

06 AREA OF SITE

5280 (Acres)

07 COMMENTS

Monsanto has 2 landfills approved by swm. They store slag. Groundwater is monitored at all the closed landfills that are covered with 3-5' of clay.

**IV. CONTAINMENT**

01 CONTAINMENT OF WASTES (Check one)

[X] A. ADEQUATE, SECURE [ ] B. MODERATE [ ] C. INADEQUATE, POOR [ ] D. INSECURE, UNSOUND, DANGEROUS

02 DESCRIPTION OF DRUMS, DIKING, LINERS, BARRIERS, ETC.

tailings ponds are used for reclaiming useful phosphorus

**V. ACCESSIBILITY**

01 WASTE EASILY ACCESSIBLE: [X] YES [ ] NO

02 COMMENTS

**VI. SOURCES OF INFORMATION** (Cite specific references, e.g. state files, sample analysis, reports)

4-6-84 - Site Investigation

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048164 |

## II. DRINKING WATER SUPPLY

**01 TYPE OF DRINKING SUPPLY** (Check all applicable)

| | SURFACE | WELL |
|---|---|---|
| COMMUNITY | A. ☐ | B. ☐ |
| NON-COMMUNITY | C. ☐ | D. ☐ |

**02 STATUS**

| ENDANGERED | AFFECTED | MONITORED |
|---|---|---|
| A. ☐ | B. ☐ | C. ☐ |
| D. ☐ | E. ☐ | F. ☐ |

**03 DISTANCE TO SITE**

A. _____ (mi)
B. _____ (mi)

## III. GROUNDWATER

**01 GROUNDWATER USE IN VICINITY** (Check one)

☐ A. ONLY SOURCE FOR DRINKING ☐ B. DRINKING (Other sources available) COMMERCIAL, INDUSTRIAL, IRRIGATION (No other water sources available) ☐ C. COMMERCIAL, INDUSTRIAL, IRRIGATION (Limited other sources available) ☐ D. NOT USED, UNUSEABLE

**02 POPULATION SERVED BY GROUND WATER** _____

**03 DISTANCE TO NEAREST DRINKING WATER WELL** _____ (mi)

| 04 DEPTH TO GROUNDWATER | 05 DIRECTION OF GROUNDWATER FLOW | 06 DEPTH TO AQUIFER OF CONCERN | 07 POTENTIAL YIELD OF AQUIFER | 08 SOLE SOURCE AQUIFER |
|---|---|---|---|---|
| _____ (ft) | _____ | _____ (ft) | _____ (gpd) | ☐ YES ☐ NO |

**09 DESCRIPTION OF WELLS** (Including usage, depth, and location relative to population and buildings)

**10 RECHARGE AREA**

☐ YES
☐ NO

COMMENTS _____

**11 DISCHARGE AREA**

☐ YES
☐ NO

COMMENTS _____

## IV. SURFACE WATER

**01 SURFACE WATER USE** (Check one)

☐ A. RESERVOIR, RECREATION, DRINKING WATER SOURCE ☐ B. IRRIGATION, ECONOMICALLY IMPORTANT RESOURCES ☐ C. COMMERCIAL, INDUSTRIAL ☐ D. NOT CURRENTLY USED

**02 AFFECTED/POTENTIALLY AFFECTED BODIES OF WATER**

| NAME | AFFECTED | DISTANCE TO SITE |
|---|---|---|
| | | (mi) |
| | | (mi) |
| | | (mi) |

## V. DEMOGRAPHIC AND PROPERTY INFORMATION

**01 TOTAL POPULATION WITHIN**

ONE (1) MILE OF SITE — A. _____ NO. OF PERSONS
TWO (2) MILES OF SITE — B. _____ NO. OF PERSONS
THREE (3) MILES OF SITE — C. _____ NO. OF PERSONS

**02 DISTANCE TO NEAREST POPULATION** _____ (mi)

**03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE** _____

**04 DISTANCE TO NEAREST OFF-SITE BUILDING** _____ (mi)

**05 POPULATION WITHIN VICINITY OF SITE** (Provide narrative description of nature of population within vicinity of site, e.g., rural, village, densely populated urban area)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
# SITE INSPECTION REPORT
## PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

## VI. ENVIRONMENTAL INFORMATION

01 PERMEABILITY OF UNSATURATED ZONE (Check one)

☐ A. $10^{-4}$ – $10^{-6}$ cm/sec ☐ B. $10^{-4}$ – $10^{-6}$ cm/sec ☐ C. $10^{-4}$ – $10^{-6}$ cm/sec ☐ D. GREATER THAN $10^{-3}$ cm/sec

02 PERMEABILITY OF BEDROCK (Check one)

☐ A. IMPERMEABLE (Less than $10^{-6}$ cm/sec) ☐ B. RELATIVELY IMPERMEABLE ($10^{-4}$ – $10^{-6}$ cm/sec) ☐ C. RELATIVELY PERMEABLE ($10^{-2}$ – $10^{-4}$ cm/sec) ☐ D. VERY PERMEABLE (Greater than $10^{-2}$ cm/sec)

| 03 DEPTH TO BEDROCK | 04 DEPTH OF CONTAMINATED SOIL ZONE | 05 SOIL pH |
|---|---|---|
| _____ (ft) | _____ (ft) | _____ |

| 06 NET PRECIPITATION | 07 ONE YEAR 24 HOUR RAINFALL | 08 SLOPE: SITE SLOPE | DIRECTION OF SITE SLOPE | TERRAIN AVERAGE SLOPE |
|---|---|---|---|---|
| _____ (in) | _____ (in) | _____ % | | _____ % |

| 09 FLOOD POTENTIAL | 10 |
|---|---|
| SITE IS IN _____ YEAR FLOODPLAIN | ☐ SITE IS ON BARRIER ISLAND, COASTAL HIGH HAZARD AREA, RIVERINE FLOODWAY |

| 11 DISTANCE TO WETLANDS (5 acre minimum) | 12 DISTANCE TO CRITICAL HABITAT (of endangered species) |
|---|---|
| ESTUARINE: A. _____ (mi) OTHER: B. _____ (mi) | _____ (mi) ENDANGERED SPECIES: _____ |

13 LAND USE IN VICINITY

DISTANCE TO:

| COMMERCIAL/INDUSTRIAL | RESIDENTIAL AREAS; NATIONAL, STATE PARKS, FORESTS, OR WILDLIFE RESERVES | AGRICULTURAL LANDS: PRIME AG LAND | AGRICULTURAL LANDS: AG LAND |
|---|---|---|---|
| A. _____ (mi) | B. _____ (mi) | C. _____ (mi) | D. _____ (mi) |

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

## VII. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 6 - SAMPLE AND FIELD INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| TN | TND004804810 |

## II. SAMPLES TAKEN

| SAMPLE TYPE | 01 NUMBER OF SAMPLES TAKEN | 02 SAMPLES SENT TO | 03 ESTIMATED DATE RESULTS AVAILABLE |
|---|---|---|---|
| GROUNDWATER | | | |
| SURFACE WATER | | | |
| WASTE | | N/A | |
| AIR | | | |
| RUNOFF | | | |
| SPILL | | | |
| SOIL | | | |
| VEGETATION | | | |
| OTHER | | | |

## III. FIELD MEASUREMENTS TAKEN

| 01 TYPE | 02 COMMENTS |
|---|---|
| | |
| | |
| | |
| | |
| | |

## IV. PHOTOGRAPHS AND MAPS

01 TYPE ☐ GROUND ☐ AERIAL

02 IN CUSTODY OF _____ (Name of organization or individual)

03 MAPS ☐ YES ☐ NO

04 LOCATION OF MAPS _____

## V. OTHER FIELD DATA COLLECTED (Provide narrative description)

## VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 7 - OWNER INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

**II. CURRENT OWNER(S)** | **PARENT COMPANY** (if applicable)

| 01 NAME | 02 D+B NUMBER | 08 NAME | 09 D+B NUMBER |
|---|---|---|---|
| Monsanto Chemical Co. Inc. | | Monsanto Chemical Co. | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 10 STREET ADDRESS (P.O. Box, RFD #, etc.) | 11 SIC CODE |
|---|---|---|---|
| Monsanto Rd. | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 12 CITY | 13 STATE | 14 ZIP CODE |
|---|---|---|---|---|---|
| Columbia | TN | | Missouri → | | |

| 01 NAME | 02 D+B NUMBER | 08 NAME | 09 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 10 STREET ADDRESS (P.O. Box, RFD #, etc.) | 11 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 12 CITY | 13 STATE | 14 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

| 01 NAME | 02 D+B NUMBER | 08 NAME | 09 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 10 STREET ADDRESS (P.O. Box, RFD #, etc.) | 11 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 12 CITY | 13 STATE | 14 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

| 01 NAME | 02 D+B NUMBER | 08 NAME | 09 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 10 STREET ADDRESS (P.O. Box, RFD #, etc.) | 11 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 12 CITY | 13 STATE | 14 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

**III. PREVIOUS OWNER(S)** (List most recent first) | **IV. REALTY OWNER(S)** (if applicable, list most recent first)

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

**V. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

EPA FORM 2070-13 (7-81)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 8 - OPERATOR INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| TN | TND004645104 |

## II. CURRENT OPERATOR (Provide if different from owner)

| 01 NAME | 02 D+B NUMBER |
|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE |
| 08 YEARS OF OPERATION | 09 NAME OF OWNER |

## OPERATOR'S PARENT COMPANY (If applicable)

| 10 NAME | 11 D+B NUMBER |
|---|---|
| 12 STREET ADDRESS (P.O. Box, RFD #, etc.) | 13 SIC CODE |
| 14 CITY | 15 STATE / 16 ZIP CODE |

## III. PREVIOUS OPERATOR(S) (List most recent first; provide only if different from owner)

| 01 NAME | 02 D+B NUMBER |
|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE |
| 08 YEARS OF OPERATION | 09 NAME OF OWNER DURING THIS PERIOD |

## PREVIOUS OPERATORS' PARENT COMPANIES (If applicable)

| 10 NAME | 11 D+B NUMBER |
|---|---|
| 12 STREET ADDRESS (P.O. Box, RFD #, etc.) | 13 SIC CODE |
| 14 CITY | 15 STATE / 16 ZIP CODE |

| 01 NAME | 02 D+B NUMBER |
|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE |
| 08 YEARS OF OPERATION | 09 NAME OF OWNER DURING THIS PERIOD |

| 10 NAME | 11 D+B NUMBER |
|---|---|
| 12 STREET ADDRESS (P.O. Box, RFD #, etc.) | 13 SIC CODE |
| 14 CITY | 15 STATE / 16 ZIP CODE |

| 01 NAME | 02 D+B NUMBER |
|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE |
| 08 YEARS OF OPERATION | 09 NAME OF OWNER DURING THIS PERIOD |

| 10 NAME | 11 D+B NUMBER |
|---|---|
| 12 STREET ADDRESS (P.O. Box, RFD #, etc.) | 13 SIC CODE |
| 14 CITY | 15 STATE / 16 ZIP CODE |

| 01 NAME | 02 D+B NUMBER |
|---|---|
| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
| 05 CITY | 06 STATE / 07 ZIP CODE |
| 08 YEARS OF OPERATION | 09 NAME OF OWNER DURING THIS PERIOD |

| 10 NAME | 11 D+B NUMBER |
|---|---|
| 12 STREET ADDRESS (P.O. Box, RFD #, etc.) | 13 SIC CODE |
| 14 CITY | 15 STATE / 16 ZIP CODE |

## IV. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 9 - GENERATOR/TRANSPORTER INFORMATION

**I. IDENTIFICATION**

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048121 |

**II. ON-SITE GENERATOR**

| 01 NAME | 02 D+B NUMBER |
|---|---|
| Monsanto Chemical Co. | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|
| Monsanto Rd. | |

| 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|
| Columbia | TN | 38401 |

**III. OFF-SITE GENERATOR(S)**

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

**IV. TRANSPORTER(S)**

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

| 01 NAME | 02 D+B NUMBER | 01 NAME | 02 D+B NUMBER |
|---|---|---|---|
| | | | |

| 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE | 03 STREET ADDRESS (P.O. Box, RFD #, etc.) | 04 SIC CODE |
|---|---|---|---|
| | | | |

| 05 CITY | 06 STATE | 07 ZIP CODE | 05 CITY | 06 STATE | 07 ZIP CODE |
|---|---|---|---|---|---|
| | | | | | |

**V. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

4-6-84 - Site Investigation

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 10 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION

| 01 STATE | 02 SITE NUMBER |
|---|---|
| TN | TND004048104 |

II. PAST RESPONSE ACTIVITIES

01 ☐ A. WATER SUPPLY CLOSED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ B. TEMPORARY WATER SUPPLY PROVIDED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ C. PERMANENT WATER SUPPLY PROVIDED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ D. SPILLED MATERIAL REMOVED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ E. CONTAMINATED SOIL REMOVED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ F. WASTE REPACKAGED — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ G. WASTE DISPOSED ELSEWHERE — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ H. ON SITE BURIAL — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ I. IN SITU CHEMICAL TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ J. IN SITU BIOLOGICAL TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ K. IN SITU PHYSICAL TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ L. ENCAPSULATION — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ M. EMERGENCY WASTE TREATMENT — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ N. CUTOFF WALLS — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ O. EMERGENCY DIKING/SURFACE WATER DIVERSION — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ P. CUTOFF TRENCHES/SUMP — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

01 ☐ Q. SUBSURFACE CUTOFF WALL — 02 DATE _____ 03 AGENCY _____
04 DESCRIPTION

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
### PART 10 - PAST RESPONSE ACTIVITIES

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| TN | TND004048104 |

**II PAST RESPONSE ACTIVITIES** (Continued)

01 ☐ R. BARRIER WALLS CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ S. CAPPING/COVERING — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ T. BULK TANKAGE REPAIRED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ U. GROUT CURTAIN CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ V. BOTTOM SEALED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ W. GAS CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ X. FIRE CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ Y. LEACHATE TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ Z. AREA EVACUATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 1. ACCESS TO SITE RESTRICTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 2. POPULATION RELOCATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

01 ☐ 3. OTHER REMEDIAL ACTIVITIES — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION

**III. SOURCES OF INFORMATION** (Cite specific references, e.g., state files, sample analysis, reports)

EPA

# POTENTIAL HAZARDOUS WASTE SITE
## SITE INSPECTION REPORT
## PART 11 - ENFORCEMENT INFORMATION

| I. IDENTIFICATION | |
|---|---|
| 01 STATE | 02 SITE NUMBER |
| TN | TND004045104 |

## II. ENFORCEMENT INFORMATION

01 PAST REGULATORY/ENFORCEMENT ACTION ☒ YES ☐ NO

02 DESCRIPTION OF FEDERAL, STATE, LOCAL REGULATORY/ENFORCEMENT ACTION

## III. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

Godwin Quad

Godwin Quad (57-NE)

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION IV

345 COURTLAND STREET, N.E.
ATLANTA, GEORGIA 30365

AUG 05 1992

4WD-WPB

Ms. Sherrilyn Williams
The Travelers Companies
1201 Louisiana, Suite 3300
Houston, TX 77002

RE: 4-RIN-02281-92

Dear Ms. Williams:

This is in response to your Freedom of Information Act (FOIA) request regarding Monsanto Company Columbia plant (TND004048104).

Please find enclosed the requested material.

Fees are waived as de minimis.

Should you have questions, please contact Loften Carr at (404) 347-5065.

Sincerely yours,

H. Kirk Lucius, Chief
Waste Programs Branch
Waste Management Division

Enclosure

bcc: FOIA Office
Action Office FOIA Coordinator

CA:m:07/29/92x5065 Disk: Carr Doc: 2281.foi

CARR DEIAL HANKE for LUCIUS

7/29/92 7/30 7/31 7/31

Printed on Recycled Paper

# U.S. EPA REGION IV

# SDMS

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2. Increase or decrease the Screen resolution.

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1. For dark image page, increase the brightness and decrease the contrast.
2. For light image page, decrease the brightness and increase the contrast.

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4WD-SAS 4WD-SAS 4WD-SAS 4WD-SISB

STEVENS WARREN KUMAR LUCIUS

CS:ZC:05/02/88:5065

# FOI REQUEST

**EXPEDITIOUS HANDLING REQUIRED**

ROUTING SLIP DATE 4-18-88

RIN - 796 -88

DUE DATE 5-2-88

1. Waste SFB - LEAD
2. SISB
3. Dick 4/25

JON 4/25 — IS THIS OUPS?

COMMENTS AND CLARIFICATION:

No known NPL site in Columbia, TN — check with Camilla Warren re: CERCLIS

PROCEDURES FOR HANDLING FOIA REQUESTS

1. The FOI Officer will maintain FOIA records and will forward a copy of each request to the appropriate ACTION OFFICE FOI Coordinator. ACTION OFFICE personnel will gather the requested information and, as required, consult a designated Assistant Regional Counsel for withholding any records.

2. If the request is too broad, or asks for voluminous records, ACTION OFFICE personnel who are most familiar with the requested records should call the requester and ask for clarification .

3. Use the checklist to ensure all procedures are followed.

4. The ACTION OFFICE Coordinator will calculate fees according to the regulations and prepare the written response. They will also assist in coordinating with ORC and the FOI Office when any requested information is to be withheld.

5. If you need an extension beyond the normal 10 working day limit to respond to an FOIA request, please contact your FOIA Coordinator.

6. For detailed procedures on responding to an FOI request, you should consult the Regional Order and FOI Manual.

# MANTA AND WELGE

ATTORNEYS AT LAW

37TH FLOOR

ONE COMMERCE SQUARE

2005 MARKET STREET

PHILADELPHIA, PENNSYLVANIA 19103

(215) 851-6600

TELECOPIER (215) 851-6644

DIRECT DIAL (215) 851- 6646

JOSEPH G. MANTA
MARK A. WELGE
WILLIAM R. HOURICAN
ALBERT L. PICCERILLI*
JOHN C. SULLIVAN*
JOEL SCHNEIDER*
JOSEPH M. CINCOTTA**
JAMES V. BIELUNAS
MARY E. RUGALA*
JOHN E. SCHUPPERT, III
ANTHONY J. VETRANO'
FRANCIS J. SHERRY
SUSAN SIMPSON-BROWN
JOANNE M. WALKER*
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TIMOTHY W. GARVEY*
ANTON G. MARZANO*
MARGARET E. WENKE*

*ALSO MEMBER N. J. BAR
**ALSO MEMBER N. Y. BAR
'ALSO MEMBER ILL. BAR

NEW JERSEY OFFICE
SUITE 600
1040 NORTH KINGS HIGHWAY
CHERRY HILL, NEW JERSEY 08034
(609) 795-7611


Comp in 4-18-88
H-RIN-796-88
due 5-2-88

Waste
ORC

April 14, 1988

Mr. Wally Jones
Freedom of Information Officer
Environmental Protection Agency
Region IV
345 Courtland Road, Southwest
Atlanta, GA 30365

Re: Freedom of Information Act Request
Our File No: 5600-24/5600-25

Dear Ms. Sullivan:

Pursuant to the Freedom of Information Act ("FOIA"), 5 U.S.C. §552, I am writing to request documents concerning a facility located in Columbia, TN. I am interested in obtaining all disclosable information, including by not limited to the following:

1. Information request letters relating to this site sent by the EPA to Monsanto Company pursuant to §104 of the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. §9604 and/or §3007 of the Resource Conservation and Recovery Act, 42 U.S.C. §6927;

2. Any and all documents submitted to the EPA by Monsanto Company in response to the information request letters identified in item 1 above;

3. All correspondence from the EPA to any Potentially Responsible Party ("PRP") relating to this site, including, without limitation, notice letters informing the PRPs of potential liability for cleanup and/or informing PRPs of the opportunity to conduct or participate in the development of a Remedial Investigation and Feasibility Study ("RI/FS") for this site;

4. Any documents which state the date the problem was discovered at the site;

5. All documents alleging when Monsanto Company generated hazardous substances and/or hazardous wastes at the site;

6. All documents summarizing the type and total volume of hazardous substances and/or hazardous wastes generated by Monsanto Company in connection with this site;

7. All documents relating to any emergency response, immediate or planned removal action and/or long-term remedial action taken or planned in connection with this site and the costs involved; and

8. The Record of Decision entered on this site.

For purposes of this request, the term "document" includes, without limitation, all correspondence, memoranda, inter- and intra-agency communications, minutes, reports, notes, schedules, analyses, photographs, contracts, proposals, and all other such documents tangible or retrievable of any kind.

As provided under the FOIA, I expect to receive a reply to this request within ten (10) working days. In the event that a determination is made that some of all of the documents requested are exempt from disclosure under the FOIA, please identify those documents withheld and the basis for the Agency's exemption in each instance. Also, if the materials to be sent exceed the cost of twenty-five ($25.00) dollars, please contact me at (215) 851-6646 so I may determine what we specifically need. Should you need any additional information in order to process this request, do not hesitate to call.

Thank you in advance for your assistance.

Very truly yours,

MANTA AND WELGE

By Gwendolyn Williams
Gwendolyn Williams
Legal Assistant

GW/hjs

M.2 - SITE MAINTENANCE FORM

* ACTION: _

EPA ID : TND004048104

SITE NAME: MONSANTO CO INC SOURCE: H

STREET : MONSANTO RD CONG DIST: 06

CITY : COLUMBIA ZIP: 38401

CNTY NAME: MAURY CNTY CODE : 119

LATITUDE : 35/40/00.0 LONGITUDE : 087/07/00.2

LL-SOURCE: R LL-ACCURACY:

SMSA : HYDRO UNIT: 06040003

INVENTORY IND: Y REMEDIAL IND: Y REMOVAL IND: N FED FAC IND: N

NPL IND: N NPL LISTING DATE: NPL DELISTING DATE:

SITE/SPILL IDS:

RPM NAME: RPM PHONE: - -

SITE CLASSIFICATION: SITE APPROACH:

DIOXIN TIER: REG FLD1: REG FLD2: 6

RESP TERM: PENDING ( ) NO FURTHER ACTION ( )

ENF DISP: NO VIABLE RESP PARTY ( ) VOLUNTARY RESPONSE ( )
ENFORCED RESPONSE ( ) COST RECOVERY ( )

SITE DESCRIPTION:

PENDING (_) NO FURTHER ACTION (_)

M.2 - ALIAS/ALIAS LOCATION MAINTENANCE FORM

* ACTION: _ *

SITE: MONSANTO CO INC

EPA ID: TND004048104 ALIAS SEQ NO: 01

ALIAS NAME: COLUMBIA ELEMENTAL PHOSPHATES SOURCE: S * _____ _ *

ALIAS LOCATION * ACTION: _ *

CONTIGUOUS PORTION OF SITE? C FED FAC IND: N * _ _ *

STREET : CONG DIST : 06 * _____ __ *

CITY : COLUMBIA ST: TN ZIP: 38401 * _____ __ _____-____ *

CNTY NAME: MAURY CNTY CODE: 119 * _____ ___ *

LATITUDE : 35/36/54.0 LONGITUDE : 087/02/12.0 * __/__/__._ ___/__/__._ *

LL-SOURCE: G LL-ACCURACY: * _ _ *

SMSA : HYDRO UNIT: 06040003 * ____ _____ *

ALIAS DESCRIPTION:

* _____ *

* _____ *

* _____ *

* _____ *

M.2 - PROGRAM MAINTENANCE FORM

ACTION: _

SITE: MONSANTO CO INC

EPA ID: TND004048104 PROGRAM CODE: H01 PROGRAM TYPE: _

PROGRAM QUALIFIER: ALIAS LINK :

PROGRAM NAME: SITE EVALUATION

DESCRIPTION:

M.2 - EVENT MAINTENANCE FORM

* ACTION: _ *

SITE: MONSANTO CO INC
PROGRAM: SITE EVALUATION

EPA ID: TND004048104 PROGRAM CODE: H01 EVENT TYPE: DS1

FMS CODE: EVENT QUALIFIER : EVENT LEAD: E * _ ___ _ *

EVENT NAME: DISCOVERY STATUS: * _____ _ *

DESCRIPTION:

* _____ *
* _____ *
* _____ *
* _____ *

| ORIGINAL | CURRENT | ACTUAL | | | |
|---|---|---|---|---|---|
| START: | START: | START: | __/__/__ | __/__/__ | __/__/__ |
| COMP : | COMP : | COMP : 11/01/79 | __/__/__ | __/__/__ | __/__/__ |

HQ COMMENT:

* _____ *

RG COMMENT:

* _____ *

| COOP AGR # | AMENDMENT # | STATUS | STATE % | | | |
|---|---|---|---|---|---|---|
| | | | 0 | _____ | _____ | __ | ___ |

M.2 - EVENT MAINTENANCE FORM

* ACTION: _ *

SITE: MONSANTO CO INC
PROGRAM: SITE EVALUATION

EPA ID: TND004048104 PROGRAM CODE: H01 EVENT TYPE: PA1

FMS CODE: EVENT QUALIFIER : EVENT LEAD: S * _ ___ _ *

EVENT NAME: PRELIMINARY ASSESSMENT STATUS: * _____ _ *

DESCRIPTION:

* _____ *
* _____ *
* _____ *
* _____ *

| ORIGINAL | CURRENT | ACTUAL | | | |
|---|---|---|---|---|---|
| START: | START: | START: | __/__/__ | __/__/__ | __/__/__ |
| COMP : | COMP : | COMP : 11/01/83 | __/__/__ | __/__/__ | __/__/__ |

HQ COMMENT:

* _____ *

RG COMMENT:

* _____ *

| COOP AGR # | AMENDMENT # | STATUS | STATE % |
|---|---|---|---|
| | | | 0 |

* _____ _____ __ ___ *

M.2 - EVENT MAINTENANCE FORM

* ACTION: _ *

SITE: MONSANTO CO INC
PROGRAM: SITE EVALUATION

EPA ID: TND004048104 PROGRAM CODE: H01 EVENT TYPE: SI1

FMS CODE: EVENT QUALIFIER : EVENT LEAD: S * _ ___ _ *

EVENT NAME: SITE INSPECTION STATUS: * _____ _ *

DESCRIPTION:

* _____ *
* _____ *
* _____ *
* _____ *

| ORIGINAL | CURRENT | ACTUAL | | | |
|---|---|---|---|---|---|
| START: | START: | START: 06/01/84 | __/__/__ | __/__/__ | __/__/__ |
| COMP : | COMP : | COMP : 08/01/84 | __/__/__ | __/__/__ | __/__/__ |

HQ COMMENT:

* _____ *

RG COMMENT:

* _____ *

| COOP AGR # | AMENDMENT # | STATUS | STATE % | | | | |
|---|---|---|---|---|---|---|---|
| | | | 0 | _____ | _____ | __ | ___ |

M.2 - COMMENT MAINTENANCE FORM

SITE: MONSANTO CO INC

EPA ID: TND004048104

| COM NO | COMMENT | ACTION |
|---|---|---|
| 001 | TNS000001096-SEE FILE | |
| 002 | DELETED TND039055900 COLUMBIA PLT A ND ADDED INFO TO MONSANTO AS AN | |
| 003 | ALIAS AT REQUEST OF TENN STATE PERS ONNEL | |

# SITE INSPECTION WORKSHEETS

| CERCLIS IDENTIFICATION NUMBER |
|---|
| |

| SITE LOCATION | | | |
|---|---|---|---|
| SITE NAME: LEGAL, COMMON, OR DESCRIPTIVE NAME OF SITE<br>Monsanto Company | | | |
| STREET ADDRESS, ROUTE, OR SPECIFIC LOCATION IDENTIFIER<br>Monsanto Rd. | | | |
| CITY<br>Columbia | STATE<br>TN | ZIP CODE | TELEPHONE<br>( ) |
| COORDINATES: LATITUDE and LONGITUDE | TOWNSHIP, RANGE, AND SECTION | | |

| OWNER/OPERATOR IDENTIFICATION | | | | | |
|---|---|---|---|---|---|
| OWNER | | | OPERATOR | | |
| OWNER ADDRESS | | | OPERATOR ADDRESS | | |
| CITY | | | CITY | | |
| STATE | ZIP CODE | TELEPHONE<br>( ) | STATE | ZIP CODE | TELEPHONE<br>( ) |

F.O.I.A. EXEMPTION 5

11/13/93
Date

AUTHORIZING OFFICIAL

| SITE EVALUATION | | |
|---|---|---|
| AGENCY/ORGANIZATION | | |
| INVESTIGATOR | | |
| CONTACT | | |
| ADDRESS | | |
| CITY | STATE | ZIP CODE |
| TELEPHONE<br>( ) | | |

DRAFT



JUN 18 1992

# GENERAL INFORMATION

**Site Description and Operational History:** Provide a brief description of the site and its operational history. State the site name, owner, operator, type of facility and operations, size of property, active or inactive status, and years of waste generation. Summarize waste treatment, storage, or disposal activities that have or may have occurred at the site; note also if these activities are documented or alleged. Identify all source types and prior spills, floods, or fires. Summarize highlights of the PA and other investigations. Cite references.

DRAFT

JUN 18 1992

## GENERAL INFORMATION (continued)

Site Sketch: Provide a sketch of the site. Indicate all pertinent features of the site and nearby environments including: sources of wastes, areas of visible and buried wastes, buildings, residences, access roads, parking areas, fences, fields, drainage patterns, water bodies, vegetation, wells, sensitive environments, and other features.



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## GENERAL INFORMATION (continued)

**Source Descriptions:** Describe all sources at the site. Identify source type and relate to waste disposal operations. Provide source dimensions and the best available waste quantity information. Describe the condition of sources and all containment structures. Cite references.

## SOURCE TYPES

**Landfill:** A man-made (by excavation or construction) or natural hole in the ground into which wastes have come to be disposed by backfilling, or by contemporaneous soil deposition with waste disposal.

**Surface Impoundment:** A natural topographic depression, man-made excavation, or diked area, primarily formed from earthen materials (lined or unlined) designed to hold an accumulation of liquid wastes, wastes containing free liquids, or sludges not backfilled or otherwise covered; depression may be wet with exposed liquid or dry if deposited liquid has evaporated, volatilized or leached; structures that may be described as lagoon, pond, aeration pit, settling pond, tailings pond, sludge pit; also a surface impoundment that has been covered with soil after the final deposition of waste materials (i.e., buried or backfilled).

**Drums:** A portable container designed to hold a standard 55-gallon volume of wastes.

**Tanks and Non-Drum Containers:** Any device other than drums designed to contain an accumulation of waste that provides structural support and is constructed primarily of fabricated materials (such as wood, concrete, steel, or plastic); any portable or mobile device in which waste is stored or otherwise handled.

**Contaminated Soil:** An area or volume of soil onto which hazardous substances have been spilled, spread, disposed, or deposited.

**Pile:** Any non-containerized accumulation above the ground surface of solid, non-flowing wastes; includes open dumps. Some types of waste piles are:

- Chemical Waste Pile: A pile consisting primarily of discarded chemical products, by-products, radioactive wastes, or used or unused feedstocks.
- Scrap Metal or Junk Pile: A pile consisting primarily of scrap metal or discarded durable goods (such as appliances, automobiles, auto parts, batteries, etc.) composed of materials containing hazardous substances.
- Tailings Pile: A pile consisting primarily of any combination of overburden from a mining operation and tailings from a mineral mining, beneficiation, or processing operation.
- Trash Pile: A pile consisting primarily of paper, garbage, or discarded non-durable goods containing hazardous substances.

**Land Treatment:** Landfarming or other land treatment method of waste management in which liquid wastes or sludges are spread over land and tilled, or liquids are injected at shallow depths into soils.

**Other:** Sources not in categories listed above.

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## GENERAL INFORMATION (continued)

**Source Description:** Include description of containment per pathway for ground water (see HRS Table 3-2), surface water (see HRS Table 4-2), and air (see HRS Tables 6-3 and 6-9).

**Hazardous Waste Quantity (HWQ) Calculation:** SI Tables 1 and 2 (See HRS Tables 2-5, 2-6, and 5-2)

Landfill

| Site | Volume ($yd^3$) |
|---|---|
| 3 | 9,000 |
| 4west | 45,000 |
| 4N+S | 420,000 |
| 5 | 87,000 |
| 8 | 61,000 |
| 11 | 608,000 |
| 12 | 35,000 |
| 13 | 400,000 |
| 18 | 108,000 |
| 20 | 726,000 |
| Total | 2,499,000 |

$\frac{2,499,000}{2,500} = 999.60$

Contaminated Soil

| Site | Volume ($yd^3$) |
|---|---|
| 6 | 1,900 |
| 7 | 97,000 |
| 17 | 58,000 |
| 19 | 69,000 |
| Total | 225,900 |

$\frac{225,900}{2,500} = 90.36$

999.60
90.36
474,400
475,489.96

Surface Impoundment

| Site | Volume |
|---|---|
| 9(sediment) | 740,000 $yd^3$ |
| 9(water) | 90,000,000 gal. |

$90,000,000\ gal \left(\frac{0.1337\ ft^3}{gal}\right)\left(\frac{1\ yd^3}{27\ ft^3}\right)$

446,000 $yd^3$
+740,000 $yd^3$
1,186,000 $yd^3$

$\frac{1,186,000}{2.5} = 474,400$

HWQ = 10,000

Attach additional pages, if necessary

HWQ = 10,000

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## SI TABLE 1: HAZARDOUS WASTE QUANTITY (HWQ) SCORES FOR SINGLE SOURCE SITES AND FORMULAS FOR MULTIPLE SOURCE SITES

| | | Single Source Sites (assigned HWQ scores) | |
|---|---|---|---|
| (Column 1) TIER | (Column 2) Source Type | (Column 3) HWQ = 10 | (Column 4) HWQ = 100 |
| A Hazardous Constituent Quantity | N/A | HWQ = 1 if Hazardous Constituent Quantity data are complete<br>HWQ = 10 if Hazardous Constituent Quantity data are not complete | >100 to 10,000 lbs |
| B Wastestream | N/A | ≤ 500,000 lb. | >500,000 to 50 million lbs |
| C Volume | Landfill | ≤ 6.75 million $ft^3$<br>≤ 250,000 $yd^3$ | >6.75 million to 675 million $ft^3$<br>>250,000 to 25 million $yd^3$ |
| | Surface impoundment | ≤6,750 $ft^3$<br>≤250 $yd^3$ | >6,750 to 675,000 $ft^3$<br>>250 to 25,000 $yd^3$ |
| | Drums | ≤1,000 drums | >1,000 to 100,000 drums |
| | Tanks and non-drum containers | ≤50,000 gallons | >50,000 to 5 million gallons |
| | Contaminated soil | ≤6.75 million $ft^3$<br>≤250,000 $yd^3$ | >6.75 million to 675 million $ft^3$<br>>250,000 to 25 million $yd^3$ |
| | Pile | ≤6,750 ft3<br>≤250 yd3 | >6,750 to 675,000 $ft^3$<br>>250 to 25,000 $yd^3$ |
| | Other | ≤6,750 $ft^3$<br>≤250 $yd^3$ | >6,750 to 675,000 $ft^3$<br>>250 to 25,000 $yd^3$ |
| D Area | Landfill | ≤340,000 $ft^3$<br>≤7.8 acres | >340,000 to 34 million $ft^2$<br>>7.8 to 780 acres |
| | Surface impoundment | ≤1,300 $ft^3$<br>≤0.029 acres | >1,300 to 130,000 $ft^2$<br>>0.029 to 2.9 acres |
| | Contaminated soil | ≤3.4 million $ft^3$<br>≤0.029 acres | > 3.4 million to 340 million $ft^2$<br>> 78 to 7,800 acres |
| | Pile | ≤1,300 $ft^3$<br>≤0.029 acres | >1,300 to 130,000 $ft^2$<br>>0.029 to 2.9 acres |
| | Land treatment | ≤27,000 $ft^3$<br>≤0.62 acres | >27,000 to 2.7 million $ft^2$<br>>0.62 to 62 acres |

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TABLE 1 (CONTINUED)

| Single Source Sites (assigned HWQ scores) | | Multiple Source Sites | | |
|---|---|---|---|---|
| (Column 5) HWQ = 10,000 | (Column 6) HWQ = 1,000,000 | (Column 7) Divisors for Assigning Source WQ Values | (Column 2) Source Type | (Column 1) TIER |
| >10,000 to 1 million lbs | > 1 million lbs | lbs ÷ 1 | N/A | A Hazardous Constituent Quantity |
| >50 million to 5 billion lbs | > 5 billion lbs | lbs ÷ 5,000 | N/A | B Wastestream |
| >675 million to 67.5 billion $ft^3$<br>>25 million to 2.5 billion $yd^3$ | > 67.5 billion $ft^3$<br>> 2.5 billion $yd^3$ | $ft^3$ ÷ 67,500<br>$yd^3$ ÷ 2,500 | Landfill | C Volume |
| >675,000 to 67.5 million $ft^3$<br>>25,000 to 2.5 million $yd^3$ | > 67.5 million $ft^3$<br>> 2.5 million $yd^3$ | $ft^3$ ÷ 67.5<br>$yd^3$ ÷ 2.5 | Surface Impoundment | |
| >100,000 to 10 million drums | > 10 million drums | drums ÷ 10 | Drums | |
| >5 million to 500 million gallons | > 500 million gallons | gallons ÷ 500 | Tanks and non-drum containers | |
| >675 million to 67.5 billion $ft^3$<br>>25 million to 2.5 billion $yd^3$ | > 67.5 billion $ft^3$<br>> 2.5 billion $yd^3$ | $ft^3$ ÷ 67,500<br>$yd^3$ ÷ 2,500 | Contaminated Soil | |
| >675,000 to 67.5 million $ft^3$<br>>25,000 to 2.5 million $yd^3$ | > 67.5 million $ft^3$<br>> 2.5 million $yd^3$ | $ft^3$ ÷ 67.5<br>$yd^3$ ÷ 2.5 | Pile | |
| >675,000 to 67.5 million $ft^3$<br>>25,000 to 2.5 million $yd^3$ | > 67.5 million $ft^3$<br>> 2.5 million $yd^3$ | $ft^3$ ÷ 67.5<br>$yd^3$ ÷ 2.5 | Other | |
| >34 million to 3.4 billion $ft^2$<br>>780 to 78,000 acres | > 3.4 billion $ft^2$<br>>78,000 acres | $ft^2$ ÷ 3,400<br>acres ÷ 0.078 | Landfill | D Area |
| >130,000 to 13 million $ft^2$<br>>2.9 to 290 acres | > 13 million $ft^2$<br>> 290 acres | $ft^2$ ÷ 13<br>acres ÷ 0.00029 | Surface Impoundment | |
| > 340 million to 34 billion $ft^2$<br>> 7,800 to 780,000 acres | > 34 billion $ft^2$<br>> 780,000 acres | $ft^2$ ÷ 34,000<br>acres ÷ 0.78 | Contaminated Soil | |
| > 130,000 to 13 million $ft^2$<br>> 2.9 to 290 acres | > 13 million $ft^2$<br>> 290 acres | $ft^2$ ÷ 13<br>acres ÷ 0.00029 | Pile | |
| >2.7 million to 270 million $ft^2$<br>>62 to 6,200 acres | > 270 million $ft^2$<br>> 6,200 acres | $ft^2$ ÷ 270<br>acres ÷ 0.0062 | Land Treatment | |

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## HAZARDOUS WASTE QUANTITY (HWQ) CALCULATION

For each migration pathway, evaluate HWQ associated with sources that are available (i.e., incompletely contained) to migrate to that pathway. (Note: If *Actual Contamination Targets* exist for ground water, surface water, or air migration pathways, assign the calculated HWQ score or 100, whichever is greater, as the HWQ score for that pathway.) For each source, evaluate HWQ for one or more of the four tiers (SI Table 1; HRS Table 2-5) for which data exist: constituent quantity, wastestream quantity, source volume, and source area. Select the tier that gives the highest value as the source HWQ. Select the source volume HWQ rather than source area HWQ if data for both tiers are available.

Column 1 of SI Table 1 indicates the quantity tier. Column 2 lists source types for the four tiers. Columns 3, 4, 5, and 6 provide ranges of waste amount for sites with only one source, corresponding to HWQ scores at the tops of the columns. Column 7 provides formulas to obtain source waste quantity values at sites with multiple sources.

1. Identify each source type.
2. Examine all waste quantity data available for each source. Record constituent quantity and waste stream mass or volume. Record dimensions of each source.
3. Convert source measurements to appropriate units for each tier to be evaluated.
4. For each source, use the formulas in the last column of SI Table 1 to determine the waste quantity value for each tier that can be evaluated. Use the waste quantity value obtained from the highest tier as the quantity value for the source.
5. Sum the values assigned to each source to determine the total site waste quantity.
6. Assign HWQ score from SI Table 2 (HRS Table 2-6).

Note these exceptions to evaluate soil exposure pathway HWQ (see HRS Table 5-2):

- The divisor for the area (square feet) of a landfill is 34,000.
- The divisor for the area (square feet) of a pile is 34.
- Wet surface impoundments and tanks and non-drum containers are the only sources for which volume measurements are evaluated for the soil exposure pathway.

SI TABLE 2: HWQ SCORES FOR SITES

| Site WQ Total | HWQ Score |
|---|---|
| > 0 to 100 | 10 |
| > 100 to 10,000 | 100 |
| > 10,000 to 1 million | 10,000 |
| > 1 million | 1,000,000 |

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## SI TABLE 3: WASTE CHARACTERIZATION WORKSHEET

**Site Name:** _____ **References** _____

**Sources:**

1. _____ 4. _____ 7. _____
2. _____ 5. _____ 8. _____
3. _____ 6. _____ 9. _____

| SOURCE | HAZARDOUS SUBSTANCE | TOXICITY | GROUND WATER PATHWAY | | SURFACE WATER PATHWAY | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | OVERLAND/FLOOD MIGRATION | | | | | | | GROUND WATER TO SURFACE WATER | | | |
| | | | GW Mobility (HRS Table 3-8) | Tox/ Mobility Value (HRS Table 3-9) | Per (HRS Table 4-10 and 4-11) | Tox/Per Value (HRS Table 4-12) | Bioac Pot. (HRS Table 4-15) | Tox/ Pers/ Bioac Value (HRS Table 4-16) | Ecotox (HRS Table 4-19) | Ecotox/ Pers (HRS Table 4-20) | Ecotox/ Pers/ Bioacc Value (HRS Table 4-21) | Tox/ Mob/ Pers Value (HRS Table 4-26) | Tox/ Mob/ Pers/ Bioacc Value (HRS Table 4-26) | Ecotox/ Mob/ Pers Value (HRS Table 4-26) | Ecotox/ Mob/ Per/ Bioacc Value (HRS Table 4-26) |
| 17+19 | Fluoride | 10 | 1 | 10 | 0.4 | 4 | 0.5 | 2 | — | — | — | 4 | 2 | — | — |
| " | Chromium | 10,000 | 1 | 10000 | 1 | 10000 | 5.0 | 50 000 | 10 000 | 10 000 | 50 000 | 10 000 | 50 000 | 10 000 | 50 000 |
| " | Arsenic | 10 000 | 1 | 10 000 | 1 | 10000 | 5.0 | 50 000 | 10 | 10 | 500 | 10 000 | 50000 | 10 | 500 |
| " | Cyanide | 100 | 1 | 100 | 0.4 | 40 | 0.5 | 20 | 1000 | 400 | 200 | 40 | 20 | 400 | 200 |
| " | Lead | 10 000 | 1 | 10 000 | 1 | 10 000 | 50 | 500 000 | 1000 | 1000 | 5 000 000 | 10 000 | 500 000 | 1000 | 5 000 000 |
| 6 | Fluoride | | | | | | | | | | | | | | |
| " | Chrominm | | | | | | | | | | | | | | |
| " | Cyanide | | | | | | | | | | | | | | |
| " | Phosphate | | | | | | | | | | | | | | |
| " | | | | | | | | | | | | | | | |
| | Phosphorus | 1000 | 1 | 1000 | | | | | | | | | | | |
| | Cadmium | 10,000 | 1 | 10,000 | 1 | 10,000 | 5,000 | 5 E+7 | 1000 | 1,000 | 5 E+6 | 10,000 | 5 E+7 | 1,000 | 5 E+6 |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

## Ground Water Observed Release Substances Summary Table

On SI Table 4, list the hazardous substances associated with the site detected in ground water samples for that aquifer. Include only those substances directly observed or with concentrations significantly greater than background levels. Obtain toxicity values from the Superfund Chemical Data Matrix (SCDM). Assign mobility a value of 1 for all observed release substances regardless of the aquifer being evaluated. For each substance, multiply the toxicity by the mobility to obtain the toxicity/mobility factor value; enter the highest toxicity/mobility value for the aquifer in the space provided.

## Ground Water Actual Contamination Targets Summary Table

If there is an observed release at a drinking water well, enter each hazardous substance meeting the requirements for an observed release by well and sample ID on SI Table 5, and record the detected concentration. Obtain benchmark, cancer risk, and reference dose concentrations from SCDM. For MCL and MCLG benchmarks, determine the highest percentage of benchmark obtained for any substance. For cancer risk and reference dose, sum the percentages for the substances listed. If benchmark, cancer risk, or reference dose concentrations are not available for a particular substance, enter N/A for the percentage. If the highest benchmark percentage or the percentage sums calculated for cancer risk or reference dose equal or exceed 100%, evaluate the population using the well as Level I targets. If these percentages are less than 100% or all are N/A, evaluate the population using the well as Level II targets for that aquifer.

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## SI TABLE 4: GROUND WATER OBSERVED RELEASE SUBSTANCES (BY AQUIFER)

| Sample ID | Hazardous Substance | Bckgrd. Conc. | Toxicity/ Mobility | Reference |
|---|---|---|---|---|
| | Lead | | | |
| | Phosphorus | 0.001 µg/L | 1000 | SI '85 |
| | Cadmium | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | Highest Toxicity/Mobility | | |

## SI TABLE 5: GROUND WATER ACTUAL CONTAMINATION TARGETS

Well ID: Girl Scout "A" Level I _____ Level II ✓ Population Served _____ References _____

| Sample ID | Hazardous Substance | Conc. (µg/L) | Benchmark Conc. (MCL or MCLG) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Reference Dose | % of Reference Dose |
|---|---|---|---|---|---|---|---|---|
| | Phosphorus | 0.014 | — | | — | | — | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

Well ID: _____ Level I _____ Level II _____ Population Served _____ References _____

| Sample ID | Hazardous Substance | Conc. (µg/L) | Benchmark Conc. (MCL or MCLG) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Reference Dose | % of Reference Dose |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

# GROUND WATER PATHWAY
# GROUND WATER USE DESCRIPTION

**Describe Ground Water Use within 4 Miles of the Site:**
Describe generalized stratigraphy, aquifers, municipal and private wells

**Show Calculations of Ground Water Drinking Water Populations for each Aquifer:**
Provide apportionment calculations for blended supply systems.
County average number of persons per household: _____ Reference _____



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# GROUND WATER PATHWAY WORKSHEET

| LIKELIHOOD OF RELEASE | Score | Data Type | Refs |
|---|---|---|---|
| 1. OBSERVED RELEASE: If sampling data or direct observation supports a release to the aquifer, assign a score of 550. Record observed release substances on SI Table 4. | 550 ? ~~555~~ | | |
| 2. POTENTIAL TO RELEASE: Depth to aquifer: _____ feet. If sampling data do not support a release to the aquifer, and the site is in karst terrain or the depth to aquifer is 70 feet or less, assign a score of 500; otherwise, assign a score of 340 Optionally, evaluate potential to release according to HRS Section 3. | | | |
| LR = | 550 | | |

| TARGETS | | | |
|---|---|---|---|
| Are any wells part of a blended system? Yes____ No ✓ If yes, attach a page to show apportionment calculations. | | | |
| 3. ACTUAL CONTAMINATION TARGETS: If analytical evidence indicates that any target drinking water well for the aquifer has been exposed to a hazardous substance from the site, evaluate the factor score for the number of people served (SI Table 5). Level I: _____ people x 10 = _____ Level II: _____ people x 1 = _____ Total = | 0 | | |
| 4. POTENTIAL CONTAMINATION TARGETS: Determine the number of people served by drinking water wells for the aquifer or overlying aquifers that are not exposed to a hazardous substance from the site; record the population for each distance category in SI Table 6a or 6b. Sum the population values and multiply by 0.1. | ~~19.0~~ 89.5 | | |
| 5. NEAREST WELL: Assign a score of 50 for any Level I Actual Contamination Targets for the aquifer or overlying aquifer. Assign a score of 45 if there are Level II targets but no Level I targets. If no Actual Contamination Targets exist, assign the Nearest Well score from SI Table 6a or 6b. If no drinking water wells exist within 4 miles, assign 0. | ~~20~~ ~~45~~ 70 | | |
| 6. WELLHEAD PROTECTION AREA (WHPA): If any source lies within or above a WHPA for the aquifer, or if a ground water observed release has occurred within a WHPA, assign a score of 20; assign 5 if neither condition applies but a WHPA is within 4 miles; otherwise assign 0. | 0 | | |
| 7. RESOURCES: Assign a score of 5 if one or more ground water resources applies; assign 0 if none applies. • Irrigation (5 acre minimum) of commercial food crops or commercial forage crops • Watering of commercial livestock • Ingredient in commercial food preparation • Supply for commercial aquaculture • Supply for a major or designated water recreation area, excluding drinking water use | ~~0~~ 5 | | |
| Sum of Targets T= | ~~39.0~~ ~~44~~ 114.5 | | |

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## SI TABLE 6 (From HRS TABLE 3-12): VALUES FOR POTENTIAL CONTAMINATION GROUND WATER TARGET POPULATIONS

### SI Table 6a: Other Than Karst Aquifers

| Distance from Site | Pop. | Nearest Well (choose highest) | Population Served by Wells within Distance Category | | | | | | | | | | | | Pop Value | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 to 10 | 11 to 30 | 31 to 100 | 101 to 300 | 301 to 1000 | 1001 to 3000 | 3001 to 10,000 | 10,001 to 30,000 | 30,001 to 100,000 | 100,001 to 300,000 | 300,001 to 1,000,000 | 1,000,000 to 3,000,000 | | |
| 0 to $\frac{1}{4}$ mile | | 20 | 4 | 17 | 53 | 164 | 522 | 1,633 | 5,214 | 16,325 | 52,137 | 163,246 | 521,360 | 1,632,455 | | |
| > $\frac{1}{4}$ to $\frac{1}{2}$ mile | | 18 | 2 | 11 | 33 | 102 | 324 | 1,013 | 3,233 | 10,122 | 32,325 | 101,213 | 323,243 | 1,012,122 | | |
| > $\frac{1}{4}$ to 1 mile | | 9 | 1 | 5 | 17 | 52 | 167 | 523 | 1,669 | 5,224 | 16,684 | 52,239 | 166,835 | 522,385 | | |
| > 1 to 2 miles | | 5 | 0.7 | 3 | 10 | 30 | 94 | 294 | 939 | 2,939 | 9,385 | 29,384 | 93,845 | 293,842 | | |
| > 2 to 3 miles | | 3 | 0.5 | 2 | 7 | 21 | 68 | 212 | 678 | 2,122 | 6,778 | 21,222 | 67,777 | 212,219 | | |
| >3 to 4 miles | | 2 | 0.3 | 1 | 4 | 13 | 42 | 131 | 417 | 1,306 | 4,171 | 13,060 | 41,709 | 130,596 | | |

Nearest Well = [ ]  Score = [ ]

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## SI TABLE 6 (From HRS TABLE 3-12): VALUES FOR POTENTIAL CONTAMINATION GROUND WATER TARGET POPULATIONS (continued)

### SI Table 6b: Karst Aquifers

| Distance from Site | Pop. | Nearest Well (choose highest) | Population Served by Wells within Distance Category | | | | | | | | | | | | Pop Value | Ref. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 to 10 | 11 to 30 | 31 to 100 | 101 to 300 | 301 to 1000 | 1001 to 3000 | 3001 to 10,000 | 10,001 to 30,000 | 30,001 to 100,000 | 100,001 to 300,000 | 300,001 to 1,000,000 | 1,000,000 to 3,000,000 | | |
| 0 to $\frac{1}{4}$ mile | 90.1 | 20 | 4 | 17 | 53 | 164 | 522 | 1,633 | 5,214 | 16,325 | 52,137 | 163,246 | 521,360 | 1,632,455 | ~~0~~ | 53 |
| > $\frac{1}{4}$ to $\frac{1}{2}$ mile | 57.6 ~~0~~ | 20 | 2 | 11 | 33 | 102 | 324 | 1,013 | 3,233 | 10,122 | 32,325 | 101,213 | 323,243 | 1,012,122 | ~~0~~ | 33 |
| > $\frac{1}{2}$ to 1 mile | 55.0 ~~0~~ | 20 | 2 | 9 | 26 | 82 | 261 | 817 | 2,607 | 8,163 | 26,068 | 81,623 | 260,680 | 816,227 | ~~0~~ | 26 |
| > 1 to 2 miles | 362 ~~<100~~ | 20 | 2 | 9 | 26 | 82 | 261 | 817 | 2,607 | 8,163 | 26,068 | 81,623 | 260,680 | 816,227 | ~~26~~ | 261 |
| > 2 to 3 miles | 511 ~~<200~~ | 20 | 2 | 9 | 26 | 82 | 261 | 817 | 2,607 | 8,163 | 26,068 | 81,623 | 260,680 | 816,227 | ~~82~~ | 261 |
| > 3 to 4 miles | 964 ~~<200~~ | 20 | 2 | 9 | 26 | 82 | 261 | 817 | 2,607 | 8,163 | 26,068 | 81,623 | 260,680 | 816,227 | ~~82~~ | 261 |
| Nearest Well = | | 20 | | | | | | | | | | | | | Score = ~~190~~ | 895 |

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# GROUND WATER PATHWAY WORKSHEET (concluded)

| WASTE CHARACTERISTICS | Score | Data Type | Does not Apply |
|---|---|---|---|
| 8. If any Actual Contamination Targets exist for the aquifer or overlying aquifers, assign the calculated hazardous waste quantity score or a score of 100, whichever is greater; if no Actual Contamination Targets exist, assign the hazardous waste quantity score calculated for sources available to migrate to groundwater. | 10,000 | | |
| 9. Assign the highest ground water toxicity/mobility value from SI Table 3 or 4. | 10,000 | | |
| 10. Multiply the ground water toxicity/mobility and waste quantity scores. Assign the Waste Characteristics score from the table below: (from HRS Table 2-7) | 100 | | |
| WC = | 100 | | |

| Product | WC Score |
|---|---|
| 0 | 0 |
| >0 to <10 | 1 |
| 10 to <100 | 2 |
| 100 to <1,000 | 3 |
| 1,000 to < 10,000 | 6 |
| 10,000 to <1E + 05 | 10 |
| 1E + 05 to <1E + 06 | 18 |
| 1E + 06 to <1E + 07 | 32 |
| 1E + 07 to <1E + 08 | 56 |
| 1E + 08 or greater | 100 |

Multiply LR by T and by WC. Divide the product by 82,500 to obtain the groundwater pathway score for each aquifer. Select the highest aquifer score. If the pathway score is greater than 100, assign 100.

**GROUND WATER PATHWAY SCORE:**

$$LR \times T \times WC = \frac{\quad}{82{,}500}$$

~~26.0~~ 76.3

(Maximum of 100)

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# SURFACE WATER PATHWAY

**Sketch of the Surface Water Migration Route:**
Label all surface water bodies. Include runoff route and drainage direction, probable point of entry and 15-mile target distance limit. Mark sample locations, intakes, fisheries, and sensitive environments. Indicate flow directions and tidal influence. Indicate flow direction and rate.

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## SURFACE WATER PATHWAY

### Surface Water Observed Release Substances Summary Table

On SI Table 7, list the hazardous substances detected in surface water samples for the watershed, which can be attributed to the site. Include only those substances detected at concentration levels significantly above background levels or in observed releases by direct observation. Obtain toxicity, persistence, bioaccumulation potential, and ecotoxicity values from SCDM. Enter the highest toxicity/persistence, toxicity/persistence/bioaccumulation, and ecotoxicity/persistence/ecobioaccumulation values in the spaces provided.

- TP = Toxicity x Persistence
- TPB = TP x bioaccumulation
- ETPB = EP x bioaccumulation (EP = ecotoxicity* x persistence)

* EP is ecotoxicity/persistence

### Drinking Water Actual Contamination Targets Summary Table

For an observed release at or beyond a drinking water intake, on SI Table 8 enter each hazardous substance by sample ID and the detected concentration. For surface water sediment samples detecting a hazardous substance at or beyond an intake, evaluate the intake as Level II contamination. Obtain benchmark, cancer risk, and reference dose concentrations for each substance from SCDM. For MCL and MCLG benchmarks, determine the highest percentage of benchmark obtained for any substance. For cancer risk and reference dose, sum the percentages of the substances listed. If benchmark, cancer risk, or reference dose concentrations are not available for a particular substance, enter N/A for the percentage. If the highest benchmark percentage or the percentage sums calculated for cancer risk or reference dose equal or exceed 100%, evaluate the population served by the intake as Level I targets. If the percentages are less than 100% or all are N/A, evaluate the population served by the intake as Level II targets.

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## SI TABLE 7: SURFACE WATER OBSERVED RELEASE SUBSTANCES

| Sample ID | Hazardous Substance | Bckgrd. Conc. | Toxicity/ Persistence | Toxicity/ Persis./ Bioaccum | Ecotoxicity/ Persis/ Ecobioaccum | Reference |
|---|---|---|---|---|---|---|
| | Cyanide | < 5.0 | 40 | 20 | 200 | |
| | | | | | | |
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| | | | | | | |
| | | | | | | |
| | | Highest Values | | | | |

## SI TABLE 8: SURFACE WATER DRINKING WATER ACTUAL CONTAMINATION TARGETS

Intake ID: _____ Sample Type _____ Level I _____ Level II _____ Population Served _____ References _____

| Sample ID | Hazardous Substance | Conc. (µg/L) | Benchmark Conc. (MCL or MCLG) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Rfd | % of Rfd |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

Intake ID: _____ Sample Type _____ Level I _____ Level II _____ Population Served _____ References _____

| Sample ID | Hazardous Substance | Conc. (µg/L) | Benchmark Conc. (MCL or MCLG) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Rfd | % of Rfd |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

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# SURFACE WATER PATHWAY
## LIKELIHOOD OF RELEASE AND DRINKING WATER THREAT WORKSHEET

| LIKELIHOOD OF RELEASE-OVERLAND/FLOOD MIGRATION | Score | Data Type | Refs |
|---|---|---|---|
| 1. OBSERVED RELEASE: If sampling data or direct observation supports a release to surface water in the watershed, assign a score of 550. Record observed release substances on SI Table 7. | ~~550~~ | | |
| 2. POTENTIAL TO RELEASE: Distance to surface water: ____(feet) If sampling data do not support a release to surface water in the watershed, use the table below to assign a score from the table below based on distance to surface water and flood frequency. | 7 | | |
| Optionally, evaluate surface potential to release according to HRS Section 4.1.2.1.2 | 500 | | |
| LR = | ~~550~~ 500 | | |

| Distance to surface water <2500 feet | 500 |
|---|---|
| Distance to surface water >2500 feet, and: | |
| Site in annual or 10 yr floodplain | 500 |
| Site in 100-yr floodplain | 400 |
| Site in 500-yr floodplain | 300 |
| Site outside 500-yr floodplain | 100 |

| LIKELIHOOD OF RELEASE GROUND WATER TO SURFACE WATER MIGRATION | Score | Data Type | Refs |
|---|---|---|---|
| 1. OBSERVED RELEASE: If sampling data or direct observation supports a release to surface water in the watershed, assign a score of 550. Record observed release substances on SI Table 7 | | | |
| NOTE: Calculate ground water to surface water migration only for a surface water body that meets all of the following conditions: | | | |
| 1) A portion of the surface water is within 1 mile of site sources having a containment factor greater than 0. | | | |
| 2) No aquifer discontinuity is established between the source and the above portion of the surface water body. | | | |
| 3) The top of the uppermost aquifer is at or above the bottom of the surface water | | | |
| Elevation of top of uppermost aquifer _____ | | | |
| Elevation of bottom of surface water body _____ | ~~550~~ | | |
| 2. POTENTIAL TO RELEASE: Use the ground water potential to release. Optionally, evaluate surface water potential to release according to HRS Section 3.1.2. | ~~500~~ | | |
| LR = | ~~550~~ ~~500~~ | | |

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# SURFACE WATER PATHWAY
## LIKELIHOOD OF RELEASE AND DRINKING WATER THREAT WORKSHEET (CONTINUED)

| DRINKING WATER THREAT TARGETS | Score | Data Type | Refs |
|---|---|---|---|
| Record the water body type, flow, and number of people served by each drinking water intake within the target distance limit in the watershed. If there is no drinking water intake within the target distance limit, assign 0 to factors 3, 4, and 5.<br><br>Intake Name ____ Water Body Type ____ Flow ____ People Served ____<br>____ ____ ____ ____<br>____ ____ ____ ____<br>____ ____ ____ ____<br><br>Are any intakes part of a blended system? Yes ____ No ____<br>If yes, attach a page to show apportionment calculations.<br><br>3. ACTUAL CONTAMINATION TARGETS: If analytical evidence indicates a drinking water intake has been exposed to a hazardous substance from the site, list the intake name and evaluate the factor score for the drinking water population (SI Table 8).<br><br>____ , ____<br><br>Level I: ____ people x 10 = ____<br>Level II: ____ people x 1 = ____ Total = | 0 | | |
| 4. POTENTIAL CONTAMINATION TARGETS: Determine the number of people served by drinking water intakes for the watershed that have not been exposed to a hazardous substance from the site. Assign the population values from SI Table 9. Sum the values and multiply by 0.1. | 0.5 | | |
| 5. NEAREST INTAKE: Assign a score of 50 for any Level I Actual Contamination Drinking Water Targets for the watershed. Assign a score of 45 if there are Level II targets for the watershed, but no Level I targets. If no Actual Contamination Drinking Water Targets exist, assign a score for the intake nearest the PPE from SI Table 9. If no drinking water intakes exist, assign 0. | ~~0~~ 2 | | |
| 6. RESOURCES: Assign a score of 5 if one or more surface water resources applies; assign 0 if none applies.<br>• Irrigation (5 acre minimum) of commercial food crops or commercial forage crops<br>• Watering of commercial livestock<br>• Ingredient in commercial food preparation<br>• Major or designated water recreation area, excluding drinking water use | 5 | | |
| SUM OF TARGETS T= | ~~8~~ 7.5 | | |

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## SI Table 9 (From HRS Table 4-14): DILUTION-WEIGHTED POPULATION VALUES FOR POTENTIAL CONTAMINATION FOR SURFACE WATER MIGRATION PATHWAY

| Type of Surface Water Body | Pop. | Nearest Intake | Number of people | | | | | | | | | Pop. Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0 | 1 to 10 | 11 to 30 | 31 to 100 | 101 to 300 | 301 to 1,000 | 1,001 to 3,000 | 3,001 to 10,000 | 10,001 to 30,000 | |
| Minimal Stream (<10 cfs) | | 20 | 0 | 4 | 17 | 53 | 164 | 522 | 1,633 | 5,214 | 16,325 | |
| Small to moderate stream (10 to 100 cfs) | 35 | 2 | 0 | 0.4 | 2 | 5 | 16 | 52 | 163 | 521 | 1,633 | 5 |
| Moderate to large stream (> 100 to 1,000 cfs) | | 0 | 0 | 0.04 | 0.2 | 0.5 | 2 | 5 | 16 | 52 | 163 | |
| Large Stream to river (>1,000 to 10,000 cfs) | | 0 | 0 | 0.004 | 0.02 | 0.05 | 0.2 | 0.5 | 2 | 5 | 16 | |
| Large River (> 10,000 to 100,000 cfs) | | 0 | 0 | 0 | 0.002 | 0.005 | 0.02 | 0.05 | 0.2 | 0.5 | 16 | |
| Very Large River (>100,000 cfs) | | 0 | 0 | 0 | 0 | 0.001 | 0.002 | 0.005 | 0.02 | 0.05 | 0.2 | |
| Shallow ocean zone or Great Lake (depth < 20 feet) | | 0 | 0 | 0 | 0.002 | 0.005 | 0.02 | 0.05 | 0.2 | 0.5 | 2 | |
| Moderate ocean zone or Great Lake (Depth 20 to 200 feet) | | 0 | 0 | 0 | 0 | 0.001 | 0.002 | 0.005 | 0.02 | 0.05 | 0.2 | |
| Deep ocean zone or Great Lake (depth > 200 feet) | | 0 | 0 | 0 | 0 | 0 | 0.001 | 0.003 | 0.008 | 0.03 | 0.08 | |
| 3 mile mixing zone in quiet flowing river (≥ 10 cfs) | | 10 | 0 | 2 | 9 | 26 | 82 | 261 | 817 | 2,607 | 8,163 | |

Nearest Intake = 2

Total = 5

References _____

## SURFACE WATER PATHWAY

### Human Food Chain Actual Contamination Targets Summary Table

On SI Table 10, list the hazardous substances detected in sediment, aqueous, sessile benthic organism tissue, or fish tissue samples (taken from fish caught within the boundaries of the observed release) by sample ID and concentration. Evaluate fisheries within the boundaries of observed releases detected by sediment or aqueous samples as Level II, if at least one observed release substance has a bioaccumulation potential factor value of 500 or greater (see SI Table 7). Obtain benchmark, cancer risk, and reference dose concentrations from SCDM. For FFDAAL benchmarks, determine the highest percentage of benchmark obtained for any substances. For cancer risk and reference dose, sum the percentages for the substances is listed. If benchmark, cancer risk, or reference dose concentrations are not available for a particular substance, enter N/A for the percentage. If the highest benchmark percentage sums calculated for cancer risk or reference dose equal or exceed 100%, evaluate this portion of the fishery as subject to Level I concentrations. If the percentages are less than 100% or all are N/A, evaluate the fishery as a Level II target.

### Sensitive Environment Actual Contamination Targets Summary Table

On SI Table 11, list each hazardous substance detected in aqueous or sediment samples at or beyond wetlands or a surface water sensitive environment by sample ID. Record the concentration. If contaminated sediments or tissues are detected at or beyond a sensitive environment, evaluate the sensitive environment as Level II. Obtain benchmark concentrations from SCDM. For AWOC/AALAC benchmarks, determine the highest percentage of benchmark of the substances detected in aqueous samples. If benchmark concentrations are not available for a particular substance, enter N/A for the percentage. If the highest benchmark percentage equals or exceeds 100%, evaluate that part of the sensitive environment subject to Level I concentrations. If the percentages are less than 100%, or all are N/A, evaluate the sensitive environment as Level II.

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## SI TABLE 10: HUMAN FOOD CHAIN ACTUAL CONTAMINATION TARGETS FOR WATERSHED

Fishery ID: _____ Sample Type _____ Level I _____ Level II _____ References _____

| Sample ID | Hazardous Substance | Conc. (mg/kg) | Benchmark Concentration (FDAAL) | % of Benchmark | Cancer Risk Concentration. | % of Cancer Risk Concentration | Rfd | % of Rfd |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

## SI TABLE 11: SENSITIVE ENVIRONMENT ACTUAL CONTAMINATION TARGETS FOR WATERSHED

Environment ID: _____ Sample Type _____ Level I _____ Level II _____ Environment Value _____

| Sample ID | Hazardous Substance | Conc.. (µg/L) | Benchmark Concentration (AWQC or AALAC) | % of Benchmark |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | Highest Percent | |

References _____

Environment ID: _____ Sample Type _____ Level I _____ Level II _____ Environment Value _____

| Sample ID | Hazardous Substance | Conc.. (µg/L) | Benchmark Concentration (AWQC or AALAC) | % of Benchmark |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | Highest Percent | |

References _____

## SURFACE WATER PATHWAY (continued)
## HUMAN FOOD CHAIN THREAT WORKSHEET

| HUMAN FOOD CHAIN THREAT TARGETS | Score | Data Type | Refs |
|---|---|---|---|
| Record the water body type and flow for each fishery within the target distance limit. If there is no fishery within the target distance limit, assign a score of 0 at the bottom of this page. | | | |

| Fishery Name | Water Body Type | Flow |
|---|---|---|
| | | cfs |
| | | cfs |
| | | cfs |
| | | cfs |
| | | cfs |

FCI Value =

7. ACTUAL CONTAMINATION FISHERIES:

If analytical evidence indicates that a fishery has been exposed to a hazardous substance with a bioaccumulation factor greater than or equal to 500 (SI Table 10), assign a score of 50 if there is a Level I fishery. Assign 45 if there is a Level II fishery, but no Level I.

0

8. POTENTIAL CONTAMINATION FISHERIES: If there is a release of a substance with a bioaccumulation factor greater than or equal to 500 to a watershed containing fisheries within the target distance limit, but there are no Level I or Level II fisheries, assign a score of 20. If there is no observed release to the watershed, assign a value for potential contamination fisheries from the table below using the lowest flow at all fisheries within the target distance limit.

| Lowest Flow | FCI Value |
|---|---|
| <10 cfs | 20 |
| 10 to 100 cfs | 2 |
| >100 cfs, coastal tidal waters, oceans, or Great Lakes | 0 |

0

SUM OF TARGETS T = 0

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# SURFACE WATER PATHWAY (continued)
# ENVIRONMENTAL THREAT WORKSHEET

When measuring length of wetlands that are located on both sides of a surface water body, sum both frontage lengths. For a sensitive environment that is more than one type, assign a value for each type. Multiply Level I environment values by 10.

| ENVIRONMENTAL THREAT TARGETS | Score | Data Type | Refs |
|---|---|---|---|
| Record the water body type and flow for each surface water sensitive environment within the target distance (see SI Table 12). If there is no sensitive environment within the target distance limit, assign a score of 0 at the bottom of the page. | | | |

| Environment Name | Water Body Type | Flow |
|---|---|---|
| | | cfs |
| | | cfs |
| | | cfs |
| | | cfs |
| | | cfs |

9. ACTUAL CONTAMINATION SENSITIVE ENVIRONMENTS: If sampling data or direct observation indicates any sensitive environment has been exposed to a hazardous substance from the site, record this information on SI Table 11, and assign a factor value for the environment (SI Tables 13 and 14).

| Environment Name | Environment Type and Value (SI Tables 13 & 14) | Multiplier (10 for Level I, 1 for Level II) | Product |
|---|---|---|---|
| | | x = | |
| | | x = | |
| | | x = | |
| | | x = | |
| | | Sum = | 0 |

10. POTENTIAL CONTAMINATION SENSITIVE ENVIRONMENTS:

| Flow | Dilution Weight (SI Table 12) | Environment Type and Value (SI Tables 13 & 14) | Pot. Cont. | Product |
|---|---|---|---|---|
| 2091 cfs | 0.001 x | 150 x | 0.1 = | 0.15 |
| cfs | x | x | 0.1 = | |
| cfs | x | x | 0.1 = | |
| cfs | x | x | 0.1 = | |
| cfs | x | x | 0.1 = | |
| | | | Sum = | 0.15 |

T = 0.15

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## SI TABLE 12 (HRS Table 4-13): SURFACE WATER DILUTION WEIGHTS

| Type of Surface Water Body | | Assigned Dilution Weight |
|---|---|---|
| **Descriptor** | **Flow Characteristics** | |
| Minimal stream | < 10 cfs | 1 |
| Small to moderate stream | 10 to 100 cfs | 0.1 |
| Moderate to large stream | > 100 to 1,000 cfs | 0.01 |
| Large stream to river | > 1,000 to 10,000 cfs | 0.001 |
| Large river | > 10,000 to 100,000 cfs | 0.0001 |
| Very large river | > 100,000 cfs | 0.00001 |
| Coastal tidal waters | Flow not applicable; depth not applicable | 0.001 |
| Shallow ocean zone or Great Lake | Flow not applicable; depth less than 20 feet | 0.001 |
| Moderate depth ocean zone or Great Lake | Flow not applicable; depth 20 to 200 feet | 0.0001 |
| Deep ocean zone or Great Lake | Flow not applicable; Depth greater than 200 feet | 0.000005 |
| 3-mile mixing zone in quiet flowing river | 10 cfs or greater | 0.5 |

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## SI TABLE 13 (HRS TABLE 4-23): SURFACE WATER AND AIR SENSITIVE ENVIRONMENTS VALUES

| SENSITIVE ENVIRONMENT | ASSIGNED VALUE |
|---|---|
| Critical habitat for Federally designated endangered or threatened species<br>Marine Sanctuary<br>National Park<br>Designated Federal Wilderness Area<br>Ecologically important areas identified under the Coastal Zone Wilderness Act<br>Sensitive Areas identified under the National Estuary Program or Near Coastal Water Program of the Clean Water Act<br>Critical Areas identified under the Clean Lakes Program of the Clean Water Act (subareas in lakes or entire small lakes)<br>National Monument (air pathway only)<br>National Seashore Recreation Area<br>National Lakeshore Recreation Area | 100 |
| Habitat known to be used by Federally designated or proposed endangered or threatened species<br>National Preserve<br>National or State Wildlife Refuge<br>Unit of Coastal Barrier Resources System<br>Coastal Barrier (undeveloped)<br>Federal land designated for the protection of natural ecosystems<br>Administratively Proposed Federal Wilderness Area<br>Spawning areas critical for the maintenance for fish/shellfish species within a river system, bay, or estuary<br>Migratory pathways and feeding areas critical for the maintenance of anadromous fish species within river reaches or areas in lakes or coastal tidal waters in which the fish spend extended periods of time<br>Terrestrial areas utilized by large or dense aggregations of vertebrate animals (semi-aquatic foragers) for breeding<br>National river reach designated as recreational | 75 |
| Habitat known to be used by State designated endangered or threatened species<br>Habitat known to be used by a species under review as to its Federal endangered or threatened status<br>Coastal Barrier (partially developed)<br>Federally designated Scenic or Wild River | 50 |
| State land designated for wildlife or game management<br>State designated Scenic or Wild River<br>State designated Natural Area<br>Particular areas, relatively small in size, important to maintenance of unique biotic communities | 25 |
| State designated areas for the protection of maintenance of aquatic life under the Clean Water Act | 5 |
| Wetlands See SI Table 14 (Surface Water Pathway) or SI Table 23 (Air Pathway) | |

## SI TABLE 14 (HRS TABLE 4-24): SURFACE WATER WETLANDS FRONTAGE VALUES

| Total Length of Wetlands | Assigned Value |
|---|---|
| Less than 0.1 mile | 0 |
| 0.1 to 1 mile | 25 |
| Greater than 1 to 2 miles | 50 |
| Greater than 2 to 3 miles | 75 |
| Greater than 3 to 4 miles | 100 |
| Greater than 4 to 8 miles 4.2 miles | 150 |
| Greater than 8 to 12 miles | 250 |
| Greater than 12 to 16 | 350 |
| Greater than 16 to 20 | 450 |
| Greater than 20 miles | 500 |

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## SURFACE WATER PATHWAY (concluded)
### WASTE CHARACTERISTICS, THREAT, AND PATHWAY SCORE SUMMARY

| WASTE CHARACTERISTICS | | Score |
|---|---|---|
| 14. | If an Actual Contamination Target (drinking water human food chain or environmental threat exists for the watershed, assign the calculated hazardous waste quantity score, or a score of 100, whichever is greater. | 10,000 |
| 15. | Assign the highest value from SI Table 7 (observed release) or SI Table 3 (no observed release) for the hazardous substance waste characterization factors below. Multiply each by the surface water waste quantity score and determine the waste characteristics score for each threat. | WC Score (From Table) (Maximum of 100) |

| | Substance Value | | HWQ | | Product | WC Score (From Table) (Maximum of 100) |
|---|---|---|---|---|---|---|
| Drinking Water Threat Toxicity/Persistence | 10,000 | x | 10,000 | = | 1 E+8 | 100 |
| Food Chain Threat Toxicity/Persistence/ Bioaccumulation | 50,000 | x | 10,000 | = | 5 E+8 | 100 |
| Environmental Threat Ecotoxicity/Persistence/ Ecobioaccumulation | 5,000,000 | x | 10,000 | = | 5 E+10 | 1000 |

| Product | WC Score |
|---|---|
| 0 | 0 |
| >0 to <10 | 1 |
| 10 to <100 | 2 |
| 100 to <1,000 | 3 |
| 1,000 to < 10,000 | 6 |
| 10,000 to <1E + 05 | 10 |
| 1E + 05 to <1E + 06 | 18 |
| 1E + 06 to <1E + 07 | 32 |
| 1E + 07 to <1E + 08 | 56 |
| 1E + 08 to <1E + 09 | 100 |
| 1E + 09 or greater | 1000 |

### SURFACE WATER PATHWAY THREAT SCORES

| Threat | Likelihood of Release (LR) Score | Targets (T) Score | Pathway Waste Characteristics (WC) Score (determined above) | Threat Score LR x T x WC = ___ / 82,500 |
|---|---|---|---|---|
| Drinking Water | ~~550~~ 500 | 7.5 | 100 | (maximum of 100) ~~3.33~~ ~~3.03~~ 4.55 |
| Human Food Chain | ~~550~~ 500 | 0 | 100 | (maximum of 100) 0 |
| Environmental | ~~550~~ 500 | 0.15 | 1000 | (maximum of 60) ~~1.0~~ 0.91 |

| | |
|---|---|
| SURFACE WATER PATHWAY SCORE (Drinking Water Threat + Human Food Chain Threat + Environmental Threat) | (maximum of 100) ~~4.33~~ ~~3.94~~ 5.46 |



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## SOIL EXPOSURE PATHWAY

If there is no observed contamination (e.g., ground water plume with no known surface source), do not evaluate the soil exposure pathway. Discuss evidence for no soil exposure pathway.

### Soil Exposure Resident Population Targets Summary

If there is an area of observed contamination on the property and within 200 feet of a residence, school, or day care center, enter on Table 15 each hazardous substance by sample ID. Record the detected concentration. Obtain cancer risk, and reference dose concentrations from SDCM. Sum the cancer risk and reference dose percentages for the substances listed. If cancer risk or reference dose concentrations are not available for a particular substance, enter N/A for the percentage. If the percentage sums calculated for cancer risk or reference dose equal or exceed 100%, evaluate the residents and students as Level I. If both percentages are less than 100% or all are N/A, evaluate the targets as Level II.

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## SI TABLE 15: SOIL EXPOSURE RESIDENT POPULATION TARGETS

Residence ID: _____ Level I _____ Level II _____ Population _____

| Sample ID | Hazardous Substance | Conc. (mg/kg) | Cancer Risk Concentration | % of Cancer Risk Conc. | RfD | % of RfD | Toxicity Value | References |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

Residence ID: _____ Level I _____ Level II _____ Population _____

| Sample ID | Hazardous Substance | Conc. (mg/kg) | Cancer Risk Concentration | % of Cancer Risk Conc. | RfD | % of RfD | Toxicity Value | References |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

Residence ID: _____ Level I _____ Level II _____ Population _____

| Sample ID | Hazardous Substance | Conc. (mg/kg) | Cancer Risk Concentration | % of Cancer Risk Conc. | RfD | % of RfD | Toxicity Value | References |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | Highest Percent | | Sum of Percents | | Sum of Percents | |

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# SOIL EXPOSURE PATHWAY WORKSHEET
## RESIDENT POPULATION THREAT

| LIKELIHOOD OF EXPOSURE | Score | Data Type | Refs |
|---|---|---|---|
| 1. OBSERVED CONTAMINATION: If evidence indicates presence of observed contamination (depth of 2 feet or less), assign a score of 550; otherwise, assign a 0. Note that a likelihood of exposure score of 0 results in a soil exposure pathway score of 0 | 550 | | |
| LE = | 550 | (Worst Case) | |

| TARGETS | | | |
|---|---|---|---|
| 2. RESIDENT POPULATION: Determine the number of people occupying residences or attending school or day care on or within 200 feet of areas of observed contamination (SI Table 16 and HRS section 5.1.3).<br>Level I: _____ people x 10 = _____<br>Level II: _____ people x 1 = _____ Sum = | 0 | | |
| 3. RESIDENT INDIVIDUAL: Assign a score of 50 if any Level I resident population exists. Assign a score of 45 if there are Level II targets but no Level I targets. If no resident population exists, assion 0 (HRS Section 5.1.3). | 0 | | |
| 4. WORKERS: Assign a score from the table below for the total number of workers at the site and nearby facilities with areas of observed contamination associated with the site. | 5 | | |
| 5. TERRESTRIAL SENSITIVE ENVIRONMENTS: Assign a value for each terrestrial sensitive environment (SI Table 16) on an area of observed contamination. Sum = | 0 | | |
| 6. RESOURCES: Assign a score of 5 if any one or more of the following resources are present on an area of observed contamination at the site; assign 0 if none applies.<br>• Commercial agriculture<br>• Commercial silviculture<br>• Commercial livestock production or commercial livestock grazing | 0 | | |
| Total of Targets T= | 5 | | |

| Number of Workers | Score |
|---|---|
| 0 | 0 |
| 1 to 100 | 5 |
| 101 to 1,000 | 10 |
| >1,000 | 15 |

| Terrestrial Sensitive Environment Type | Value |
|---|---|
| | |
| | |
| | |
| | |
| | |

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## SI TABLE 16 (HRS TABLE 5-5): SOIL EXPOSURE PATHWAY TERRESTRIAL SENSITIVE ENVIRONMENT VALUES

| *TERRESTRIAL SENSITIVE ENVIRONMENT* | *ASSIGNED VALUE* |
|---|---|
| Terrestrial critical habitat for Federal designated endangered or threatened species<br>National Park<br>Designated Federal Wilderness Area<br>National Monument | 100 |
| Terrestrial habitat known to be used by Federal designated or proposed threatened or endangered species<br>National Preserve (terrestrial)<br>National or State terrestrial Wildlife Refuge<br>Federal land designated for protection of natural ecosystems<br>Administratively proposed Federal Wilderness Area<br>Terrestrial areas utilized by large or dense aggregations of animals (vertebrate species) for breeding | 75 |
| Terrestrial habitat used by State designated endangered or threatened species<br>Terrestrial habitat used by species under review for Federal designated endangered or threatened status | 50 |
| State lands designated for wildlife or game management<br>State designated Natural Areas<br>Particular areas, relatively small in size, important to maintenance of unique biotic communities | 25 |

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# SOIL EXPOSURE PATHWAY WORKSHEET
## NEARBY POPULATION THREAT

| LIKELIHOOD OF EXPOSURE | | Score | Data Type | Ref. |
|---|---|---|---|---|
| 7. Attractiveness/Accessibility (from SI Table 17 or HRS Table 5-6) | Value ~~50~~ 100 | | | |
| Area of Contamination (from SI Table 18 or HRS Table 5-7) | Value 100 | | | |
| Likelihood of Exposure (from SI Table 19 or HRS Table 5-8) | | ~~375~~ 500 | | |
| | LE = | ~~375~~ 500 | | |

| TARGETS | Score | Data Type | Ref. |
|---|---|---|---|
| 8. Determine the population within 1 mile travel distance that are not exposed to a hazardous substance from the site; record the population for each distance category in SI Table 20 (HRS Table 5-10). Sum the population values and multiply by 0.1. | 0.6 | | |
| T = | 0.6 | | |

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## SI TABLE 19 (HRS TABLE 5-8): NEARBY POPULATION LIKELIHOOD OF EXPOSURE FACTOR VALUES

| AREA OF CONTAMINATION FACTOR VALUE | ATTRACTIVENESS/ACCESSIBILITY FACTOR VALUE | | | | | | |
|---|---|---|---|---|---|---|---|
| | 100 | 75 | 50 | 25 | 10 | 5 | 0 |
| 100 | 500 | 500 | 375 | 250 | 125 | 50 | 0 |
| 80 | 500 | 375 | 250 | 125 | 50 | 25 | 0 |
| 60 | 375 | 250 | 125 | 50 | 25 | 5 | 0 |
| 40 | 250 | 125 | 50 | 25 | 5 | 5 | 0 |
| 20 | 125 | 50 | 25 | 5 | 5 | 5 | 0 |
| 5 | 50 | 25 | 5 | 5 | 5 | 5 | 0 |

## SI TABLE 20 (HRS TABLE 5-10): DISTANCE-WEIGHTED POPULATION VALUES FOR NEARBY POPULATION THREAT

| Travel Distance Category (miles) | Pop. | Number of people within the travel distance category | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | 1 to 10 | 11 to 30 | 31 to 100 | 101 to 300 | 301 to 1,000 | 1,001 to 3,000 | 3,001 to 10,001 | 10,001 to 30,000 | 30,001 to 100,000 | 100,001 to 300,000 | 300,001 to 1,000,000 |
| Greater than 0 to $\frac{1}{4}$ | 86.5 | 0 | 0.1 | 0.4 | 1.0 | 4 | 13 | 41 | 130 | 408 | 1,303 | 4,081 | 13,034 |
| Greater than $\frac{1}{4}$ to $\frac{1}{2}$ | 178.2 | 0 | 0.05 | 0.2 | 0.7 | 2 | 7 | 20 | 65 | 204 | 652 | 2,041 | 6,517 |
| Greater than $\frac{1}{2}$ to 1 | 568.5 | 0 | 0.02 | 0.1 | 0.3 | 1 | 3 | 10 | 33 | 102 | 326 | 1,020 | 3,258 |



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## SI TABLE 17 (HRS TABLE 5-6): ATTRACTIVENESS/ACCESSIBILITY VALUES

| Area of Observed Contamination | Assigned Value |
|---|---|
| Designated recreational Area | 100 |
| Regularly used for public recreation (for example, vacant lots in urban area) | 75 |
| Accessible and unique recreational area (for example, vacant lots in urban area) | 75 |
| Moderately accessible (may have some access improvements–for example, gravel road) with some public recreation use | 50 |
| Slightly accessible (for example, extremely rural area with no road improvement) with some public recreation use | 25 |
| Accessible with no public recreation use | 10 |
| Surrounded by maintained fence or combination of maintained fence and natural barriers | 5 |
| Physically inaccessible to public, with no evidence of public recreation use | 0 |

## SI TABLE 18 (HRS TABLE 5-7): AREA OF CONTAMINATION FACTOR VALUES

| Total area of the areas of observed contamination (square feet) | Assigned Value |
|---|---|
| ≥ to 5,000 | 5 |
| > 5,000 to 125,000 | 20 |
| > 125,000 to 250,000 | 40 |
| > 250,000 to 375,000 | 60 |
| > 375,000 to 500,000 | 80 |
| > 500,000 | 100 |

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## SOIL EXPOSURE PATHWAY WORKSHEET (concluded)

### WASTE CHARACTERISTICS

| | |
|---|---|
| 9. Assign the hazardous waste quantity score calculated for soil exposure | 10,000 |
| 10. Assign the highest toxicity value from SI Table 16 | 10,000 |
| 11. Multiply the toxicity and waste quantity scores. Assign the Waste Characteristics score from the table below: | WC = 100 |

| Product | WC Score |
|---|---|
| 0 | 0 |
| >0 to <10 | 1 |
| 10 to <100 | 2 |
| 100 to <1,000 | 3 |
| 1,000 to < 10,000 | 6 |
| 10,000 to <1E + 05 | 10 |
| 1E + 05 to <1E + 06 | 18 |
| 1E + 06 to <1E + 07 | 32 |
| 1E + 07 to <1E + 08 | 56 |
| 1E + 08 or greater | 100 |

RESIDENT POPULATION THREAT SCORE:

$$LE \times T \times WC = \frac{\quad}{82,500}$$

3.33
(Maximum of 100)

NEARBY POPULATION THREAT SCORE:

$$LE \times T \times WC = \frac{\quad}{82,500}$$

~~2.7~~ 0.36
(Maximum of 100)

SOIL EXPOSURE PATHWAY SCORE:
Resident Population Threat + Nearby Population Threat

~~6.03~~ 3.69
(Maximum of 100)

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## AIR PATHWAY

### Air Pathway Observed Substances Summary Table

On SI Table 21, list the hazardous substances detected in air samples of a release from the site. Include only those substances with concentrations significantly greater than background levels. Obtain benchmark, cancer risk, and reference dose concentrations from SCDM. For NAAQS/NESHAPS benchmarks, determine the highest percentage of benchmark obtained for any substance. For cancer risk and reference dose, sum the percentages for the substances listed. If benchmark, cancer risk, or reference dose concentrations are not available for a particular substance, enter N/A for the percentage. If the highest benchmark percentage or the percentage sums calculated for cancer risk or reference dose equal or exceed 100%, evaluate targets in the distance category from which the sample was taken and any closer distance categories as Level I. If the percentages are less than 100% or all are N/A, evaluate targets in that distance category and any closer distance categories that are not Level I as Level II.

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## SI TABLE 21: AIR PATHWAY OBSERVED RELEASE SUBSTANCES

Sample ID: _____ Level I _____ Level II _____ Distance from Sources (mi) ____ References _____

| Hazardous Substance | Conc. (µg/m³) | Gaseous Particulate | Benchmark Conc. (NAAQS or NESHAPS) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Rfd | % of Rfd |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | Highest Toxicity/ Mobility | | Highest Percent | | Sum of Percents | | Sum of Percents | |

Sample ID: _____ Level I _____ Level II _____ Distance from Sources (mi) ____ References _____

| Hazardous Substance | Conc. (µg/m³) | Toxicity/ Mobility | Benchmark Conc. (NAAQS or NESHAPS) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Rfd | % of Rfd |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | Highest Toxicity/ Mobility | | Highest Percent | | Sum of Percents | | Sum of Percents | |

Sample ID: _____ Level I _____ Level II _____ Distance from Sources (mi) ____ References _____

| Hazardous Substance | Conc. (µg/m³) | Toxicity/ Mobility | Benchmark Conc. (NAAQS or NESHAPS) | % of Benchmark | Cancer Risk Conc. | % of Cancer Risk Conc. | Rfd | % of Rfd |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | Highest Toxicity/ Mobility | | Highest Percent | | Sum of Percents | | Sum of Percents | |

# AIR PATHWAY WORKSHEET

| LIKELIHOOD OF RELEASE | Score | Data Type | Refs |
|---|---|---|---|
| 1. OBSERVED RELEASE: If sampling data or direct observation supports a release to air, assign a score of 550. Record observed release substances on SI Table 21 | 0 | | |
| 2. POTENTIAL TO RELEASE: If sampling data do not support a release to air, assign a score of 500. Optionally, evaluate air migration gaseous and particulate potential to release (HRS Section 6.1.2) | 500 | | |
| LR = | 500 | | |

| TARGETS | | | |
|---|---|---|---|
| 3. ACTUAL CONTAMINATION POPULATION: Determine the number of people within the target distance limit subject to exposure from a release of a hazardous substance to the air.<br>a) Level I: _____ people x 10 = _____<br>b) Level II: _____ people x 1 = _____ Total = | 0 | | |
| 4. POTENTIAL TARGET POPULATION: Determine the number of people within the target distance limit not subject to exposure from a release of a hazardous substance to the air, and assign the total population score from SI Table 22. | 5.7 (10) | | |
| 5. NEAREST INDIVIDUAL: Assign a score of 50 if there are any Level I targets. Assign a score of 45 if there are Level II targets but no Level I targets. If no Actual Contamination Population exists, assign the Nearest Individual score from SI Table 22. | 20 | | |
| 6. ACTUAL CONTAMINATION SENSITIVE ENVIRONMENTS: Sum the sensitive environment values (SI Table 13) and wetland acreage values (SI Table 23) for environments subject to exposure from the release of a hazardous substance to the air. | 0 | | |
| 7. POTENTIAL CONTAMINATION SENSITIVE ENVIRONMENTS: Use SI Table 24 to evaluate sensitive environments not subject to exposure from a release. | 3.386 | | |
| 8. RESOURCES: Assign a score of 5 if one or more air resources applies within 1/2 mile of a source; assign a 0 if none applies<br>• Commercial agriculture<br>• Commercial silviculture<br>• Major or designated recreation area | ~~0~~ 5 | | |
| T = | ~~80.386~~ ~~29.1~~ 34.1 | | |

| Sensitive Environment Type | Value |
|---|---|
| | |
| | |
| | |
| | |

| Wetland Acreage | Value |
|---|---|
| | |
| | |
| | |
| | |

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## SI TABLE 22 (From HRS TABLE 6-17): VALUES FOR POTENTIAL CONTAMINATION AIR TARGET POPULATIONS

| Distance from Site | Pop. | Nearest Individual (choose highest) | Number of People within the Distance Category | | | | | | | | | | | | Pop. Value |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 to 10 | 11 to 30 | 31 to 100 | 101 to 300 | 301 to 1000 | 1001 to 3000 | 3001 to 10,000 | 10,001 to 30,000 | 30,001 to 100,000 | 100,001 to 300,000 | 300,001 to 1,000,000 | 1,000,000 to 3,000,000 | |
| On a source | | 20 | 4 | 17 | 53 | 164 | 522 | 1,633 | 5,214 | 16,325 | 52,137 | 163,246 | 521,360 | 1,632,455 | |
| 0 to $\frac{1}{4}$ mile | 86.5 | * | 1 | 4 | 13 | 41 | 131 | 408 | 1,304 | 4,081 | 13,034 | 40,812 | 130,340 | 408,114 | 13 |
| > $\frac{1}{4}$ to $\frac{1}{2}$ mile | 178.2 | 2 | 0.2 | 0.9 | 3 | 9 | 28 | 88 | 282 | 882 | 2,815 | 8,815 | 28,153 | 88,153 | 9 |
| > $\frac{1}{2}$ to 1 mile | 568.5 | 1 | 0.06 | 0.3 | 0.9 | 3 | 8 | 26 | 83 | 261 | 834 | 2,612 | 8,342 | 26,119 | 8 |
| > 1 to 2 miles | 989 + 292 1281 | 0 | 0.02 | 0.09 | 0.3 | 0.8 | 3 | 8 | 27 | 83 | 266 | 833 | 2,659 | 8,326 | 8 |
| > 2 to 3 miles | 1383 3616 | 0 | 0.009 | 0.04 | 0.1 | 0.4 | 1 | 4 | 12 | 38 | 120 | 375 | 1,199 | 3,755 | 12 |
| > 3 to 4 miles | 1312 4747 | 0 | 0.005 | 0.02 | 0.07 | 0.2 | 0.7 | 2 | 7 | 28 | 73 | 229 | 730 | 2,285 | 7 |
| | Nearest Individual = | 20 | | | | | | | | | | | | Total = | 57 |

**References** topos

* Score a 20 if the Nearest Individual is within $\frac{1}{8}$ mile of a site; score a 7 if the Nearest Individual is between $\frac{1}{8}$ and $\frac{1}{4}$ mile of a site.

## SI TABLE 23 (HRS TABLE 6-18): AIR PATHWAY VALUES FOR WETLAND AREA

| Wetland Area | Assigned Value |
|---|---|
| < 1 acre | 0 |
| 1 to 50 acres | 25 |
| > 50 to 100 acres | 75 |
| > 100 to 150 acres | 125 |
| > 150 to 200 acres | 175 |
| > 200 to 300 acres | 250 |
| > 300 to 400 acres | 350 |
| > 400 to 500 acres | 450 |
| > 500 acres | 500 |

## SI TABLE 24: DISTANCE WEIGHTS AND CALCULATIONS FOR AIR PATHWAY POTENTIAL CONTAMINATION SENSITIVE ENVIRONMENTS

| Distance | Distance Weight | Sensitive Environment Type and Value (from SI Tables 14 and 20) | Product |
|---|---|---|---|
| On a Source | 0.10 | x 25 Wetlands | 2.5 |
| | | x | |
| 0-1/4 miles | 0.025 | x 25 Wetlands | 0.625 |
| | | x | |
| | | x | |
| 1/4-1/2 miles | 0.0054 | x 25 Wetlands | 0.135 |
| | | x | |
| | | x | |
| 1/2-1 miles | 0.0016 | x 25 Wetlands | 0.04 |
| | | x | |
| | | x | |
| 1-2 miles | 0.0005 | x 75 Wetlands | 0.0375 |
| | | x | |
| | | x | |
| 2-3 miles | 0.00023 | x 125 Wetlands | 0.02875 |
| | | x | |
| | | x | |
| 3 to 4 miles | 0.00014 | x 125 Wetlands | 0.0175 |
| | | x | |
| | | x | |
| > 4 miles | 0 | x | |

**Total Environments Score =** 3.386

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## AIR PATHWAY (concluded)

### WASTE CHARACTERISTICS

| | |
|---|---|
| 9. If any Actual Contamination Targets exist for the air pathway, assign the calculated hazardous waste quantity score or a score of 100, whichever is greater; if there are no Actual Contamination Targets for the air pathway, assign the calculated HWQ score for sources available to air migration. | 10,000 |
| 10. Assign the highest air toxicity/mobility value from SI Table 21. | ~~0~~ . 9 0.8 |
| 11. Multiply the air pathway toxicity/mobility and waste quantity scores. Assign the Waste Characteristics score from the table below: | WC = ~~0~~ 6 |

| Product | WC Score |
|---|---|
| 0 | 0 |
| >0 to <10 | 1 |
| 10 to <100 | 2 |
| 100 to <1,000 | 3 |
| 1,000 to < 10,000 | 6 |
| 10,000 to <1E + 05 | 10 |
| 1E + 05 to <1E + 06 | 18 |
| 1E + 06 to <1E + 07 | 32 |
| 1E + 07 to <1E + 08 | 56 |
| 1E + 08 or greater | 100 |

AIR PATHWAY SCORE: $\frac{LE \times T \times WC}{82,500}$ 1.24 (maximum of 100)

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| SITE SCORE CALCULATION | S | $S^2$ |
|---|---|---|
| GROUND WATER PATHWAY SCORE ($S_{GW}$) | ~~26~~ 76.3 | ~~676~~ 5822 |
| SURFACE WATER PATHWAY SCORE ($S_{SW}$) | 5.46 ~~4.33~~ ~~3.94~~ | ~~18.75~~ ~~15.5~~ 29.8 |
| SOIL EXPOSURE ($S_S$) | ~~6.03~~ 3.69 | ~~36~~ 13.6 |
| AIR PATHWAY SCORE ($S_A$) | ~~0~~ 1.24 | ~~0~~ 1.54 |
| SITE SCORE $\sqrt{\frac{S_{GW}^2+S_{SW}^2+S_S^2+S_A^2}{4}} = S$ | | ~~27.12~~ ~~13.52~~ 38.3 |
| $4S^2 - S_{SW}^2 - S_S^2 - S_A^2 = S_{GW}^2$ ; $S_{GW} \cong 56.5$ | | |

RECOMMENDATION

Further Action is Recommended.

~~No Further Action at this Time.~~

COMMENTS

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**CONFIDENTIAL**

**HAZARD RANKING SYSTEM PRELIMINARY SCORE**
**FOR**

**MONSANTO COMPANY INC.**
**COLUMBIA, MAURY COUNTY, TENNESSEE**
**EPA ID NO. TND004048104**

This preliminary score was calculated using the June 18, 1992 draft SI worksheets. Pathways evaluated include groundwater, surface water, soil exposure, and air. The following score reflects a hazardous waste quantity score of 10,000 based upon the volume and surface area of fourteen areas on Monsanto property. The hazardous waste quantity score was determined primarily by site 9, which is a tailings pond. The main contaminants found onsite were elemental phosphorus, phosphate, lead, chromium, fluoride, and arsenic.

F.O.I.A.
EXEMPTION 5

The groundwater pathway is of concern because there is significant groundwater contamination. The site was scored based on an observed release of lead. Samples taken during the site investigation conducted in 1985 show lead contamination far in excess of the MCL. More recent samples show lead contamination below the MCL, but the more recent sampling was not as extensive. There are 2000 people using private wells in the four-mile radius.

Approving Official Date

The surface water pathway is of concern because of the Monsanto drinking water intake on Greenlick Creek. Although the intake is upgradient of the probable points of entry for most of the areas on the site, the water has not been analyzed, and it may be contaminated. There are no other drinking water intakes or endangered species along the fifteen-mile surface water pathway, but there are fishing and wetlands. The tailings ponds near the Girl Scout camp were not sampled, and it is not known whether they are contaminated. However, the Girl Scouts do not use these ponds, so any possible contamination will probably have little effect on the score. Two worst case surface water pathway scores are attained by assuming Level I contamination and Level II contamination of the Monsanto intake.

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The air pathway is not of serious concern because the contaminants that have been detected on site are metals, and they have very low air mobilities.

The soil exposure pathway is of concern because there are 35 workers on-site, and there are soil contaminants. The central area is fenced, so there is little risk of non-workers being exposed there, but the vast majority of the property is accessible to the public. The unfenced area draws moderate numbers of people because it is a bird sanctuary, so this will provide a possible pathway for contamination. The Girl Scout camp is again of interest because the Girl Scouts will have significant contact with potentially contaminated soils. Only composite soil boring samples were analyzed at Monsanto, but a worst case for this pathway was scored as if surface soil samples were taken and contamination was found.

Based on these preliminary scores, further action is recommended for Monsanto Company.

**Score based on current information:**

$$S_{gw} = 76.30$$
$$S_{sw} = 3.94$$
$$S_{s} = 0.00$$
$$S_{a} = 1.24$$

**Overall Score** = 38.2

**Worst case score I:**

$$S_{gw} = 76.30$$
$$S_{sw} = 100.00$$
$$S_{s} = 3.69$$
$$S_{a} = 1.24$$

**Overall Score** = 62.9

**Worst case score II:**

$$S_{gw} = 76.30$$
$$S_{sw} = 56.70$$
$$S_{s} = 3.69$$
$$S_{a} = 1.24$$

**Overall Score** = 47.6

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | CYANIDE 100 10,000 | 32 |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | - | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | 10 | |
| 2b. Runoff | 25 | 25 | |
| 2c. Distance to Surface Water | 25 | 25 | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | 500 | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 500 |
| Waste Characteristics | | | |
| 6. Toxicity/Persistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 2 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 0 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0.5 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 7.5 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 4.55 |

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 0 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 0 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 0 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 500 |

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 0.91 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 5.46 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 5.46 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (continued)** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Score Based on Current Information

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | - | |
| 2. Potential to Release | | | |
| 2a. Gas Potential to Release | 500 | - | |
| 2b. Particulate Potential to Release | 500 | 500 | |
| 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 0.8 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 6 |
| **Targets** | | | |
| 7. Nearest Individual | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 5.7 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. Resources | 5 | 5 | |
| 10. Sensitive Environments | | | |
| 10a. Actual Contamination | c | 0 | |
| 10b. Potential Contamination | c | 3.386 | |
| 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| **Air Migration Pathway Score** | | | |
| 12. Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | 550 | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | - | |
| 2b. Runoff | 25 | - | |
| 2c. Distance to Surface Water | 25 | - | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | - | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 550 |
| Waste Characteristics | | | |
| 6. Toxicity/Presistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 0 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 0 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 5 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 3.33 |

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 550 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 20 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 20 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 13.33 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 550 |

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 1.00 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 17.66 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 17.66 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

## SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (continued)** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

a Maximum value applies to waste characteristics category.
b Maximum value not applicable.
c No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
d Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| | Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|---|
| 1. | Observed Release | 550 | - | |
| 2. | Potential to Release | | | |
| | 2a. Gas Potential to Release | 500 | - | |
| | 2b. Particulate Potential to Release | 500 | 500 | |
| | 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. | Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| | Waste Characteristics | | | |
| 4. | Toxicity/Mobility | a | 0.8 | |
| 5. | Hazardous Waste Quantity | a | 10,000 | |
| 6. | Waste Characteristics | 100 | | 6 |
| | Targets | | | |
| 7. | Nearest Individual | 50 | 20 | |
| 8. | Population | | | |
| | 8a. Level I Concentrations | b | 0 | |
| | 8b. Level II Concentrations | b | 0 | |
| | 8c. Potential Contamination | b | 5.7 | |
| | 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. | Resources | 5 | 5 | |
| 10. | Sensitive Environments | | | |
| | 10a. Actual Contamination | c | 0 | |
| | 10b. Potential Contamination | c | 3.386 | |
| | 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. | Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| | Air Migration Pathway Score | | | |
| 12. | Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | 550 | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | - | |
| 2b. Runoff | 25 | - | |
| 2c. Distance to Surface Water | 25 | - | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | - | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 550 |
| Waste Characteristics | | | |
| 6. Toxicity/Presistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 50 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 350 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 405 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 550 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 20 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 20 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 13.33 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 550 |

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 1.00 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 100 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 100 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

## SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (contin** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score I

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | - | |
| 2. Potential to Release | | | |
| 2a. Gas Potential to Release | 500 | - | |
| 2b. Particulate Potential to Release | 500 | 500 | |
| 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 0.8 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 6 |
| **Targets** | | | |
| 7. Nearest Individual | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 5.7 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. Resources | 5 | 5 | |
| 10. Sensitive Environments | | | |
| 10a. Actual Contamination | c | 0 | |
| 10b. Potential Contamination | c | 3.386 | |
| 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| **Air Migration Pathway Score** | | | |
| 12. Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# GROUND WATER MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| Likelihood of Release to an Aquifer | Maximum Value | Value Assigned | |
|---|---|---|---|
| 1. Observed Release | 550 | 550 | |
| 2. Potential to Release | | | |
| 2a. Containment | 10 | - | |
| 2b. Net Precipitation | 10 | - | |
| 2c. Depth to Aquifer | 5 | - | |
| 2d. Travel Time | 35 | - | |
| 2e. Potential to Release [lines 2a x (2b + 2c + 2d)] | 500 | - | |
| Likelihood of Release (higher of lines 1 and 2e) | 550 | | 550 |
| **Waste Characteristics** | | | |
| 4. Toxicity/Mobility | a | 10,000 | |
| 5. Hazardous Waste Quantity | a | 10,000 | |
| 6. Waste Characteristics | 100 | | 100 |
| **Targets** | | | |
| 7. Nearest Well | 50 | 20 | |
| 8. Population | | | |
| 8a. Level I Concentrations | b | 0 | |
| 8b. Level II Concentrations | b | 0 | |
| 8c. Potential Contamination | b | 89.5 | |
| 8d. Population (lines 8a + 8b + 8c) | b | 89.5 | |
| 9. Resources | 5 | 5 | |
| 10. Wellhead Protection Area | 20 | 0 | |
| 11. Targets (lines 7 + 8d + 9 + 10) | b | | 114.5 |
| **Ground Water Migration Score for an Aquifer** | | | |
| 12. Aquifer Score [(lines 3 x 6 x 11)/82,500][c] | 100 | | 76.3 |
| **Ground Water Migration Pathway Score** | | | |
| 13. Pathway Score ($S_{gw}$), (highest value from line 12 for all aquifers evaluated)[c] | 100 | | 76.3 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **DRINKING WATER THREAT** | | | |
| Likelihood of Release | | | |
| 1. Observed Release | 550 | 550 | |
| 2. Potential Release by Overland Flow | | | |
| 2a. Containment | 10 | - | |
| 2b. Runoff | 25 | - | |
| 2c. Distance to Surface Water | 25 | - | |
| 2d. Potential to Release by Overland Flow [lines 2a x (2b + 2c)] | 500 | - | |
| 3. Potential to Release by Flood | | | |
| 3a. Containment (Flood) | 10 | - | |
| 3b. Flood Frequency | 50 | - | |
| 3c. Potential to Release by Flood (lines 3a x 3b) | 500 | - | |
| 4. Potential to Release (lines 2d + 3c, subject to a maximum of 500) | 500 | - | |
| 5. Likelihood of Release (higher of lines 1 and 4) | 550 | | 550 |
| Waste Characteristics | | | |
| 6. Toxicity/Persistence | a | 10,000 | |
| 7. Hazardous Waste Quantity | a | 10,000 | |
| 8. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 9. Nearest Intake | 50 | 45 | |
| 10. Population | | | |
| 10a. Level I Concentrations | b | 35 | |
| 10b. Level II Concentrations | b | 0 | |
| 10c. Potential Contamination | b | 0 | |
| 10d. Population (lines 10a + 10b + 10c) | b | 0 | |
| 11. Resources | 5 | 5 | |
| 12. Targets (lines 9 + 10d + 11) | b | | 85 |
| Drinking Water Threat Score | | | |
| 13. Drinking Water Threat Score [(lines 5 x 8 x 12)/82,500, subject to a maximum of 100) | 100 | | 56.7 |

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **HUMAN FOOD CHAIN THREAT** | | | |
| Likelihood of Release | | | |
| 14. Likelihood of Release (same value as line 5) | 550 | | 550 |
| Waste Characteristics | | | |
| 15. Toxicity/Persistence/Bioaccumulation | a | 50,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 1000 | | 100 |
| Targets | | | |
| 18. Food Chain Individual | 50 | 20 | |
| 19. Population | | | |
| 19a. Level I Concentrations | b | 0 | |
| 19b. Level II Concentrations | b | 0 | |
| 19c. Potential Human Food Chain Contamination | b | 0 | |
| 19d. Population (lines 19a + 19b + 19c) | b | 0 | |
| 20. Targets (lines 18 + 19d) | | | 20 |
| Human Food Chain Threat Score | | | |
| 21. Human Food Chain Threat Score [(lines 14 x 17 x 20)/82,5000, subject to a maximum of 100) | 100 | | 13.33 |
| **ENVIRONMENTAL THREAT** | | | |
| Likelihood of Release | | | |
| 22. Likelihood of Release (same value as line 5) | 550 | | 550 |

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

## SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORESHEET
(continued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **ENVIRONMENTAL THREAT, (concluded)** | | | |
| Waste Characteristics | | | |
| 23. Ecosystem Toxicity/Persistence/Bioaccumulation | a | $5 * 10^6$ | |
| 24. Hazardous Waste Quantity | a | 10,000 | |
| 25. Waste Characteristics | 1000 | | 1,000 |
| 26. Sensitive Environments | | | |
| 26a. Level I Concentrations | b | 0 | |
| 26b. Level II Concentrations | b | 0 | |
| 26c. Potential Contamination | b | 0.15 | |
| 26d. Sensitive Environments (lines 26a + 26b + 26c) | b | 0.15 | |
| Targets | | | |
| 27. Targets (value from line 26d) | | | 0.15 |
| Environmental Threat Score | | | |
| 28. Environmental Threat Score [(lines 22 x 25 x 27)/82,500, subject to a maximum of 60] | 60 | | 1.00 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE FOR A WATERSHED** | | | |
| 29. Watershed Score[c] (lines 13 + 21 + 28, subject to a miximum of 100) | 100 | | 57.7 |
| **SURFACE WATER OVERLAND/FLOOD MIGRATION COMPONENT SCORE** | | | |
| 30. Component Score ($S_{oF}$)[c] (highest score from line line 29 for all watersheds evaluated, subject to a maximum of 100) | 100 | | 57.7 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# SOIL EXPOSURE PATHWAY SCORESHEET

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **RESIDENT POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 1. Likelihood of Exposure | 550 | | 550 |
| Waste Characteristics | | | |
| 2. Toxicity | a | 10,000 | |
| 3. Hazardous Waste Quantity | a | 10,000 | |
| 4. Waste Characteristics | 100 | | 100 |
| Targets | | | |
| 5. Resident Individual | 50 | 0 | |
| 6. Resident Population | | | |
| 6a. Level I Concentrations | b | 0 | |
| 6b. Level II Concentrations | b | 0 | |
| 6c. Resident Population (lines 6a + 6b) | b | 0 | |
| 7. Workers | 15 | 5 | |
| 8. Resources | 5 | 0 | |
| 9. Terrestrial Sensitive Environments | c | 0 | |
| 10. Targets (lines 5 + 6c + 7 + 8 + 9) | b | | 5 |
| Resident Population Threat Score | | | |
| 11. Resident Population Threat (lines 1 x 4 x 10)/82,500 | b | | 3.33 |
| **NEARBY POPULATION THREAT** | | | |
| Likelihood of Exposure | | | |
| 12. Attractiveness/Accessibility | 100 | 100 | |
| 13. Area of Contamination | 100 | 100 | |
| 14. Likelihood of Exposure | 500 | | 500 |
| Waste Characteristics | | | |
| 15. Toxicity | a | 10,000 | |
| 16. Hazardous Waste Quantity | a | 10,000 | |
| 17. Waste Characteristics | 100 | | 100 |

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

## SOIL EXPOSURE PATHWAY SCORESHEET
(contiued)

| Factor Categories and Factors | Maximum Value | Value Assigned | |
|---|---|---|---|
| **NEARBY POPULATION THREAT, (contin** | | | |
| Targets | | | |
| 18. Nearby Individual | 1 | N/A | |
| 19. Population Within 1 Mile | b | 0.6 | |
| 20. Targets (lines 18 +19) | b | | 0.6 |
| Nearby Population Threat Score | | | |
| 21. Nearby Population Threat (lines 14x17x20)/82500 | b | | 0.36 |
| **SOIL EXPOSURE PATHWAY SCORE** | | | |
| 22. Soil Exposure Pathway Score[d] ($S_s$), (lines [11 + 21] subject to a maximum of 100) | 100 | | 3.69 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

Site Name: Monsanto Company - Worst Case Score II

Location: Columbia, Maury County, Tennessee

# AIR MIGRATION PATHWAY SCORESHEET

## FACTOR CATEGORIES AND FACTORS

| | Likelihood of Release | Maximum Value | Value Assigned | |
|---|---|---|---|---|
| 1. | Observed Release | 550 | - | |
| 2. | Potential to Release | | | |
| | 2a. Gas Potential to Release | 500 | - | |
| | 2b. Particulate Potential to Release | 500 | 500 | |
| | 2c. Potential to Release (higher of lines 2a and 2b) | 500 | 500 | |
| 3. | Likelihood of Release (higher of lines 1 and 2c) | a | | 500 |
| | **Waste Characteristics** | | | |
| 4. | Toxicity/Mobility | a | 0.8 | |
| 5. | Hazardous Waste Quantity | a | 10,000 | |
| 6. | Waste Characteristics | 100 | | 6 |
| | **Targets** | | | |
| 7. | Nearest Individual | 50 | 20 | |
| 8. | Population | | | |
| | 8a. Level I Concentrations | b | 0 | |
| | 8b. Level II Concentrations | b | 0 | |
| | 8c. Potential Contamination | b | 5.7 | |
| | 8d. Population (lines 8a + 8b + 8c) | b | 5.7 | |
| 9. | Resources | 5 | 5 | |
| 10. | Sensitive Environments | | | |
| | 10a. Actual Contamination | c | 0 | |
| | 10b. Potential Contamination | c | 3.386 | |
| | 10c. Sensitive Environments (lines 10a + 10b) | c | 3.386 | |
| 11. | Targets (lines 7 + 8d + 9 + 10c) | b | | 34.086 |
| | **Air Migration Pathway Score** | | | |
| 12. | Pathway Score ($S_a$) [(lines 3 x 6 x 11)/82,500][d] | 100 | | 1.24 |

[a] Maximum value applies to waste characteristics category.
[b] Maximum value not applicable.
[c] No specific maximum value applies to factor. However pathway score based solely on sensitive environments is limited to maximum of 60.
[d] Do not round to nearest integer.

U.S. EPA REGION IV

# SDMS

## Unscannable Material Target Sheet

DocID: 10707465 Site ID: TND004048104

Site Name: Monsanto Co. Inc.

Nature of Material:

| | | | |
|---|---|---|---|
| Map: | ☑ | Computer Disks: | ☐ |
| Photos: | ☐ | CD-ROM: | ☐ |
| Blueprints: | ☐ | Oversized Report: | ☐ |
| Slides: | ☐ | Log Book: | ☐ |

Other (describe): Business map (Ref. 1)

Amount of material: _____

* Please contact the appropriate Records Center to view the material *

LATITUDE AND LONGITUDE CALCULATION WORKSHEET #2
LI USING ENGINEER'S SCALE (1/60)

SITE NAME: Monsanto Company, Inc. CERCLIS #: _____

AKA: _____ SSID: _____

ADDRESS: Monsanto Rd.

CITY: Columbia STATE: Tn. ZIP CODE: _____

SITE REFERENCE POINT: BM MS 502 627

USGS QUAD MAP NAME: _____ TOWNSHIP: ____ N/S RANGE: ____ E/W

SCALE: 1:24,000 MAP DATE: _____ SECTION: ____1/4 ____1/4 ____1/4

MAP DATUM: (1927) 1983 (CIRCLE ONE) MERIDIAN: _____

COORDINATES FROM LOWER RIGHT (SOUTHEAST) CORNER OF 7.5' MAP (attach photocopy):

LONGITUDE: 87 ° 00 ' 00 " LATITUDE: 35 ° 37 ' 30"

COORDINATES FROM LOWER RIGHT (SOUTHEAST) CORNER OF 2.5' GRID CELL:

LONGITUDE: 87 ° 05 ' 00 " LATITUDE: 35 ° 37 ' 30"

CALCULATIONS: LATITUDE (7.5' QUADRANGLE MAP)

A) NUMBER OF RULER GRADUATIONS FROM LATITUDE GRID LINE TO SITE REF POINT: 426

B) MULTIPLY (A) BY 0.3304 TO CONVERT TO SECONDS:

A x 0.3304 = 140 . 75"

C) EXPRESS IN MINUTES AND SECONDS (1'= 60"): 2 ' 20 . 75"

D) ADD TO STARTING LATITUDE: 35° 37' 30 . 0 " + 2 ' 20 . 75 =

SITE LATITUDE: 35 ° 39 ' 50 . 75 "

CALCULATIONS: LONGITUDE (7.5' QUADRANGLE MAP)

A) NUMBER OF RULER GRADUATIONS FROM RIGHT LONGITUDE LINE TO SITE REF POINT: 395.5

B) MULTIPLY (A) BY 0.3304 TO CONVERT TO SECONDS:

A x 0.3304 = 130 . 67 "

C) EXPRESS IN MINUTES AND SECONDS (1'= 60"): 2 ' 10 . 67"

D) ADD TO STARTING LONGITUDE: 87 ° 05 ' 00 . 00 " + 2 ' 10 . 67 =

SITE LONGITUDE: 87 ° 07 ' 10 . 67 "

INVESTIGATOR: Ken Lemons DATE: 11-5-92

Series 1952, No. 7

Issued October 1959

# SOIL SURVEY

REFERENCE 3

# Maury County Tennessee

OUR SOIL ★ OUR STRENGTH

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
TENNESSEE AGRICULTURAL EXPERIMENT STATION
TENNESSEE VALLEY AUTHORITY

# SOIL SURVEY OF MAURY COUNTY, TENNESSEE[1]

By A. B. HARMON, JR., EDWIN LUSK, JOE OVERTON, JOHN H. ELDER, JR., and LEWIS D. WILLIAMS, Tennessee Agricultural Experiment Station

Correlation by MAX J. EDWARDS, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with Tennessee Agricultural Experiment Station and Tennessee Valley Authority

MAURY COUNTY is in the central part of Tennessee. It is somewhat rectangular in shape. The average length, east to west, is about 26 miles, and the average width, north to south, is about 22 miles. Columbia, the county seat and principal town, is southwest of Nashville and northwest of Chattanooga. Distances by air from Columbia to principal cities in the State are shown in figure 1. The land area of the county is 614 square miles, or 392,960 acres.

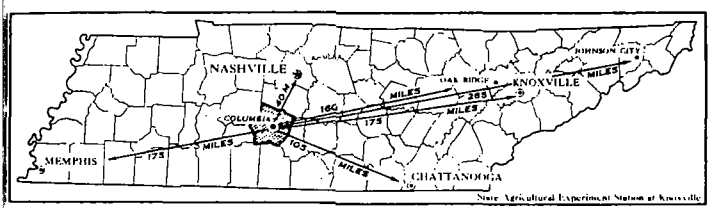


*Figure 1.*—**Location of Maury County in Tennessee.**

## *General Description of the County*

This section is provided mainly for those not familiar with Maury County. It tells about the early settlement and population; physiography, relief, and drainage; climate; water supply; and public facilities and industries. Details about agriculture of the county will be found in the section Agriculture in Maury County.

## Settlement and Population

Maury County was settled largely by Revolutionary War soldiers or their descendants. They mostly came from North Carolina, South Carolina, and Virginia. Maury County was formed in November 1807 from the southern part of Williamson County. Columbia, the county seat, was established in the central part of the county on the Duck River and was incorporated in 1817 (*8*)[2].

The population of the county in 1810 was 7,772, and by 1900 it had increased to 42,703. According to the United States census, the population in 1950 was 40,368. Population is fairly well distributed over the county, except in the western part, which is sparsely populated. Columbia, the principal town, had a population of 10,911 in 1950.

## Physiography, Relief, and Drainage

Maury County lies within the Interior Low Plateau province. The four main physiographic divisions of the county are shown in figure 2. They are (1) the Highland Rim, (2) the outer Central Basin, (3) the inner Central Basin, and (4) the terraces and bottom lands of the Duck River Valley (*7*).

The Highland Rim is a belt of thoroughly dissected land that rises abruptly about 300 feet above the outer Central Basin. It crosses the county in a north and south direction and roughly parallels the western boundary of the county. It has hilly to steep relief. In Maury County this physiographic division consists mainly of spurs or narrow winding ridges that extend from the Highland Rim proper into the outer Central Basin area. It is sometimes called the Highland Rim escarpment. Also included in this Highland Rim escarpment area are knobs or moundlike hills that have been isolated by geologic erosion and are generally capped by the same rock found on the Highland Rim proper. Because the streams cut back into the Highland Rim, the boundary between the Central Basin and the Highland Rim is often indefinite and irregular.

In the extreme southwestern part of the county, there is a very small area within the Highland Rim known as the Highland Rim Plateau. This is a gently rolling plateau that extends into the adjoining Lawrence and Lewis Counties.

The rock formations of the Highland Rim area are bedded almost horizontally, and some are exposed on very steep slopes (*9*). They consist of cherty limestone underlain by layers of shale. The Fort Payne chert formation forms the main surface rock of the Highland Rim area. The cherty rocks are apparently more resistant to weathering than the layers of shale and are responsible for the outlying knobs in the Central Basin area as well as the steep break between the Highland Rim and the Central Basin.

The thin layers of Chattanooga and Maury shales and the lower shaly faces of the Fort Payne chert are exposed in many places. The base of the Chattanooga

[1] Fieldwork for this study was done when the division of Soil Survey was a part of the Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

[2] Italic numbers in parentheses refer to Literature Cited, p. 94.

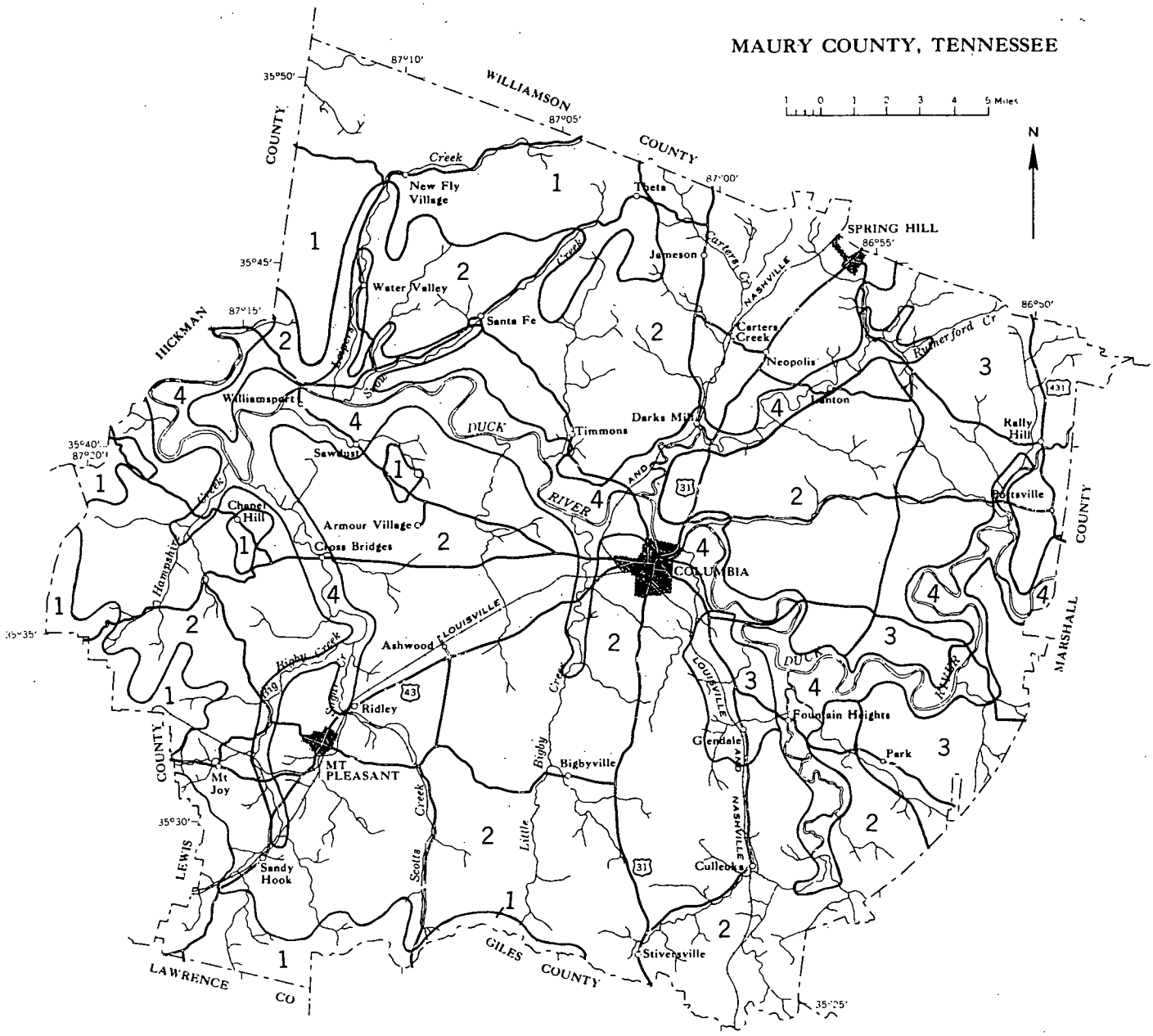


*Figure 2.*—**Physiographic divisions of Maury County, Tenn.: 1, Highland Rim; 2, outer Central Basin; 3, inner Central Basin; 4, terrace and bottom lands of the Duck River Valley.**

black shale is generally accepted as the separation line between the Highland Rim and the outer Central Basin.

The central and eastern parts of the county fall essentially within the Central Basin. This area is below the Highland Rim area. The Central Basin consists of the outer Central Basin and the inner Central Basin. The outer basin lies between the Highland Rim and the inner basin and at a somewhat higher altitude than the inner basin.

The rocks of the outer Central Basin are comparatively pure limestone. Many contain phosphorus. The Bigby formation in this area yields commercial phosphate in places (*9*). The Hermitage formation is the lowest in phosphatic limestone. Its base marks the line of separation between the outer and inner Central Basins.

The rocks of the inner Central Basin consist of massive and argillaceous limestones that occur in alternate layers. The argillaceous limestones are called clayey limestones because they contain thin lenses of brown shale. Nearly flat rocky areas with very little soil occur throughout the inner Central Basin and are commonly called glades. Limestone sinks are also found in this area. They vary considerably in depth and size. Some are very wide and

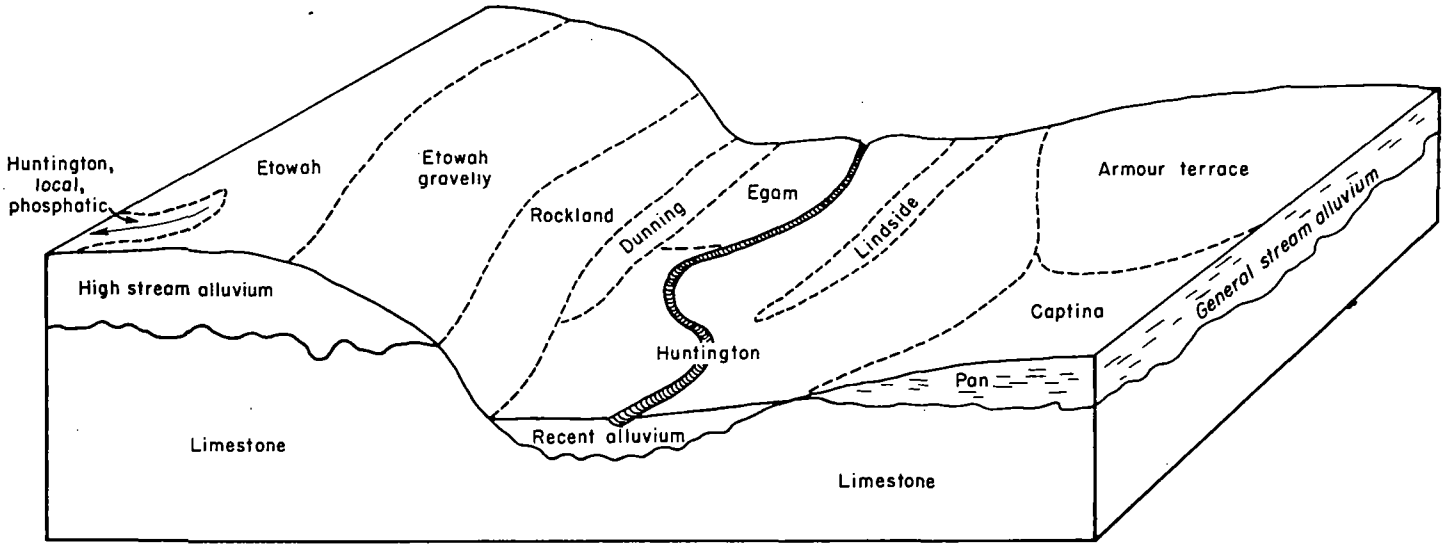


*Figure 12.*—**Sketch showing relative positions of soils in the Etowah-Huntington (local alluvium phosphatic phase)-Emory and Huntington-Lindside-Armour (terrace phases)-Egam associations.**

Soils of capability classes II and III predominate in this association. High productivity is not difficult to maintain on these. Soils of class IV occupy the steeper slopes. A great part of the acreage in this association has been cleared and is used mainly for crops. Parts of the cleared areas are used for pasture that is generally rotated with other crops.

### *Huntington-Lindside-Armour (terrace phases)-Egam association*

The soils of this association are probably the most fertile in the county, but their use is somewhat limited by periodic flooding. They occupy low stream terraces and bottom lands along the Duck River and tributary creeks. Most areas are in the meanders of the streams and consist of undulating to rolling stream terraces and irregular strips of nearly level bottom lands along the rivers and creek channels. The relative positions of the soils in this association are shown in figure 12.

The soils on the stream terraces have moderate to high fertility and are moderately well drained to well drained. The soils on the bottom lands are very fertile and easily worked, and most of them are moderately well drained to well drained. The soils of the bottom lands near the inner Central Basin consist partially of materials washed from very clayey limestone. Those near the Highland Rim have chert fragments throughout the profile. These fragments washed from the cherty hills.

The Huntington soils occupy the bottom lands. They are well drained and have brown soil layers. Frequent overflows help maintain their fertility.

The Lindside soils generally occur along the depressed areas in the bottoms, and water often stands on the surface after the floods have receded. The Lindside soils have many characteristics similar to those of the Huntington soils but are less well drained.

The Egam and Dunning soils are darker colored than the other bottom-land soils and generally have a compact or somewhat heavy soil layer below the surface. The Egam soils are moderately well drained and occur with the Huntington soils on the higher bottoms near the streams. The Dunning soils are very dark gray or black, poorly drained, and generally in low places back from the streams.

The Armour terrace phase soils occupy the broad smooth terraces. They have developed from stream deposits washed from areas of phosphatic limestone in the uplands. They have dark-brown surface layers and brown subsoils.

The Captina soils occupy low terraces similar to and near those occupied by the Armour soils. They are made up of the same soil materials as the Armour terrace phase soils, but they are lighter colored and have a brittle fragipan layer below the subsoil.

The soils of this association are cleared for the most part, except along the bluffs and streambanks. On the streambanks such trees as silver maple, sycamore, willow, boxelder, sweetgum, white elm, and white and green ash are common.

This association is one of the most productive in the county, and crop yields are relatively high. Soils of capability classes I and II predominate on the bottom lands, and soils of class II on the low stream terraces. The fertility, especially of the bottom lands, is easily maintained, and the soils of the terraces are well suited to a variety of crops without especially exacting management. Parts of the cleared areas on the low terraces are used for pasture grown in rotation with other crops. Much of the bottom land is used intensively for row crops, chiefly corn, although hay and pasture are grown to some extent. Rotations are more common on the terraces, where corn, small grain, and hay are grown.

## Relations of the Soil Series

Some of the relations of soils to each other can be brought out by a reference to the position of each soil series in the landscape where it is located. Soils are located on the uplands, the colluvial lands, the alluvial terraces, and the bottom lands. Table 4 shows the

lacks the top few inches of friable soil material. These areas are somewhat black in color. A few small areas of Huntington and Lindside soils may be included in this mapping unit because the gradual transitions among the soils were difficult to show on the map.

This soil is medium acid, contains a moderate amount of organic matter, and is high in many plant nutrients, particularly phosphorus. Runoff is slow, and internal drainage is moderately slow, but the soil dries in time for planting after floods.

*Present use.*—All of this soil is cleared and used chiefly for corn. A small acreage is used for small grains and hay. Very little is idle. Fertilizers and lime are hardly ever used, and little special management is given to this soil.

*Suitable uses* (unit IIw–1).—This soil is moderately productive and suited to intensive use. But its suitability is limited to some extent by the compact, somewhat droughty subsoil layers and periodic flooding. A good management program should include the selection of moderately drought-resistant crops as well as improved seedbed preparation and cultivation. Corn is well suited, but small grains may give higher yields.

Often the seedbed on this soil is not properly prepared because plowing is poorly timed. The moisture range for satisfactory tillage is narrow.

### *Emory series*

The Emory series consists of well-drained soils of the colluvial lands. They are not extensive soils, and they occupy areas at the foot of slopes and along narrow drainageways. They have developed from accumulations of soil material that came from adjacent slopes of Hagerstown and Talbott soils. Small areas of the Emory soils occur in the eastern part of the county in association with soils of the inner Central Basin.

The Emory soils are darker and somewhat less developed than the Hermitage soils. In many characteristics they are similar to the Huntington soils, but they are more red than brown and are not so frequently flooded or ponded.

Only one soil of the Emory series is mapped in Maury County.

**Emory silt loam, gently sloping phase** (0 to 6 percent slopes) (Eb).—This soil is limited chiefly to the eastern part of the county, in the inner Central Basin. Few slopes are greater than 3 percent.

Representative profile:

0 to 14 inches, reddish-brown friable silt loam; slightly acid.

14 to 24 inches +, yellowish-red friable silt loam or silty clay loam splotched with brown and yellow; has a few black concretions and finely weathered fragments of parent material in the lower part.

Depth to limestone bedrock ranges from 3 to 6 feet.

A few small areas that have some fine chert fragments on the surface are included with this mapping unit. Also included are areas that have been covered by a thin layer of subsoil material recently washed from severely eroded upland soils.

This soil is slightly acid and has a moderately high amount of organic matter. It is very productive, easily worked, and suited to intensive use. Runoff and internal drainage are medium. The moisture-supplying capacity is high.

*Present use.*—Nearly all of this soil is used for crops and pasture. It is generally farmed along with other soils. A few areas are used separately, especially those that are adjacent to severely eroded or abandoned areas. Corn is the principal crop, and although fertilizers are not commonly used, yields are fairly high.

*Suitable uses* (unit I–1).—This soil is well suited to intensive production of row crops. Short rotations can be used.

This soil does not have exacting management requirements, as little erosion takes place, but it should be protected from subsoil deposits that are washed from adjacent severely eroded areas.

### *Etowah series*

The Etowah soils have developed on well-drained, fairly high terraces in the main valley along the Duck River and, to a lesser extent, along the lower reaches of the major creeks. They were formed from stream sediments washed from soils underlain chiefly by high-grade limestone. These alluvial sediments were deposited near the streams before they had cut down to their present channels, as the terraces on which they now occur are above the present area of overflow. The Etowah soils are associated mainly with the Armour and Captina soils that occupy lower terraces on the inside bends of creeks and rivers. They also occur with many upland soils in the county. The Etowah soils in the outer Central Basin are phosphatic. The higher areas of these soils contain less phosphorus than the somewhat lower areas.

The Etowah soils were derived from parent materials similar to those of the Armour soils. Generally, however, their surface layer is less brown and their subsoil is redder. The Etowah soils are better drained and have browner surface soil and redder subsoil than the pan soils of the Captina series.

**Etowah silt loam, eroded gently sloping phase** (0 to 5 percent slopes) (Ef).—This soil is in the eastern part of the county in the inner Central Basin. The areas are small and mostly are along the Duck River in a belt that extends about a mile back from the river. This soil is closely associated with other Etowah soils, with the phosphatic Armour soils on lower terraces, and with the Hagerstown and Talbott soils of the uplands. It is very important agriculturally because it generally occurs in areas comprised of soils and miscellaneous land types having very limited suitability for use.

Representative profile:

0 to 10 inches, brown to light-brown friable silt loam; medium acid.

10 to 20 inches, yellowish-red friable silty clay loam; contains a few brown concretions; strongly acid.

20 to 36 inches +, red to light-red firm silty clay loam; contains small black concretions and rounded gravel in lower part; strongly acid.

Limestone is at depths of 5 to 20 feet.

In places rounded gravel (fig. 13) occurs in small spots on the surface; these areas are shown on the map by the proper symbol. Included in this mapping

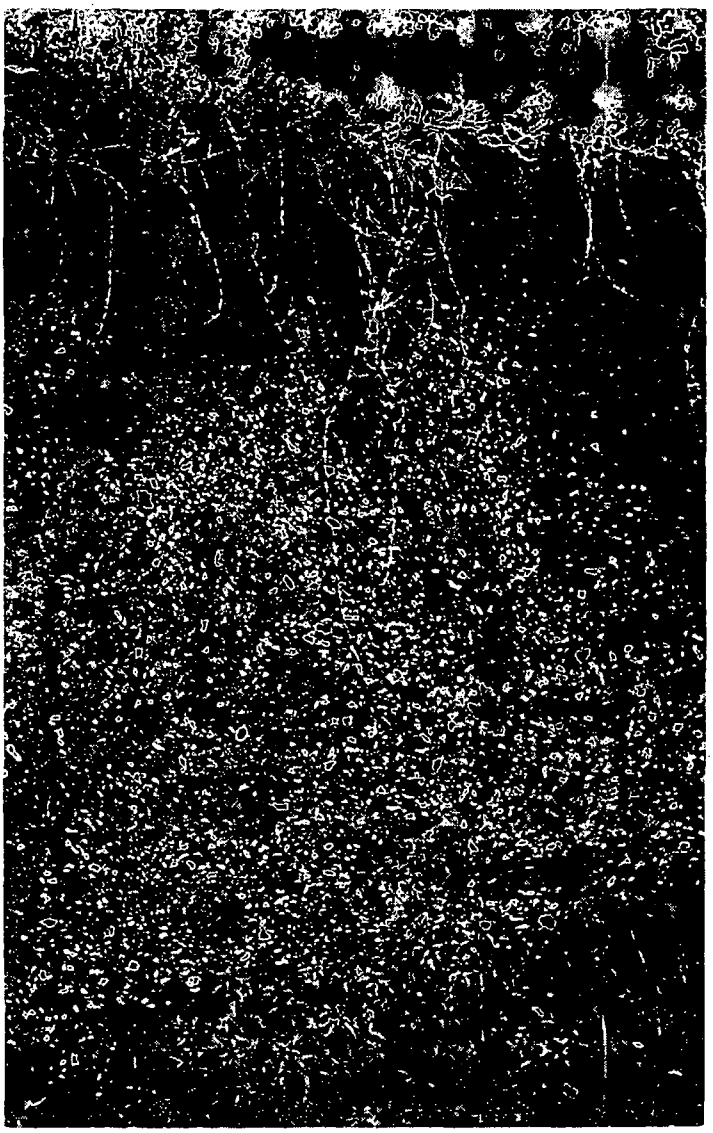

*Figure 13.*—**Irregular gravel deposits in substratum below subsoil of Etowah silt loam, eroded gently sloping phase.**

unit are a few areas that have lost most of the original surface soil.

This soil is medium acid and moderately to highly productive. The amount of organic matter, however, has been reduced because of intensive cropping and erosion. Runoff and internal drainage are medium. The soil is readily permeable to air, plant roots, and water.

*Present use.*—All this soil has been cleared and cropped intensively. Very little acreage is used for pasture, and very little is idle. Few special practices are used for checking erosion or improving the soil's productivity.

*Suitable uses* (unit IIe–1).—This soil is physically well suited to a wide variety of crops and to pasture. It is responsive to good management. Comparatively high productivity can be maintained under a short rotation that includes a legume crop, preferably a deep-rooted one.

**Etowah silt loam, eroded gently sloping phosphati phase** (0 to 5 percent slopes) (Eg).—Except for cor taining a medium to large amount of phosphorus, thi soil differs little from Etowah silt loam, eroded gentl sloping phase, and variations in characteristics withi this soil are similar to those described for that phas It is associated with the phosphatic Armour soils o low terraces along streams and with many other soil in the outer Central Basin. It occurs in an irregula belt of terrace deposits about a mile wide. This bel adjoins the Duck River throughout its course in th outer Central Basin.

*Present use.*—This soil is well suited to the pro duction of crops and is nearly all cultivated. Th soil is closely associated with the eroded sloping phos phatic phase, and the two soils are generally use and managed together. Crops are commonly rotate but not in proper sequence. Small to moderate quar tities of soil amendments are used.

*Suitable uses* (unit IIe–1).—This productive soil i easy to work and moderately easy to conserve. Unde good management, corn, tobacco, grass and legum hay, small grains, and other crops can be grow successfully. Applications of phosphate generally ar not needed for crops.

**Etowah silt loam, eroded sloping phosphatic phas** (5 to 12 percent slopes) (Eh).—This soil has a greate amount of phosphorus, is more eroded, and occupie steeper slopes than Etowah silt loam, eroded gentl sloping phase. Except for these differences, the tw soils are essentially the same. This soil is associate with other Etowah soils and with the Armour soils o the low terraces.

*Present use.*—All areas of this soil are used for crop and pasture. On many farms systematic rotations ar used and fertilizers are applied in moderate amounts Generally row crops should be grown less frequentl than they now are.

*Suitable uses* (unit IIIe–1).—This soil is productiv and well suited to most all the field crops commonl grown in the county. A rotation of moderate lengt that includes a deep-rooted legume is desirable. Rota tions should be longer than on Etowah silt loam, erode gently sloping phase.

**Etowah gravelly silty clay loam, severely erode sloping phase** (5 to 12 percent slopes) (Ec).—This so differs from Etowah silt loam, eroded gently slopin phase, chiefly in having lost most of the original sur face soil and part of the upper subsoil through erosion The finer soil materials have been removed, and a accumulation of waterworn pebbles has been left o the surface. In places there is enough gravel t interfere materially with cultivation. Sheet erosio has been severe. In many places limestone outcrop occur at the base of slopes. Runoff is medium t rapid, but internal drainage is medium to slow. Thi soil is generally strongly acid, lacks organic matte and is somewhat droughty.

This soil is associated with Etowah silt loam, erode gently sloping phase, and was derived from the sam type of parent material. It occurs in the eastern pa of the county on the higher terrace levels near th present course of the Duck River.

*Present use.*—All this soil has been used for crop

or pasture. A large acreage is now used for row crops, small grains, and hay. A few areas are idle or abandoned. Because this soil frequently occurs adjacent to rockland and soils somewhat shallow to bedrock, it has been intensively cropped through necessity. Although the soil was originally suited to many different crops, severe erosion resulting from poor use and management has limited its suitability for use.

*Suitable uses* (unit IIIe–1).—This soil is suited to crops requiring tillage. Because of the high content of pebbles and poor tilth, however, it is probably best suited to semipermanent hay crops or pasture. Good pasture or hay crops can be established and maintained. The areas having a few shallow gullies and outcrops of limestone bedrock should be used for permanent pasture.

**Etowah gravelly silty clay loam, severely eroded sloping phosphatic phase** (5 to 12 percent slopes) (Ed).—The profile of this soil is similar to that of Etowah silt loam, eroded gently sloping phase, except that most of the upper soil layer has been eroded away. The present plow layer contains gravel, which increases with depth. This layer is generally a mixture of the subsoil and the remaining surface soil. In many places it consists entirely of subsoil material.

Limestone rock outcrops are at the base of slopes in many places. Where there are a few pockets of gravel, the profile is lighter in color, very low in organic matter, very strongly acid, and droughty. Among the variations mapped with this soil are a few areas that have a darker red subsoil.

This soil occurs with other phosphatic soils and was derived from the same kind of parent material.

*Present use.*—All of this soil has been used for crops and pasture. Some of it is now idle, and some is in unimproved pasture. Most areas, however, are still used for crops and are managed along with more level Etowah soils. This management increases the possibility of further erosion. Crop yields are very low. In many places soil improvement or maintenance is not being attempted.

*Suitable uses* (unit IIIe–1).—This soil is physically suited to crops requiring tillage. Because of its gravel content and poor tilth, it is best suited to semipermanent hay crops or pasture. Areas that have rock outcrops and shallow gullies should be used for permanent pasture. Management requirements are similar to those for the severely eroded sloping phase.

**Etowah gravelly silty clay loam, severely eroded moderately steep phosphatic phase** (12 to 25 percent slopes) (Ee).—This soil differs from Etowah silt loam, eroded gently sloping phosphatic phase, chiefly in that most of the upper soil layer has been removed by erosion and the phosphatic subsoil layer is thinner and contains more gravel. Shallow gullies are common in many areas, and outcrops of limestone are numerous. This soil occurs on the hilly parts of the high terraces along the river and creek valleys in the outer Central Basin. It generally occupies short, fairly steep slopes adjacent to and above the Armour soils on the lower terraces. It is at slightly lower elevations than other phases of the Etowah soils. A few less severely eroded areas are mapped with this soil.

*Present use.*—All of Etowah gravelly silty clay loam, severely eroded moderately steep phosphatic phase, has been cleared and used for crops and pasture. Because of the severe erosion resulting from poor use and management, most of the soil is now idle or in unimproved pasture.

*Suitable uses* (unit IVe–1).—This soil is not suitable for row crops, because of its strong eroded slopes, gravel content, and droughtiness. It is probably best suited to permanent hay or pasture. In many places runoff should be diverted from these areas to retain the productivity of more fertile soils at lower elevations.

### *Frankstown series*

The Frankstown soils have developed in materials weathered from the Fort Payne chert formation and underlying phosphatic shales. They occupy the tops and upper slopes of ridges and knobs along the border of the Highland Rim and are on most of the high knolls, hills, and ridges that extend into the Central Basin. These soils are associated with the Dellrose, Ashwood, and cherty Mimosa soils on the lower ridge slopes.

Those soils on gently rolling slopes are moderately productive and suited to crops, but because of the chert content, they are somewhat difficult to work. The chert fragments usually range from 1 to 4 inches in diameter. The content of phosphorus and potassium varies. In many places the soils have a medium to large amount of phosphorus and a medium amount of potassium.

The Frankstown soils are more brown and more cherty than the Mountview soils. The Bodine soils differ from the Frankstown soils in being shallower to parent material, in containing little or no phosphorus, and in being less productive.

**Frankstown cherty silt loam, eroded sloping phase** (4 to 12 percent slopes) (Fa).—This soil occurs in long, narrow strips on rolling ridgetops and on the tops of high ridges and hills. It is associated with other Frankstown soils and with the Dellrose, Ashwood, and cherty Mimosa soils on the lower ridge slopes. In the western part of the county the Bodine and Mountview soils are on nearby higher ridgetops.

Representative profile:

0 to 8 inches, brown to yellowish-brown friable silt loam; contains chert and shale fragments; medium to strongly acid.

8 to 16 inches, strong-brown friable silt loam; contains a few brown concretions and fragments; strongly acid.

16 to 30 inches +, reddish-yellow firm silty clay loam; splotches of rust brown and gray in lower part; very cherty; strongly acid.

The 16- to 30-inch layer is underlain by weathered cherty limestone material and phosphatic shale.

The thickness of the surface layer varies. In places it is only a few inches thick. Heavily cropped areas have a lighter colored surface soil in some places. A few small areas have a chert-free plow layer and are more nearly level than the rest of the soil. Also included are a few small, isolated, uneroded areas that are still in forest.

This soil is medium to strongly acid and has a moderate amount of phosphorus and potassium. Runoff

common field crops can be grown, but profitable yields are hardly ever obtained unless large quantities of fertilizers are used. A rotation consisting of a row crop followed by a small grain that has been seeded with a legume-grass mixture for hay or pasture is well suited to this soil.

**Hicks silt loam, eroded sloping phase** (5 to 12 percent slopes) (Hk).—Stronger slopes are the chief difference between this soil and the closely associated eroded gently sloping phase of Hicks silt loam. Other differentiating characteristics are the generally thinner surface soil and shallower depth to bedrock. A few shallow gullies occur in some areas.

*Present use.*—The same kinds of crops are generally grown on this soil as on the eroded gently sloping phase, but the yields are somewhat less.

*Suitable uses* (unit IIIe–1).—This soil is low in plant nutrients, but it responds well to management. Row crops should be followed by 2 or more years of legumes and grasses to increase yields and to improve the quality of most other crops.

**Hicks flaggy silt loam, eroded sloping phase** (5 to 12 percent slopes) (Hg).—This soil differs from the other Hicks soils mainly in having numerous flat fragments of sandy limestone on the surface and throughout the profile. It also differs from the eroded gently sloping phase of Hicks silt loam in having stronger slopes, a thinner surface soil, and in being shallower to bedrock. This is the least extensive soil of the Hicks series in the county.

*Present use.*—This soil is generally used for pasture because the loose, flat stones (or flags) interfere with mowing and cultivation. In many areas the flagstones are 4 to 6 inches or more in length. A few acres are cultivated, and some areas are still in forest.

*Suitable uses* (unit VIs–1).—Most of this flaggy soil is best suited for permanent pasture when cleared. In some areas it may be profitable to pick up the loose stones and cultivate the soil in a long crop rotation. The slopes, low fertility, and droughtiness of the soil limit its value as cropland. Grasses and legumes that can withstand a range of soil moisture are suited to this soil.

### *Huntington series*

The Huntington soils are brown, well drained, and deep. They are in depressed areas along narrow drainageways and on the first bottoms of the larger streams in the county. They consist chiefly of alluvial materials that have washed from soils underlain by high-grade limestone. These soils occur throughout the outer and inner Central Basin part of the county.

Where the Huntington soils are associated with cherty upland soils, they have a somewhat lighter colored profile and contain enough chert to make them somewhat difficult to work. Most soil areas along the larger streams are periodically overflowed, and this tends to maintain their fertility. The Huntington soils do not occupy large areas, but they are highly productive, easily maintained, and very valuable agriculturally.

The Huntington soils have developed from parent materials that are similar to those of the Lindside and Egam soils but differ in being well drained and more productive. The associated Armour and Etowah soils occupy higher elevations and have better developed profiles than the Huntington soils.

**Huntington silt loam, phosphatic phase** (0 to 3 percent slopes) (Ho).—Most areas of this soil are generally level, and they occur as long narrow strips along the stream channels. This soil is associated with the Lindside, Egam, and Dunning soils.

Representative profile:

0 to 20 inches, dark-brown friable silt loam; slightly acid.
20 to 36 inches +, brown friable silt loam to silty clay loam; a few fragments of weathered parent material in lower part.

The 20- to 36-inch layer is underlain by layers of sand, silt, and gravel over limestone bedrock.

In spots the surface layer is almost a loam. A few areas that are on slightly higher elevations in the bottom lands have some subsoil development. These variations generally can be used and managed in the same way as the rest of the soil. Most of the sloping narrow stream banks are included in this mapping unit.

In most places this soil is slightly acid and high in organic matter and phosphorus. Except when flooded, it is well drained throughout the profile. The soil is easy to work and maintain. The subsoil is permeable to air, moisture, and plant roots.

*Present use.*—Most of this soil is cultivated, mainly to corn. A small acreage that is subject to swift overflow is in permanent pasture. Narrow strips near the stream channels are normally in trees. This soil is generally used for corn year after year without fertilizers or crop rotations. Very few areas are protected from floods.

*Suitable uses* (unit I–1).—This soil is suitable for most crops grown in the area, but it is somewhat limited in use because of its susceptibility to flooding. It is one of the best soils for corn and is well suited to hay and forage crops. Mostly because of the hazards of flooding, lodging, and disease, this soil is not well suited to winter grain. Although crops are good when the soil is continually cultivated, yields can be improved by use of suitable rotations that include grasses and legumes turned under as green manure.

**Huntington silt loam, local alluvium phosphatic phase** (0 to 6 percent slopes) (Hr).—This soil differs from the Huntington silt loam, phosphatic phase, in that it is not subject to frequent flooding. It consists of alluvium that washed from the Mimosa, Maury, and Braxton soils. Depths to bedrock are generally more than 3 feet. Included with this soil are a few areas covered by a thin layer of subsoil that recently washed from the surrounding severely eroded upland soils.

This soil is not extensive, and it occurs along small drainageways and at the foot of slopes that are underlain by phosphatic limestone. Slopes seldom exceed 3 percent. The soil is mainly in the central part of the county in the outer Central Basin.

This soil is very productive. It is slightly acid, high in phosphorus, and well supplied with organic matter. Runoff and internal drainage are medium. The capacity to hold available moisture is high enough for practically all of the commonly grown crops. The subsoil is permeable to air, moisture, and plant roots.

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*Present use.*—Most of this soil has been cleared and used for nearly all the commonly grown crops, mainly corn. Yields are fairly high, although fertilizers are not commonly used. Some soil areas are managed separately, especially when they are close to severely eroded or abandoned soils.

*Suitable uses* (unit I–1).—This soil is well suited to intensive use and to many kinds of crops, including corn, tobacco, small grains, and hay. Short rotations that include winter cover crops will help to maintain the productivity of the soil.

**Huntington silt loam, depressional phase** (0 to 3 percent slopes) (Hn).—This soil differs from the Huntington silt loam, phosphatic phase, chiefly in that it is lower in phosphorus and occupies depressions. Water stands on some areas for a short time after rains, but it soon drains into crevices in the underlying limestone, or flows away through surface ditches and sinkholes. Deep-rooted legume crops are occasionally lost because of the very slow surface drainage after heavy rains. In some places soil productivity is impaired by deposits of material that have washed in from deeply gullied and severely eroded areas. However, most soil areas are very fertile and well drained and will produce good yields of most crops.

This soil occurs in the inner Central Basin of the county. It is associated with the Hagerstown and Talbott soils of the uplands and with the Emory soils of the colluvial lands.

*Present use.*—Many areas of this soil are so small that they are used and managed in the same way as the soils on surrounding slopes. They are very productive and are used mainly for row crops. However, their importance to agriculture is diminished somewhat by their small extent and close association with soils suited to very different uses.

*Suitable uses* (unit I–1).—This soil can be used intensively. Row crops can be grown continuously without causing serious damage. The soil can be satisfactorily maintained by use of short rotations that include legumes and other crops used as green manure. Adjacent upland soils should be carefully managed to prevent heavy subsoil materials from covering this soil.

**Huntington silt loam, depressional phosphatic phase** (0 to 3 percent slopes) (Hp).—This soil differs from Huntington silt loam, phosphatic phase, mainly in having a somewhat thicker surface layer and in not being subject to flooding by streams. Water stands on some areas for a short time after rains, but it soon drains into crevices in the underlying limestone, or flows away through surface ditches and sinkholes. Deep-rooted legumes are sometimes permanently damaged by the ponded water. Soil productivity is often reduced by subsoil materials that have washed in from surrounding deeply gullied or severely eroded areas. Most soil areas, however, are very fertile and produce good yields of most of the commonly grown crops.

This well-drained soil occurs in level depressions in the outer Central Basin part of the county. It has been formed from parent materials that are similar to those of Huntington silt loam, local alluvium phosphatic phase, and occurs in association with it.

*Present use.*—This soil frequently occurs as small areas that are generally farmed along with the more extensive soils in the field. A few of the larger soil areas are used separately, mainly for corn.

*Suitable uses* (unit I–1).—Most of this soil can be cropped intensively, and yields can be maintained if proper fertilizers are used. The soil is very fertile and high in phosphorus; consequently, fertilizers should be applied according to the results of soil tests. Nearby higher lying soils should be carefully managed to prevent heavy soil materials from washing to this soil.

**Huntington cherty silt loam, phosphatic phase** (0 to 3 percent slopes) (Hl).—This soil differs from Huntington silt loam, phosphatic phase, chiefly in having chert fragments on the surface and throughout the profile. In some places fragments of chert are large and numerous enough to interfere seriously with tillage.

This soil is medium to slightly acid and contains a moderate amount of organic matter and plant nutrients. It is well drained and can be worked fairly soon after floodwaters recede.

This soil occurs as small areas, mainly in the northwestern and southwestern parts of the county in association with the cherty Armour soils and with those of the Lindside and Dunning series. Most areas are nearly level. The soil areas near the Highland Rim are somewhat lighter colored throughout the profile.

*Present use.*—Much of this soil has been cleared and cropped. Corn is the chief crop, but some areas are in hay and permanent pasture. Crop rotations are not generally followed; a few crops are lightly fertilized.

*Suitable uses* (unit IIs–1).—The use of this soil is limited by chert and its susceptibility to flooding. The chert makes it difficult to work, but the soil can be cultivated over a wide range in content of moisture. Most areas are suited to corn, and, where floods are not too frequent, deep-rooted legumes can be used in plant mixtures for hay and pasture. Winter grain is frequently damaged by floods.

**Huntington cherty silt loam, local alluvium phosphatic phase** (0 to 6 percent slopes) (Hm).—This soil differs from Huntington silt loam, phosphatic phase, mainly because it is not subject to flooding and has chert on the surface and in the profile. Some soil areas that are in the narrow valleys near the edge of the Highland Rim are somewhat lighter colored than the rest of the soil and contain only a small amount of phosphorus.

The parent material of this soil has washed from the surrounding slopes of cherty Frankstown, Dellrose, and Mimosa soils. The soil is widely distributed throughout the county in the chert hills of the outer Central Basin.

*Present use.*—Nearly all of this soil has been cleared and used for crops and pasture. The cultivated areas are generally used for corn, tobacco, and garden vegetables year after year. The narrow areas of this soil near steep, cherty soils are generally used as native pasture.

*Suitable uses* (unit IIs–1).—This soil can be used intensively, and it is suited to many kinds of crops,

and of low fertility. It should be planted or allowed to seed to forest trees.

***Lindside series***

The Lindside soils are moderately well drained to somewhat poorly drained. They occupy small areas and occur throughout the county along narrow drainageways, in depressions, and along the first bottoms of the larger streams. The Lindside soils have formed mainly from materials that washed from slopes underlain by high-grade limestone.

Most areas of the Lindside soils are moderately fertile and easily worked. However, overflow from creeks and ponding of depressed areas limit their use for crops. Lindside soils in the outer Central Basin are high in phosphorus.

Lindside soils along the larger streams are associated chiefly with the Huntington, Egam, and Dunning soils of the bottom lands and with the Armour and Captina soils of the terrace lands.

Near the Highland Rim, Lindside soils are associated with cherty upland soils. In addition, they have a somewhat lighter colored profile and contain enough chert to make cultivation somewhat difficult.

The Lindside soils differ from Huntington soils primarily in being less well drained and somewhat less productive. The associated Burgin and Dunning soils are darker colored and have heavier, more plastic subsoils.

**Lindside silt loam, phosphatic phase** (0 to 3 percent slopes) (Lc).—In most places this soil occupies low or slightly depressed areas on the bottom lands at elevations below the higher lying Armour and Captina soils on the low terraces. Slopes are generally less than 3 percent in most areas.

Representative profile:

0 to 16 inches, brown friable silt loam; a few gray mottles in lower part; slightly acid.
16 to 30 inches +, dark grayish-brown friable to firm silty clay loam mottled with gray and yellow; numerous small, black concretions.

The 16- to 30-inch layer is underlain by layers of sand, clay, or gravel that overlie limestone bedrock.

In a few areas the surface layer is more than 16 inches thick and the mottled layer is nearer the surface. The surface soil is browner along the smaller streams than along the larger creeks. Included in this mapping unit are areas where the mottled subsoil layer is dark gray to black as the result of recent alluvial deposits.

This soil is high in phosphorus and contains moderate amounts of organic matter and plant nutrients. Runoff is ordinarily very slow, and internal drainage is medium to slow. The mottled yellow and gray subsoil layer indicates that the height of the water table fluctuates.

*Present use.*—Practically all of this soil has been cleared and is used for crops. When late floods prevent the planting of crops, the fields usually are idle for the season. Corn is grown continuously for several years and then followed by pasture, or the land is left idle after cropping to corn. Crops normally are not rotated or fertilized. Few areas are artificially drained or protected from erosive floodwaters.

*Suitable uses* (unit IIw–1).—This soil can be used intensively for row crops, but its suitability for them is limited by poor drainage and susceptibility to floods. It is suited to corn and spring-sown crops, but winter grains and deep-rooted legumes are usually damaged or killed by floods or by the high water table. Productivity can be improved by use of green-manure crops.

**Lindside silt loam, local alluvium phase** (0 to 6 percent slopes) (Lb).—This soil has characteristics and uses that are similar to those of Lindside silt loam, phosphatic phase, except that it is not subject to flooding and contains little if any phosphorus. It occurs in level or depressed areas and along small narrow drainageways, mostly in the inner Central Basin. There are also a few areas in the Highland Rim, where this soil contains more silt and is lighter in color. Slopes seldom exceed 3 percent.

*Present use.*—This soil is easily worked and conserved, but poor drainage limits its use mainly to summer crops such as corn, soybeans, and lespedeza. Grasses and legumes that can tolerate excessive moisture often produce good pasture or hay.

*Suitable uses* (unit IIw–1).—Where this soil has been drained by tile or open ditches, most row and hay crops can be grown successfully.

**Lindside silt loam, local alluvium phosphatic phase** (0 to 6 percent slopes) (Ld).—This soil differs from Lindside silt loam, phosphatic phase, in that it is not subject to flooding. It is slightly to medium acid, high in phosphorus, and moderate in organic matter.

This soil occurs in level depressed areas and along small drainageways in the outer Central Basin. It consists of materials that have washed from slopes of Mimosa, Maury, Braxton, and Inman soils. Slopes seldom exceed 3 percent.

*Present use.*—Practically all of this soil has been cleared and is used chiefly for corn and hay. Crops get little fertilization.

*Suitable uses* (unit IIw–1).—This soil can be used intensively, but its suitability for crops is limited by poor drainage and temporary ponding. Summer crops such as corn, soybeans, and lespedeza are best suited. If drainage is improved, most row and hay crops can be grown.

**Lindside cherty silt loam, phosphatic phase** (0 to 3 percent slopes) (La).—This soil differs from Lindside silt loam, phosphatic phase, chiefly in having chert fragments on the surface and throughout the profile. In addition, the surface soil is lighter colored in some places. In places the fragments of chert are large and numerous enough to interfere seriously with cultivation. This soil is subject to annual overflows, but normally they are of short duration and put only a shallow sheet of water on the soil.

This soil occurs principally in the northwestern and southwestern parts of the county in the cherty hills area of the outer Central Basin.

*Suitable uses* (unit IIw–1).—This soil can be used intensively, but flooding, poor drainage, and chert limit its suitability for crops. Corn, soybeans, and many hay and pasture crops that can tolerate a wide range in soil moisture are well suited. Row-crop rotations can be short, but soil productivity can be improved if

TABLE 28.—*Characteristics of Maury County soils significant to engineering*—Continued

| Map unit symbol | Soil | Slopes | Natural drainage class | Depth to seasonally high water table | Depth to bedrock | Description[1] (Selected characteristics significant to engineering) |
|---|---|---|---|---|---|---|
| | | *Percent* | | *Feet* | *Feet* | |
| Dh | Dunning and Lindside silty clay loams. | 0–3 | Somewhat poor to moderately good. | ---------- | 2–3 | These soils are on the flood plains. They are developing in young alluvium washed from limestone materials and are underlain at about 20 inches by sediments [predominantly CL or CH (A-6 or A-7)]. |
| Dg | Dunning silty clay loam, phosphatic phase. | 0–3 | Somewhat poor to poor | ---------- | 6–20 | |
| Ea | Egam silty clay loam, phosphatic phase. | 0–3 | Moderately good to good | 0–3 | 6–20+ | This soil is on the flood plains. It is developing in young alluvium washed from limestone materials and is underlain at about 20 inches by sediments [CL or CH (A-6 or A-7)]. |
| Eb | Emory silt loam, gently sloping phase. | 0–6 | Good | 0–5 | 3–6 | This young colluvial soil has developed in silty material washed from limestone materials. It is underlain at about 24 inches by limestone residuum [predominantly CH or MH (A-7)]. |
| Ef | Etowah silt loam, eroded gently sloping phase. | 0–5 | Good | 10+ | 5–20 | These soils occur on high second bottoms. They have developed in old general alluvium derived chiefly from limestone materials. They are underlain at about 36 inches by a rather thick layer of mixed gravel, sand, silt, and clay in various proportions [predominantly CL, CH, GC, or GM (A-2, A-6, or A-7)]. |
| Eg | Etowah silt loam, eroded gently sloping phosphatic phase. | 0–5 | Good | 10+ | 5–20 | |
| Eh | Etowah silt loam, eroded sloping phosphatic phase. | 5–12 | Good | 10+ | 5–20 | |
| Ec | Etowah gravelly silty clay loam, severely eroded sloping phase. | 5–12 | Good | 20+ | 3–10 | |
| Ed | Etowah gravelly silty clay loam, severely eroded sloping phosphatic phase. | 5–12 | Good | 20+ | 3–10 | |
| Ee | Etowah gravelly silty clay loam, severely eroded moderately steep phosphatic phase. | 12–25 | Good | 20+ | 3–10 | |
| Fa | Frankstown cherty silt loam, eroded sloping phase. | 4–12 | Good to excessive | 20+ | 10–30+ | These cherty upland soils occupy narrow ridgetops. They have developed in cherty limestone and shale residuum. The soils are underlain at about 30 inches by thick beds of cherty materials [predominantly GC or GM (A-2)]. |
| Fb | Frankstown cherty silt loam, moderately steep phase. | 12–25 | Good to excessive | 20+ | 10–30+ | |
| Fc | Frankstown cherty silt loam, eroded moderately steep phase. | 12–25 | Good to excessive | 20+ | 10–30+ | |
| Fd | Frankstown coarse cherty silt loam, sloping phase. | 4–12 | Good to excessive | 30+ | 5–20+ | |
| Fe | Frankstown coarse cherty silt loam, eroded sloping phase. | 4–12 | Good to excessive | 30+ | 5–20+ | |
| Ff | Frankstown coarse cherty silt loam, moderately steep phase. | 12–25 | Good to excessive | 30+ | 5–20+ | |
| Fg | Frankstown coarse cherty silt loam, eroded moderately steep phase. | 12–25 | Good to excessive | 30+ | 5–20+ | |
| Fh | Frankstown coarse cherty silt loam, steep phase. | 25–60 | Good to excessive | 30+ | 5–20+ | |

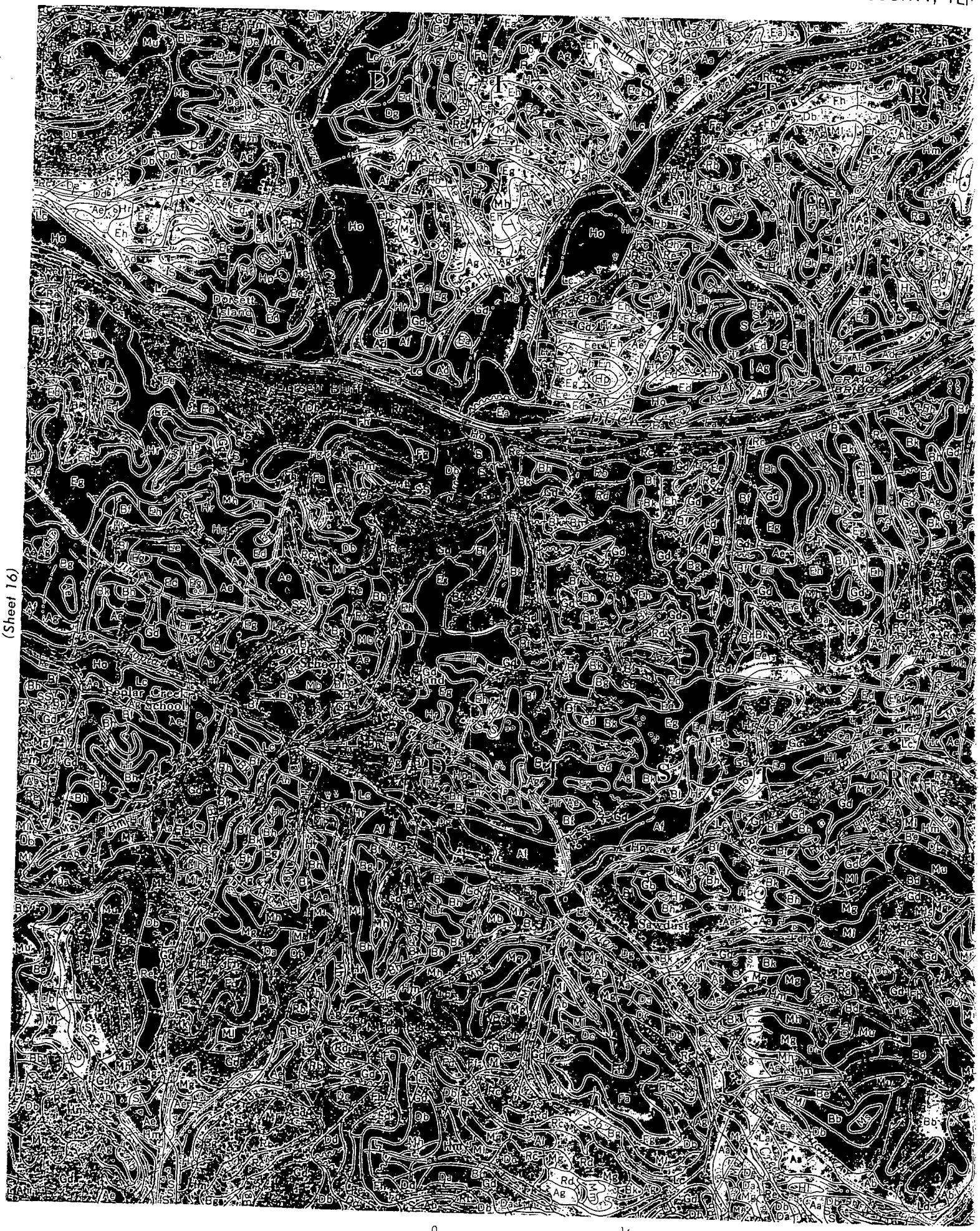
See footnotes at end of table.

TABLE 28.—*Characteristics of Maury County soils significant to engineering*—Continued

| Map unit symbol | Soil | Slopes | Natural drainage class | Depth to seasonally high water table | Depth to bedrock | Description[1] (Selected characteristics significant to engineering) |
|---|---|---|---|---|---|---|
| | | *Percent* | | *Feet* | *Feet* | |
| Hl | Huntington cherty silt loam, phosphatic phase. | 0–3 | Good | 0–5 | 4–10 | These cherty soils occur on first bottoms in flood plains. They are developing in young alluvium washed from limestone materials and are underlain at about 36 inches by cherty limestone residuum [predominantly GM or GP (A-1 or A-2)]. |
| Hm | Huntington cherty silt loam, local alluvium phosphatic phase. | 0–6 | Good | 0–5 | 4–10 | |
| Ho | Huntington silt loam, phosphatic phase. | 0–3 | Good | 0–5 | 10–20+ | These soils occur on first bottoms in flood plains. They are developing in young alluvium washed from limestone materials and are underlain at about 36 inches by sediments [predominantly CL, ML, or SC (A-2, A-4, or A-6)]. |
| Hr | Huntington silt loam, local alluvium phosphatic phase. | 0–6 | Good | 0–5 | 10–20+ | |
| Hn | Huntington silt loam, depressional phase. | 0–3 | Good | 0–5 | 10–20+ | |
| Hp | Huntington silt loam, depressional phosphatic phase. | 0–3 | Good | 0–5 | 10–20+ | |
| Ic | Inman and Hampshire silty clay loams, severely eroded sloping phases. | 4–12 | Moderately good to somewhat excessive. | 10+ | 10–20 | These upland soils have developed in shaly limestone residuum. The underlying shaly limestone residuum below about 12 inches is predominantly CH, MH, or SC (A-6 or A-7). |
| Ia | Inman shaly silty clay loam, severely eroded moderately steep phase. | 12–25 | Good to excessive | 20+ | 10–20 | These upland soils have developed in shaly or sandy limestone residuum. The underlying shaly limestone residuum below about 12 inches is predominantly CH, MH, or SC (A-6 or A-7). |
| Ib | Inman shaly silty clay loam, severely eroded steep phase. | 25–60 | Good to excessive | 20+ | 10–20 | |
| Lc | Lindside silt loam, phosphatic phase. | 0–3 | Moderately good to somewhat poor. | 0–2 | 5–20 | These soils occur on first bottoms in flood plains. They are developing in young alluvium washed from limestone materials and are underlain at about 30 inches by sediments [predominantly CL, ML or SC (A-2, A-4, or A-6)]. |
| Lb | Lindside silt loam, local alluvium phase. | 0–6 | Moderately good to somewhat poor. | 0–2 | 5–20 | |
| Ld | Lindside silt loam, local alluvium, phosphatic phase. | 0–6 | Moderately good to somewhat poor. | 0–2 | 5–20 | |
| La | Lindside cherty silt loam, phosphatic phase. | 0–3 | Moderately good to somewhat poor. | 0–3 | 4–10 | These cherty soils occur on first bottoms in flood plains. They are developing in young alluvium washed from limestone materials. Below 30 inches they are underlain by sediments [predominantly GM or GP (A-1 or A-2)]. |
| Ma | Made land | | | Variable | Variable | These are excavated and graded areas composed of soil material that varies widely. |

See footnotes at end of table.

(Sheet 16)




0 1/2 1 Mile

Scale 1:20 000

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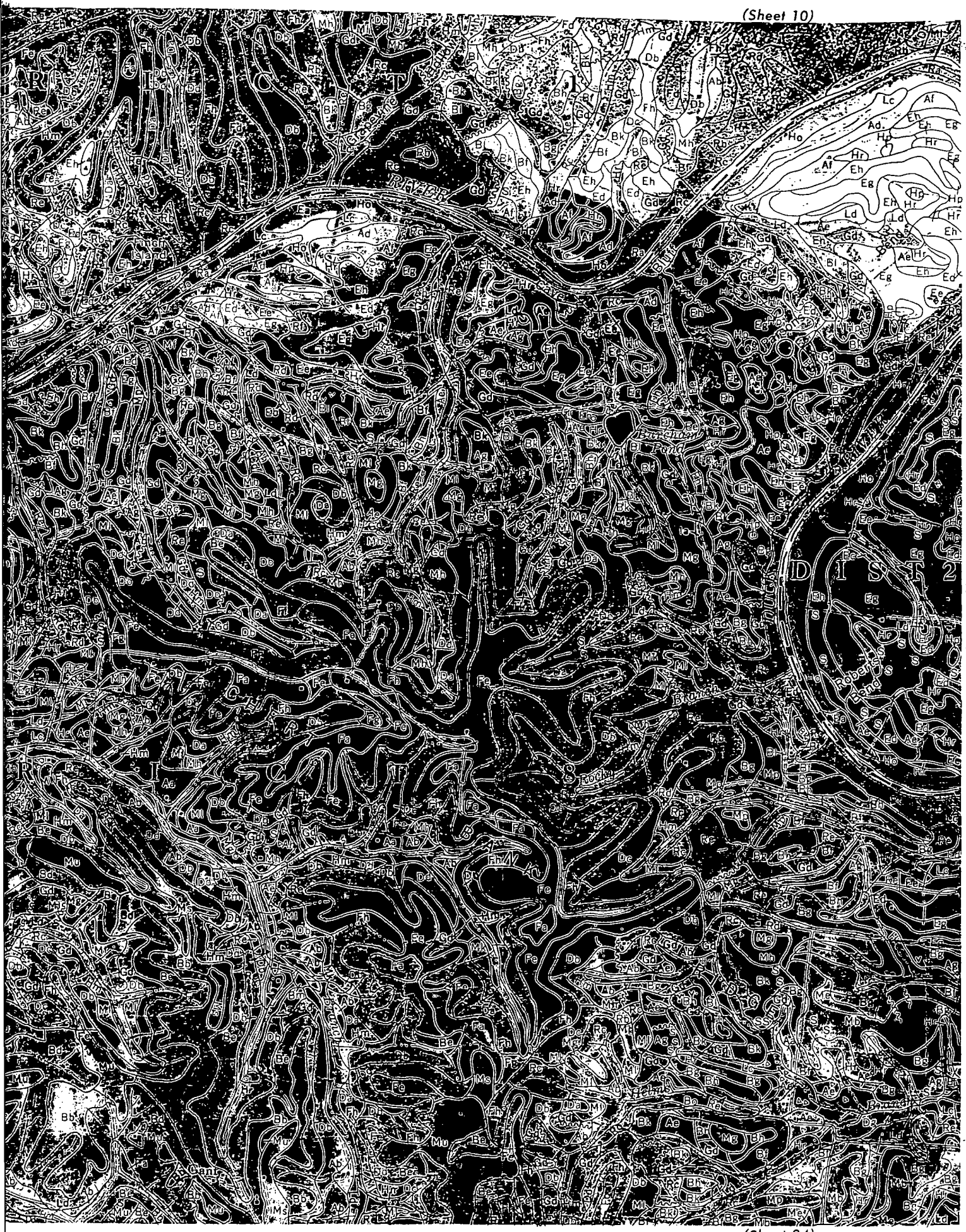


Scale 1:20 000 0 5000 Feet

18

N

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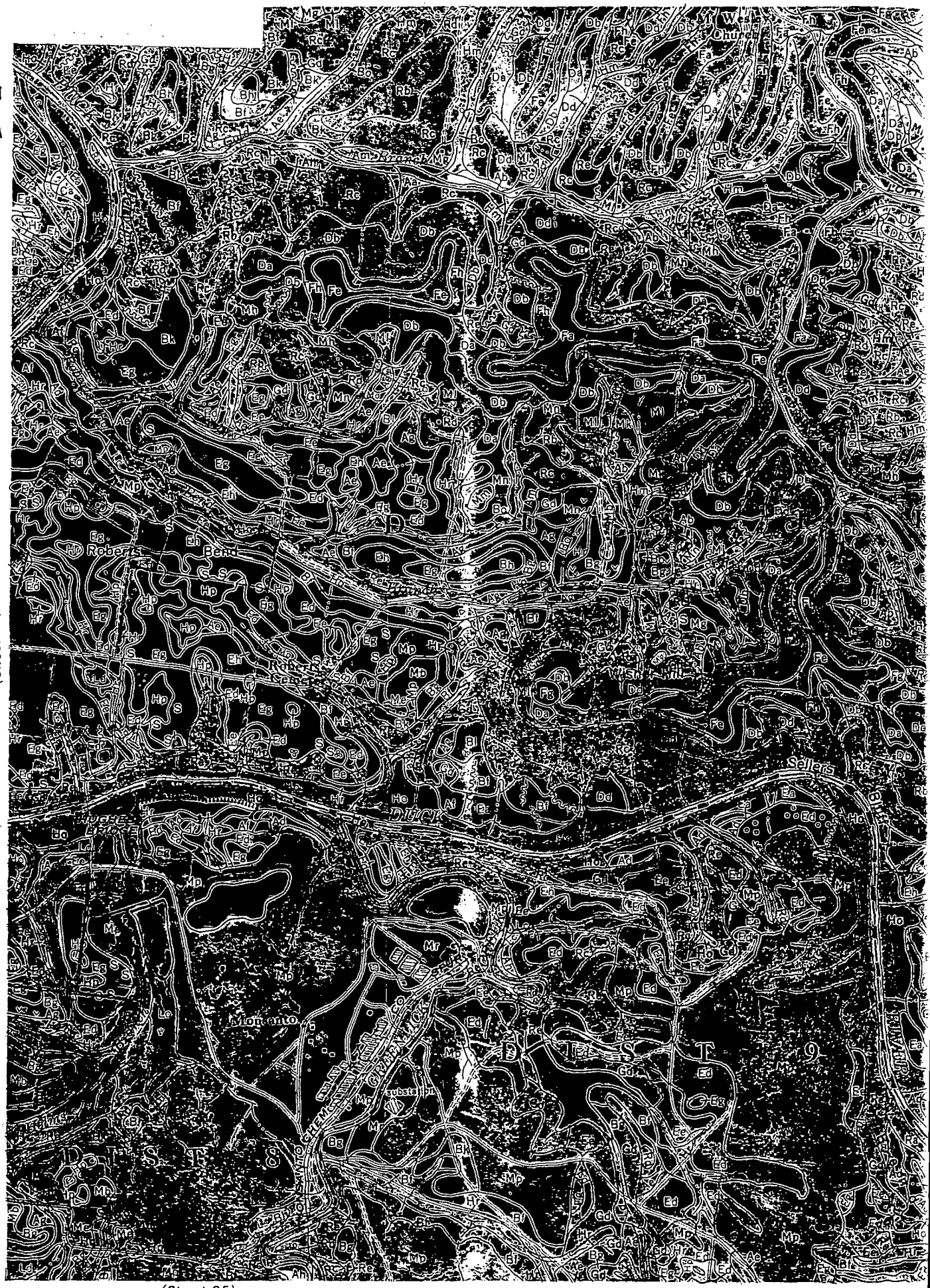


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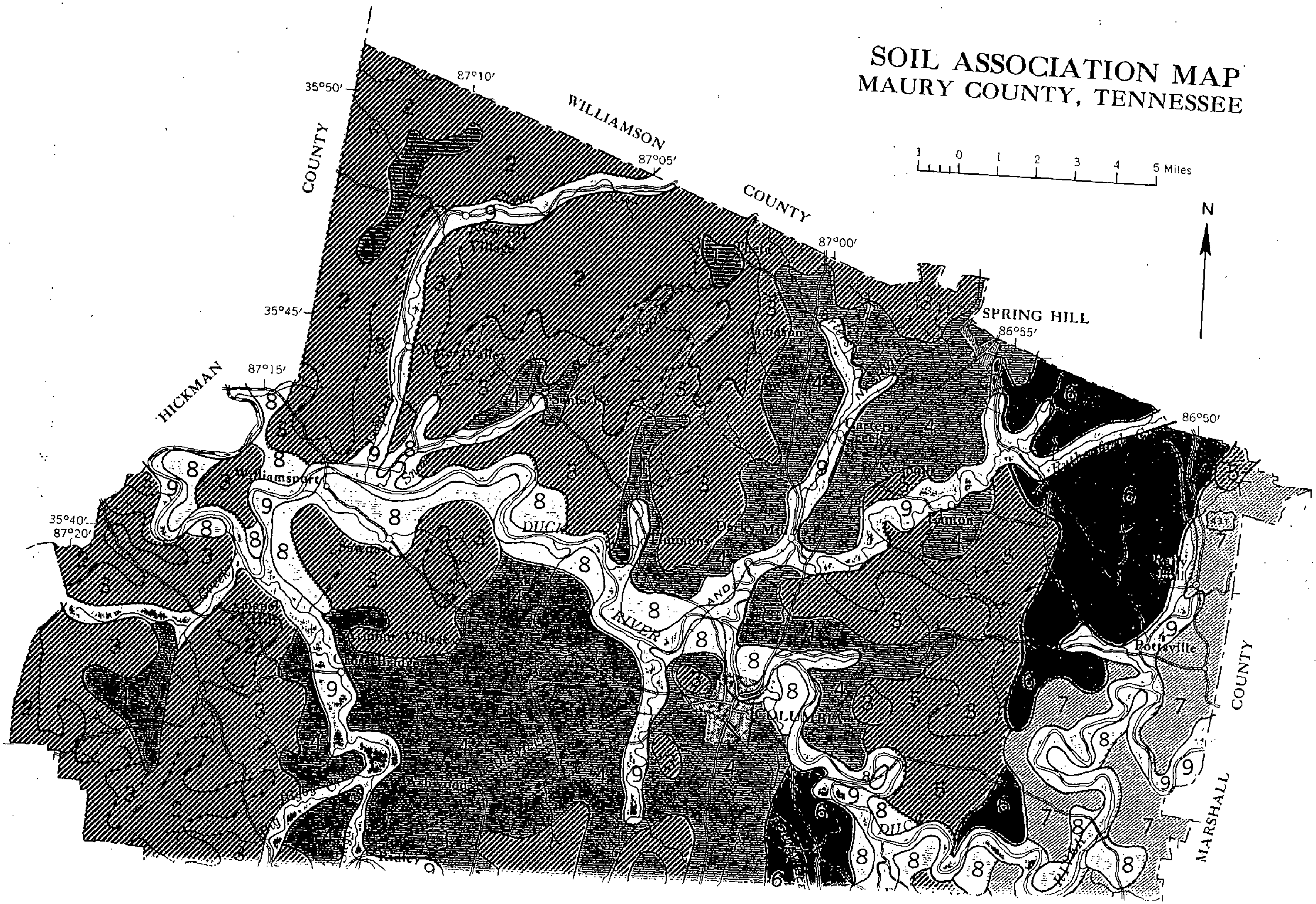
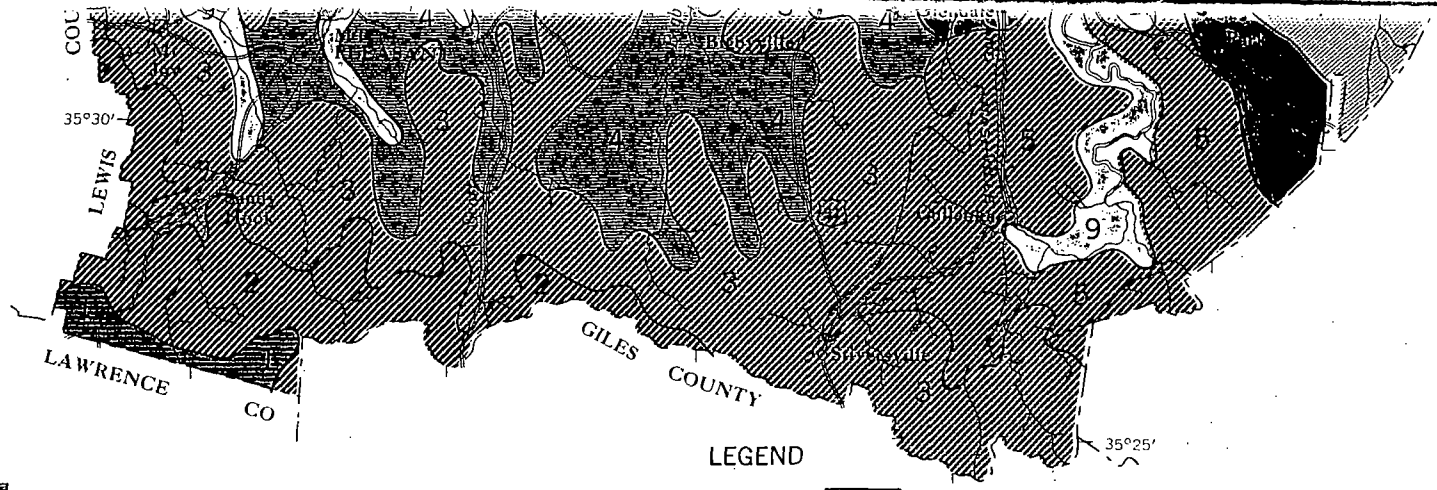
0 ½ 1 Mile

compiled from aerial photographs flown in 1949.

# SOIL ASSOCIATION MAP
## MAURY COUNTY, TENNESSEE






LEGEND

1 MOUNTVIEW - DICKSON

2 BODINE - MOUNTVIEW (SHALLOW PHASES) - PACE

3 DELLROSE - FRANKSTOWN - MIMOSA (CHERTY)

4 BRAXTON - MAURY - ARMOUR

5 INMAN - CULLEOKA - HICKS - MAURY (COARSE PHASES)

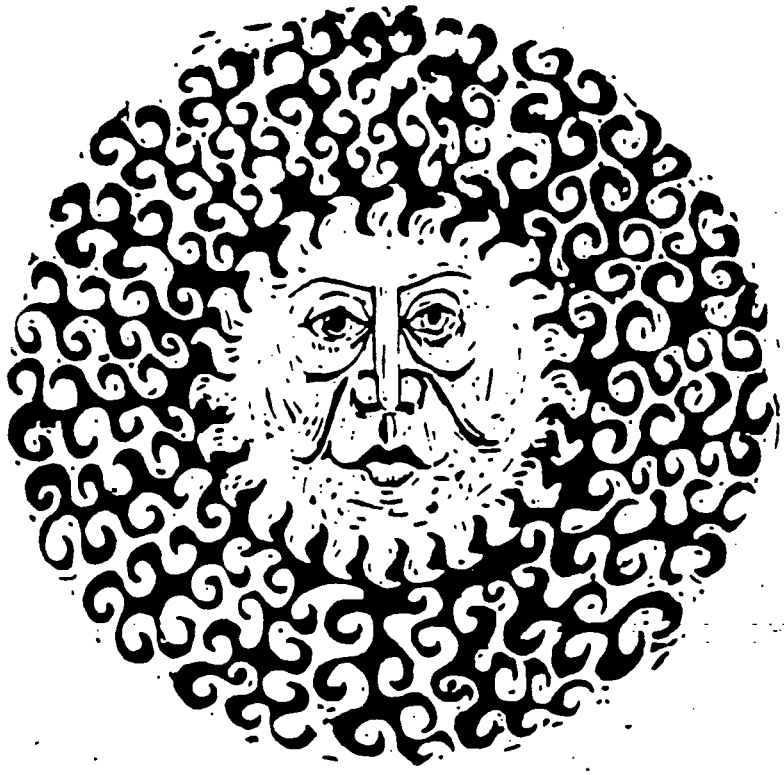
6 TALBOTT - HAGERSTOWN - ROCKLAND

7 ROCKLAND - TALBOTT - HAGERSTOWN (ROCKY)

8 ETOWAH - HUNTINGTON (LOCAL ALLUVIUM PHOSPHATIC PHASES) - EMORY

9 HUNTINGTON - LINDSIDE - ARMOUR (TERRACE PHASES) - EGAM

REFERENCE 4



# CLIMATIC ATLAS OF THE UNITED STATES

vironmental Science Services Administration . Environmental Data Servic

U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

ENVIRONMENTAL SCIENCE SERVICES ADMINISTRATION
Robert M. White, Administrator

ENVIRONMENTAL DATA SERVICE
Woodrow C. Jacobs, Director

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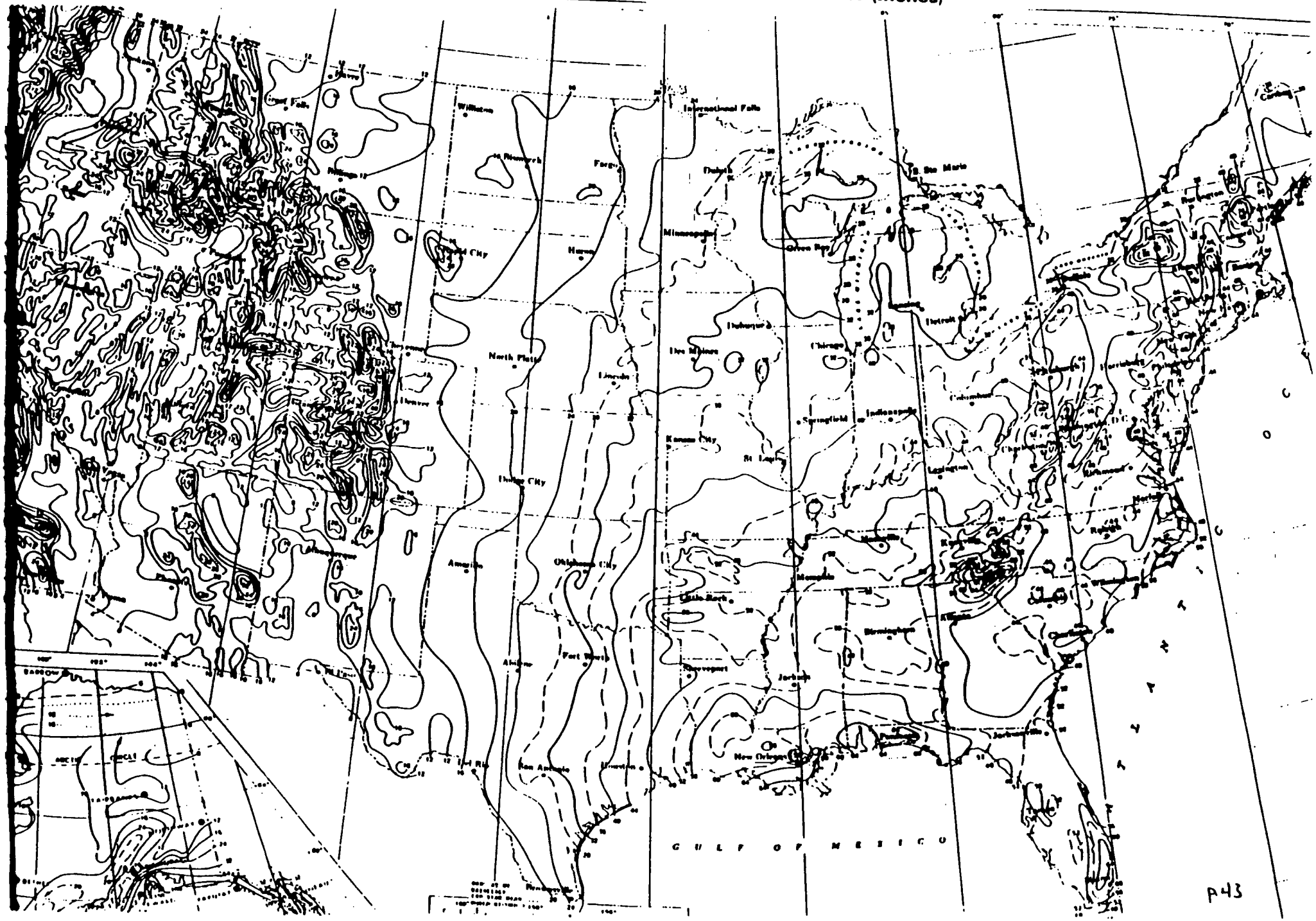
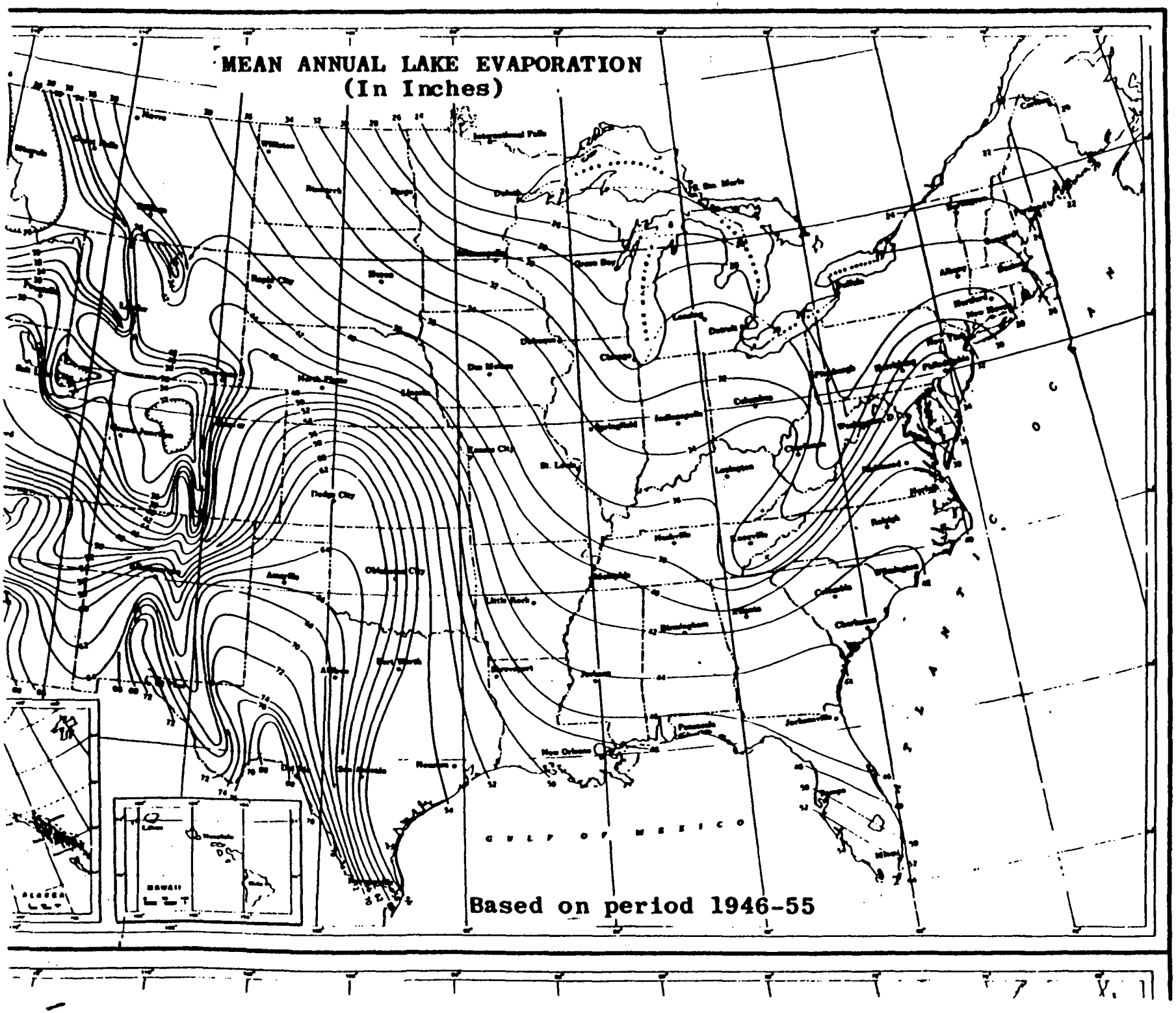
JUNE 1968

REPRINTED BY THE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
1983

# NORMAL ANNUAL TOTAL PRECIPITATION (Inches)




MEAN ANNUAL LAKE EVAPORATION
(In Inches)
Based on period 1946-55
GULF OF MEXICO

p. 63

DEPARTMENT OF COMMERCE
Jesse H. Jones, Secretary

WEATHER BUREAU
F. W. Reichelderfer, Chief

# TECHNICAL PAPER NO. 40

# RAINFALL FREQUENCY ATLAS OF THE UNITED STATES

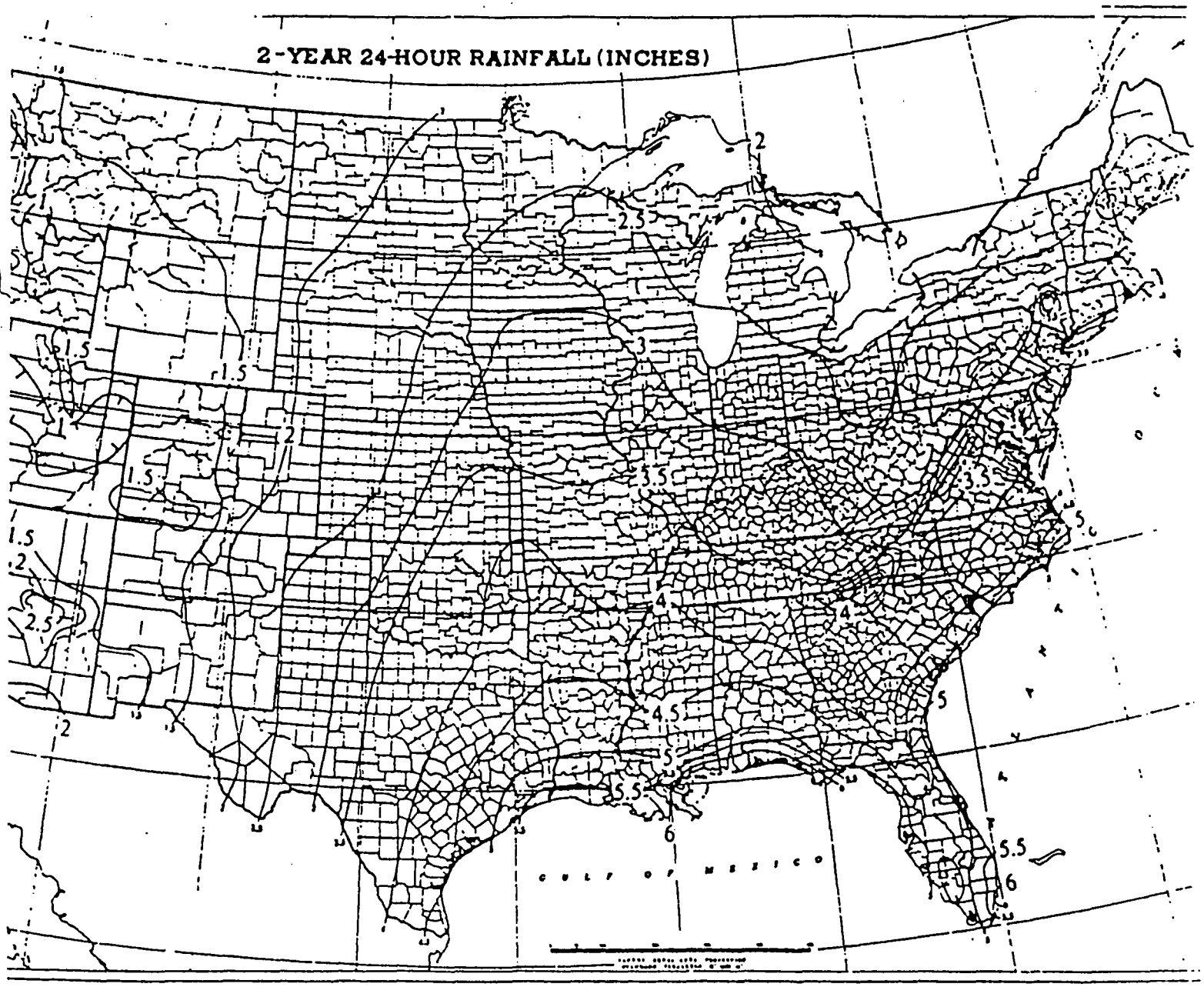
## for Durations from 30 Minutes to 24 Hours and Return Periods from 1 to 100 Years

Prepared by
DAVID M. HERSHFIELD
Cooperative Studies Section, Hydrologic Services Division
for
Engineering Division, Soil Conservation Service
U.S. Department of Agriculture

Ref. 17

PROPERTY
FIT

REFERENCE 5


2-YEAR 24-HOUR RAINFALL (INCHES)
GULF OF MEXICO
2
2.5
3
3.5
4
4.5
5
5.5
6
1.5
2.5

REFERENCE 6

# SITE INVESTIGATION
# COLUMBIA, TENNESSEE PLANT

Prepared For

MONSANTO INDUSTRIAL
CHEMICAL COMPANY

Columbia, Tennessee

December 1985

Prepared By

ENGINEERING-SCIENCE
57 Executive Park South, Suite 590
Atlanta, Georgia 30329

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# SECTION 1

# INTRODUCTION

## PROJECT BACKGROUND

The Monsanto elemental phosphorus plant at Columbia, Tennessee has been in operation since the 1930's processing phosphate ore to produce elemental phosphorus. Waste fluids and materials have been stored or disposed within the plant property boundaries continually since the operation began.

Twenty-one sites around the Monsanto plant have been identified as areas that possibly received waste or were process or storage areas. Some of these sites may have potential for impacting ground or surface water. Table 1.1 provides a summary of these sites and Figure 1.1 depicts their general location.

A program for monitoring ground water had been established at eleven of the sites. This program included drilling test borings, installing ground-water monitoring wells, measuring water levels and sampling and analyzing ground water. Past monitoring activities at each of the sites are summarized in Table 1.1.

A preliminary evaluation was conducted of the twenty-one sites with respect to site characteristics and potential impact to ground water. Data evaluated included information gained from interviews with present and retired Monsanto plant personnel. As a result of this evaluation, Sites 2, 14, 16 and 21 were dropped from further consideration because they were reported to contain negligible quantities of materials or were determined not to be actual storage or disposal sites. Additionally, Sites 1 and 10 were permitted landfills and were dropped from further investigation.

Characteristics of the remaining fifteen sites, including available data on wastes disposed in the sites and ground water quality determined from the ongoing ground water monitoring program, were evaluated. This evaluation was used to specify areas of the plant site for further

# SITE LOCATIONS AND EXISTING MONITORING WELLS

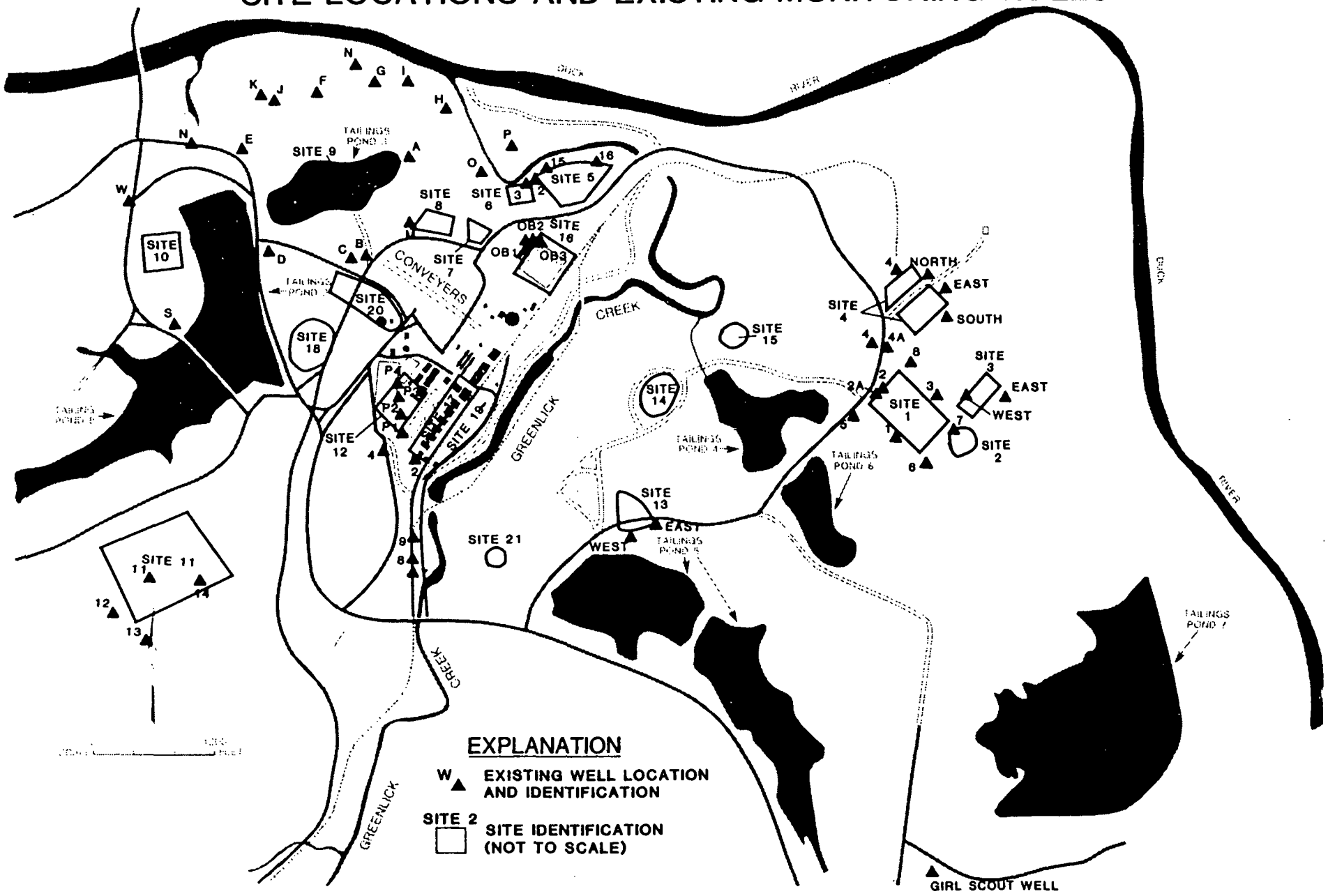


FIGURE 1.1

TABLE 1.1
SITE SUMMARY

| Site No. | Approximate years of operation | Description | Status | Monitoring program |
|---|---|---|---|---|
| 1 | 1980-1985 | Permitted phosphorus landfill | Active | 11 wells |
| 2 | 1940-1955? | Equipment erection site | Questionable disposal site | None |
| * 3 | 1950-1978 | Barrel dump (old Phos. Disposal Area) | Covered | 2 wells |
| * 4 | 1955-1978 | Phosphorus slurry dump (Phos. slurry Disposal site) | Covered | 5 wells |
| * 5 | 1950-1978 | Sanitary/solid waste dump (No. 1 Pond Disposal Facility) | Covered | 2 wells |
| 6 | 1950-1965 | Treater oil site | Covered | 2 wells |
| 7 | 1981-1985 | Dust collector dust | Active | None |
| 8 | 1973-1985 | No. 3 pond solids storage | Active | None |
| 9 | 1949-1985 | No. 3 pond-phossy process water | Active | 15 wells |
| 10 | 1979-1985 | Sanitary/solid waste landfill | Active | 3 wells |
| 11 | 1973-1985 | No. 3 pond solids disposal | Active | 4 wells |
| * 12 | 1948-1955 | Phosphorus tank farm (old Tank Farm site) | Covered | 7 wells |
| 13 | 1940-1982 | Coke dust dump | Covered | 2 wells |
| 14 | 1960-1970? | Phosphorus containing metal dump | Removed | None |
| 15 | 1965 | Wrecked phosphorus rail car scrap | Questionable waste existence | None |
| 16 | 1940-1945 | CWS Building (spills, leaks) | Questionable spills and leaks | None |

* Superfund sites



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TABLE 1.1
SITE SUMMARY

| Site No. | Approximate years of operation | Description | Status | Monitoring program |
|---|---|---|---|---|
| 17 | 1936-1985 | Phosphorus and Furnace Department | Active | None |
| 18 | 1956-1973 | No. 3 pond solids disposal | Covered | None |
| 19 | 1936-1985 | Furnace rail yard | Active | 3 wells |
| 20 | 1936-1950? | Million-gallon tank site | Covered | None |
| 21 | 1955? | Phosphorus pipe dump | Covered | None |

ground-water study. Areas were selected for study that had shown impacts to ground water in the past or that contained waste and materials that were evaluated as having a higher potential to impact ground water than other sites around the plant.

Five sites were selected as areas for further study. These included Site 4, the phosphorus slurry dump, Site 9, phossy water Pond #3, and a combination of Sites 12, 17 and 19, the tank farm, furnace area and railroad yard respectively.

Site 4 was selected because it contains large volumes of phosphorus containing slurry waste. A spring, apparently located downgradient from the site, has exhibited pH below 4.0, phosphates above 2500 mg/l and fluorides above 20 mg/l in results of past monitoring. Site 9 is a large process water pond (Pond No.3). This pond holds a large volume of process water containing elemental phosphorus and other constituents. Sites 12, 17 and 19 are areas impacted directly by plant operations and contain elemental phosphorus from spills and leaks during the years of plant operation. Elemental phosphorus was found in the ground during excavation in some areas of these sites.

The ten sites that now remained were considered for characterization by a field investigation and a review of available ground water data.

## OBJECTIVES

The objectives of this project were to determine the impacts or potential impacts of the Columbia plant operations and disposal practices on the hydrologic system. The investigation focused primarily on three major areas on the plant site to determine any impacts on ground water and any subsequent impacts on the surface receiving water bodies in the area.

## SCOPE

The scope of this project included a field investigation consisting of geophysical surveys, exploratory borings, installation of monitoring wells, stream-flow measurements and sampling of ground and surface waters as well as sediments and soils from borings.

Geophysical surveys were conducted at Sites 4, 9, 12, 17 and 19 in order to better define subsurface conditions and guide the follow-on exploratory boring and well installation program at those sites.

Monitoring wells were installed at these same sites in order to characterize ground-water quality and hydrogeologic characteristics. These sites were previously evaluated as having potential to impact ground water.

Exploratory borings for soil sampling were drilled at fourteen sites. Site 9 was not characterized by soil sampling as this site is a process water pond. Data existed on water and sediments in this pond. A minimum of one boring was drilled in each of these sites in order to obtain soil and waste samples for analysis and to aid in characterization of the sites with respect to the presence, chemical characteristics and depth of materials.

Stream-flow measurements were conducted along Greenlick Creek as part of the general hydrogeologic study in the plant site. Information was sought for determination of discharge and recharge areas of the creek.

Water was sampled from both newly installed monitoring wells and various surface sources in order to characterize water quality within potentially impacted areas of the plant site.

In addition to analysis of the results of the field investigation, this project included evaluation of previously existing data which has been collected over the years by the plant. The pre-existing data and recently collected data were used together to evaluate the site specific and overall hydrogeologic impacts that may exist at the plant site.

## SECTION 2

## FIELD INVESTIGATION

The field investigations at the Columbia plant site consisted of the following activities:

- Geophysical surveying
- Exploratory borings
- Monitoring well installation
- Boring location and well elevation surveying
- Stream flow measuring
- Surface water and sediment sampling
- Ground-water sampling
- Ground-water level measuring

A geophysical survey was conducted in each of the three major areas of study; the phosphorus slurry dump (Site 4), the Tank Farm, Furnace Area and Railyard (Sites 12, 17 and 19) and Pond No. 3 (Site 9). The geophysical survey was used to aid in the determination of overall hydrogeologic characteristics and for decisions on well installation locations.

Exploratory borings were conducted in order to provide samples of soil and waste material for characterization of the sites. A total of 54 exploratory borings were completed at 14 sites. Four borings were completed at the Slurry Dump Site, twenty-one borings were completed at the Furnace Department, Tank Farm and Railyard Site and one or more borings were completed at each of 10 other sites.

The borings at the Furnace Department, Tank Farm and Railyard Site were to aid in determining the extent of any elemental phosphorus in the area. These borings were generally advanced 20 feet into bedrock. The borings at the remaining sites were for the purpose of determining the characteristics and depth of waste material buried at each site. These borings were advanced through the waste materials until the base of

these materials was reached or bedrock was encountered. All borings were sealed with grout following sampling except those completed as wells.

Twenty-four monitoring wells were constructed at the three major areas of study. One of these wells (9-1) was completed in unconsolidated materials that overlie the bedrock. The remaining 23 wells were completed in the zone that generally included a portion of the unconsolidated materials and the weathered bedrock.

Measurements were obtained of streamflow at various locations in Greenlick Creek and water levels were measured in the newly installed ground-water monitoring wells in order to aid in overall site hydrogeologic characterization.

Samples were obtained of surface waters, sediments and ground water in order to characterize the quality of water at the plant site.

The location of new borings and wells and of surface water sampling sites are shown in Figure 2.1. Eight surface water sites (1, 2A, 3A, 5, 6, 11, 12, 13) were sampled. The sample site numbering was not sequential. A summary of field investigations conducted at each of the fifteen investigated sites is provided in Table 2.1.

## GEOPHYSICAL SURVEY

Geophysical surveys were conducted to determine the locations of fractures, solution channels, potentially impacted ground water, buried metallic objects and other information useful for the determination of site hydrogeologic conditions and waste characteristics. The surveys utilized many available methodologies, including electrical resistivity, electromagnetics, magnetometry and basic metal detection. The results of the geophysical survey are summarized below and presented in detail in Appendix A.

### Electrical Resistivity Methodology

The electrical resistivity survey consisted of both vertical and horizontal resistivity measurements. These measurements, obtained with a Bison Earth Resistivity Model 2350B meter, indicated the relative electrical resistance in ohms of the earth to the conductance of an induced electric current through metal probes or electrodes driven into the ground. As an example of the resistivity nature of the subsurface, a fresh-water uncontaminated aquifer will exhibit a relatively high

# LOCATION OF BORINGS, WELLS AND SURFACE WATER SAMPLING SITES

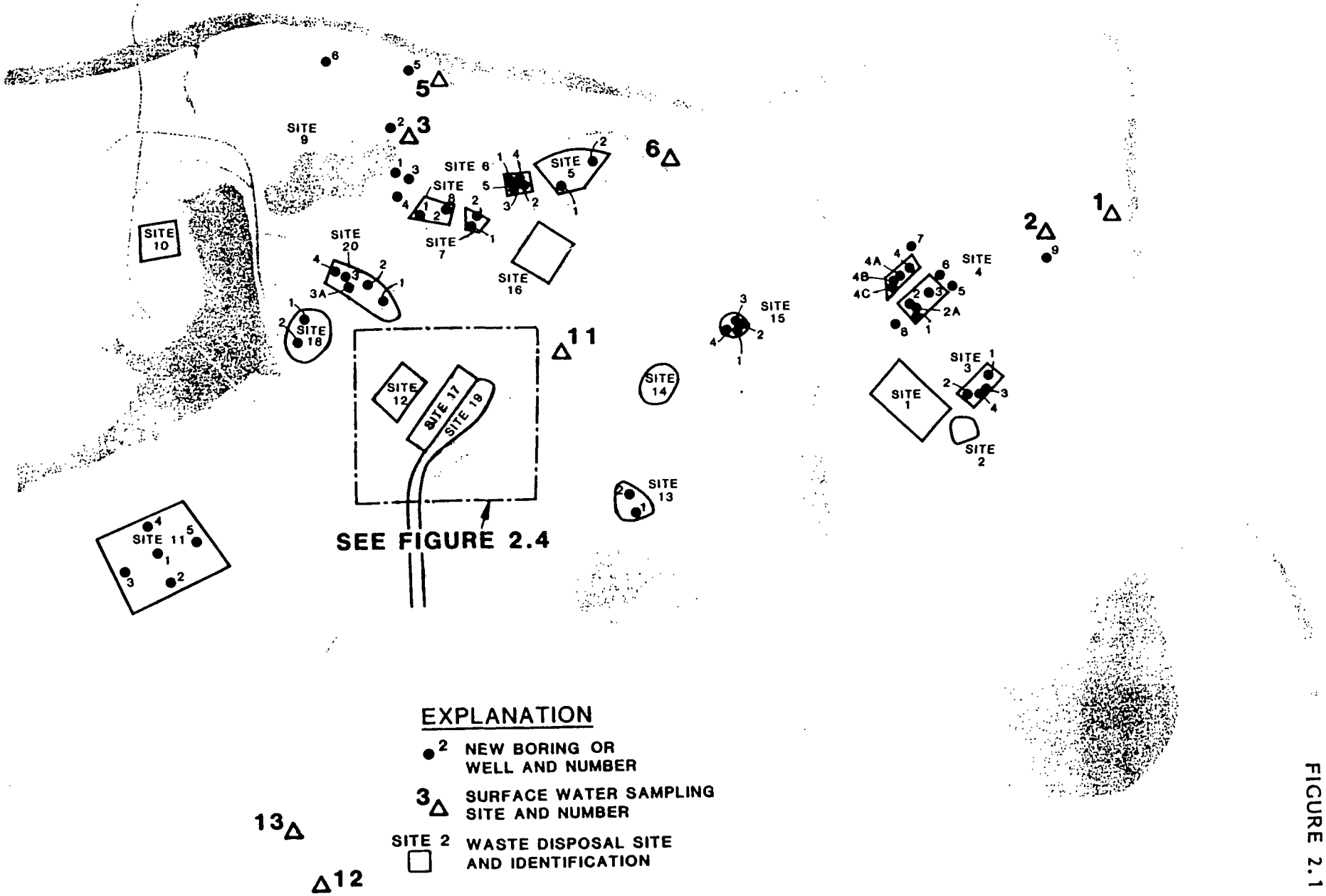



FIGURE 2.1

TABLE 2.1
SUMMARY OF FIELD INVESTIGATIONS

| Site No. | Geophysical Survey[1] | Number of Exploratory Borings | Number of Wells |
|---|---|---|---|
| 3 | MAG | 4 | - |
| 4 | ER, EM, MAG | 4 | 5 |
| 5 | - | 2 | - |
| 6 | - | 5 | - |
| 7 | - | 2 | - |
| 8 | - | 2 | - |
| 9 | ER | - | 6 |
| 11 | - | 5 | - |
| 12 | ER, EM | 8[2] | 4 |
| 13 | - | 2 | - |
| 15 | MAG | 1 | - |
| 17 | MET | 5[3] | 1 |
| 18 | - | 2 | - |
| 19 | ER | 8[4] | 8 |
| 20 | - | 4 | - |

[1] MAG - Magnetometer
ER - Electrical Resistivity
EM - Electromagnetic
MET - Metal Detector

[2] Four borings completed as wells

[3] One boring was completed as a well

[4] All borings were completed as wells

resistivity, whereas a fresh-water aquifer contaminated with organics and/or metals will exhibit a relatively low resistivity. Also, fracturing and/or solution cavities will exhibit a moderately low resistivity relative to solid bedrock. Fracturing and solution cavities are common in the bedrock of the Monsanto Plant area.

Vertical resistivity measurements are termed soundings indicating the variation of resistivity of various depths at one ground-surface point. The resistivity sounding method applied at the Monsanto Columbia Plant was the "Modified Wenner Electrode Array" (Carrington and Watson, 1981). In this method the current electrodes (those furthest from the center of the array) are stationary while the potential electrodes (those closest to the center of the array) are moved away from the center at equally spaced distances. In the "Modified Wenner Electrode Array" the potential electrode distance closely approximates the depth of investigation into the subsurface. For example, a sounding with a total potential electrode distance of thirty feet would indicate resistivity values at approximately thirty feet below the ground surface.

Horizontal resistivity measurements, on the other hand, are termed "profiles" and indicate the variation of resistivity at one approximate depth at many ground-surface locations. The resistivity profile method applied at the Monsanto Columbia Plant was the standard Wenner Array (Bison, 1975). In this method the current and potential electrodes are driven into the ground at equal distances from one another. The depth of investigation is a zone of the subsurface approximately three-fourths to one times the electrode spacing. For example, an electrode spacing of fifty feet in the Wenner Array would investigate a zone of the subsurface between approximately 38 to 50 feet deep. Three to four Wenner Arrays were utilized per site to distinguish shallow and deep subsurface variations in resistivity. The presentation of the profile data for each site is in the form of computer plots.

Electromagnetic (EM) Methodology

The electromagnetic (EM) survey consisted of continuous measurements at a constant depth of approximately six meters. These measurements, obtained with a Geonics EM31 ground conductivity meter, indicated the apparent conductivity of the ground in millimhos per meter. The EM31 operates by producing sinusoidally varying magnetic fields which

induce currents into the ground. The induced currents are linearly proportional to the terrain conductivity, the magnitude of which is determined by measuring the magnetic field they generate in the ground. The instrument then displays directly the apparent conductivity (Geonics, 1980). The EM31 was utilized at Sites 4, and 12 to confirm well and boring locations defined by electrical resistivity. As an example, given similar soil conditions per site area, the conductivity is essentially constant. The conductivity of the subsurface contaminated areas, however, was high relative to background conductivities. The areas of high conductivity correlated well with previously measured areas of low resistivity.

Magnetometer Methodology

The magnetometer survey consisted of station to station measurements to locate buried drums (Site 3) and a buried tank (Site 4 and Site 15). The measurements were obtained with a Geometrics G816/826A Proton Magnetometer which indicates the total magnetic field intensity in gammas. The magnetometer operates by temporarily polarizing the nuclei of the hydrogen atom in a sample of hydrocarbon fluid with a uniform magnetic field generated by a current in a coil of wire within the sensor. The spinning protons behave like small, spinning magnetic dipoles which, when the current is removed, precess about the direction of the earth's magnetic field. The precessing protons generate a signal in the coil within the sensor, whose frequency is precisely proportional to the total magnetic field intensity. This frequency is measured by a digitizer within the unit and converted to gammas with an accuracy of 1 gamma in the average earth magnetic field of 50,000 gammas (Breiner, 1973). As an example; background readings away from metallic or electrical objects indicate the local total magnetic field intensity. As a magnetic target (buried drum) is approached there is an increase in the local total magnetic field due to the interference produced by the target. This is indicated by the magnetometer as increased gamma readings.

Metal Detection Methodology

The metal detection survey was conducted with a Fisher TN-5 Pipe and Cable Locator. The TW-5 was used to locate buried pipes, cables, railroad tracks and various metallic debris. The TW-5 has an effective

depth of penetration of up to three feet, depending on the size of the target. The TW-5 operates by creating an alternating magnetic field around the transmitter coil. This primary magnetic field is nullified such that the receiver coil is not affected by the primary field. This is accomplished by orienting the planes of the two coils perpendicular to each other. The primary magnetic field will, therefore, induce eddy currents in a metallic target within range of the instrument. The eddy currents produce a secondary magnetic field which disrupts the existing null condition. The result is a deflection of the meter needle and an audio signal when a metallic object is within range (Benson, et al., 1982).

Summary of Findings

The use of various geophysical survey techniques proved to be fairly successful in characterizing the hydrogeology at the three major areas of investigation. Possible areas were identified where ground water may have been impacted by materials within the disposal sites. All of this information was beneficial for determining locations for monitoring well installations as well as aiding somewhat in the determination of site boundaries and site characteristics. A summary of individual site results is given in the following.

Site 3 (Phosphorus Barrel Dump)

Magnetometry was used to confirm the location of the barrels in this area. The survey was successful in locating and determining the boundaries of the buried trench. This information enabled location of an exploratory boring to sample the waste area.

Site 4 (Phosphorus Slurry Dump)

The electrical resistivity (ER) survey conducted at this site was very successful in determining the depth of the waste sites, locations of fractures and potential solution channels, and the presence and location of water with low resistivity. Evaluation of the data showed low resistivity water from the north slurry dump to the southeast around the dike and then northeast towards the Duck River. Low resistivity water was also determined to exist below both the south and west slurry dumps. A possible fracture connecting the north slurry dump and the slurry dump spring was also located.

An electromagnetic survey over the site was also conducted to confirm the results of the ER survey. Results of this information were used to place the five ground-water monitoring wells.

Site 9 (Pond No. 3)

An electrical resistivity survey was conducted at Site 9 to determine geologic characteristics and the presence of contaminant migration, if any. Good correlation was obtained between the results of soundings, with respect to the presence of fractures and formation depths, and the borings conducted at the site. ER profiles showed areas of low resistivity in ground water down to a depth of 100 feet along the eastern and northern side of the pond. However, detailed tracking of low resistivity ground water to the north was hindered by the steep topographical relief of the site. From the results of the geophysical survey conducted around Pond No. 3, no connection could be found between the pond and a sinkhole located to the east.

Site 12 (Phosphorus Tank Farm)

An electrical resistivity survey consisting of both soundings and profiles was conducted at this site. The soundings were successful in identifying the depth of unconsolidated materials at the site as well as the locations of underlying rock formations and fracture zones. The presence of fracture zones within the rock formations were interpreted as potential migration pathways.

The results of the ER profiling indicated the presence of low resistivity ground water to about 25 feet below the actual site of the abandoned tanks. Low resistivity water was found at about 10 feet deep between the "elephant pits" and the drum loading facility. At 25 feet, this low resistivity water is believed to exist southeastward from the "elephant pits" toward the location of the old spring.

This information was used for the site selection of ground-water monitoring wells. The well installations were successful in intercepting impacted water in these low resistivity areas.

An electromagnetic survey was conducted over the site of the buried tanks in order to locate them for exploratory borings. This effort was apparently successful for identifying the locations of two of the tanks.

Site 17 (Furnace Department)

Geophysical survey work using electrical resistivity in the vicinity of the furnace area was hindered by structural interferences. Metal detection was used as a guide for choosing exploratory boring locations.

Site 19 (Railyard)

An electrical resistivity survey was conducted at Site 19 utilizing both soundings and profiles. Soundings were successful in depicting the depth of unconsolidated fill material overlying the bedrock. Two separate zones of fractures were found at around 20 feet and 40 feet that were interpreted as preferential flow paths.

The results of profiling showed zones of low resistivity ground water along the road next to Greenlick Creek. Possible interference from buried ferrophosphorus material throughout Site 19 was considered. Decisions for locations of ground-water monitoring wells were guided by the results of the ER soundings and profiles.

EXPLORATORY BORINGS

The exploratory boring program at the Monsanto-Columbia plant began on June 27, 1985 and was completed on August 2, 1985. A copy of the boring and monitoring well specifications are presented in Appendix B. A total of 40 test borings were made in 13 locations. Table 2.2 provides depth information for each of these borings. Individual lithologic logs for all the borings are presented in Appendix C.

Site Number 3

This site is an inactive phosphorus barrel dump. Drums of phosphorus containing materials were reportedly brought here for disposal from the 1950's until 1978 when the area was closed and capped. According to plant personnel, the barrels were scattered about the area, and some were reportedly punctured prior to disposal. Two boring locations were initially chosen based on information from plant personnel. Both borings (3-1, 3-2) were advanced to rock without encountering either phosphorus or drums.

A survey of the area was made with a metal detector and a trench approximately 240 feet long by 30 feet wide was identified. Additional borings were drilled in the center of this trench. The first boring (3-3) was advanced to a depth of 3.5 feet where it met refusal on metal.

TABLE 2.2
EXPLORATORY BORINGS

| Boring Number | Depth |
|---|---|
| 3-1 | 54.4 |
| 3-2 | 34.3 |
| 3-3 | 3.5 |
| 3-4 | 21.6 |
| 4-1 | 28 |
| 4-2 | 66.5 |
| 4-3 | 49.6 |
| 4-4 | 10.0 |
| 5-1 | 58.9 |
| 5-2 | 57.5 |
| 6-1 | 10.5 |
| 6-2 | 13.9 |
| 6-3 | 2.5 |
| 6-4 | 13.5 |
| 6-5 | 11.9 |
| 7-1 | 42.2 |
| 7-2 | 43.8 |
| 8-1 | 3.3 |
| 8-2 | 17.9 |
| 11-1 | 13.6 |
| 11-2 | 17.4 |
| 11-3 | 23.0 |
| 11-4 | 3.3 |

TABLE 2.2

EXPLORATORY BORINGS

(CONTINUED)

| | Boring Number | Depth |
|---|---|---|
| | 11-5 | 49.0 |
| Tank area | 12-5 | 21.0 |
| | 12-6 | 13.1 |
| phosphorus spring | 12-7 | 13.9 |
| | 12-8 | 8.5 |
| | 13-1 | 49.5 |
| | 13-2 | 26.5 |
| | 15-1 | 7.5 |
| | 17-1 | 27.0 |
| | 17-2 | 34.6 |
| | 17-3 | 32.1 |
| | 17-4 | 25.4 |
| | 18-1 | 50.0 |
| | 18-2 | 46.5 |
| | 20-1 | 36.5 |
| | 20-2 | 3.7 |
| | 20-3 | 46.5 |
| | 20-4 | 19.0 |

Data on borings completed as wells are listed on Table 2.3

The drill rig was moved east a distance of about five feet and a second boring was drilled. This boring (3-4) was advanced to bedrock which was present 21.6 feet below land surface. Phosphorus bearing soil was encountered in borings 3-3 and 3-4. The site and boring locations were shown on Figure 2.1.

Site Number 4

This site is a closed phosphorus slurry dump. The site received phosphorus containing material, coke dust, and slurry from the phosphorus still and centrifuge from the mid 1950's until 1978 when it was closed and capped with a clay cap approximately three feet thick. The site also includes: (1) an area where asbestos containing phosphorus was placed, (2) an area where treater oil waste was placed, and (3) an area where some very large equipment containing phosphorus were buried.

Borings were drilled in four general locations (see Figure 2.1). Three boring locations were in the north and south dump and one in the west dump.

Boring 4-1 was located in the area which was reportedly used for treater oil disposal. Phosphorus bearing material was encountered in the boring. Boring 4-2 was located near the center of the southern portion of the slurry dump. The first boring at this site (4-2) was advanced to a depth of 34.3 feet at which point rock was encountered. The drilling rig was moved approximately 20 feet south and a second boring (4-2A) was advanced to a depth of 66.5 feet where rock was encountered. The second boring was drilled at this location because the geophysical survey conducted at the site indicated that bedrock generally occurred at depths greater than that encountered in boring 4-2. Phosphorus bearing material was encountered in both of these borings. Boring 4-3 was located in the center of the northern portion of the slurry dump. The boring at this site was advanced to refusal at a depth of 49.6 feet. Phosphorus bearing material was also encountered in this boring.

The west slurry dump consisted of slit trenches which were filled with phosphorus bearing material. Boring 4-4 was located near the center of the area. The first boring drilled at the site (4-4) met refusal at a depth of 10 feet and did not encounter any phosphorus material. Three additional borings (4-4A, 4-4B and 4-4C) were drilled in

the vicinity of 4-4 before phosphorus bearing material was encountered. Depth to rock was approximately 10 feet in all four borings.

Site Number 5

This site is a closed sanitary and solid waste disposal site. The area was originally Tailings Pond No. 1 and was used for sanitary and solid waste disposal from the 1950's until 1978, when it was closed.

Borings were drilled at two sites (see Figure 2.1). The first boring (5-1) met refusal at 12.5 feet due to obstruction from debris. A second boring (5-1A) was drilled 10 feet north of boring 5-1. This second boring reached a total depth of 58.9 feet. The boring at site 5-2 was drilled to a depth of 57.5 feet before encountering rock. Only a small amount of phosphorus bearing material was encountered at this site.

Site Number 6

Site Number 6 is a closed treater oil site which was used to store and clean oil containing phosphorus from treater explosion seals. Contaminated oil was heated with soda ash to remove the phosphorus. The oily sludge from the bottom of the treater cooker was drained to the ground.

Five borings were drilled in the area (see Figure 2.1). No phosphorus bearing material was encountered at borings 6-1, 6-2 and 6-3. Some phosphorus material and oily residue was found at boring 6-4. Boring 6-5 yielded 10 feet of oily residue and phosphorus contaminated material. Depth to rock at the drilling sites varied between 2.5 feet and 13.5 feet.

Site Number 7

Site Number 7 is an active dust collector dust storage pile. Dust collector dust and treater dust has been stored at this location since 1981. The material is recycled back into the manufacturing process. A treater oil disposal site was also located here. The area was observed to be "smoking" several times during the site investigation, indicating the presence of phosphorus containing material.

Two borings were drilled in this area (see Figure 2.1). Boring 7-1 was located near the center of the site, and boring 7-2 was located near the abandoned treater oil site. An oil sludge was encountered in boring 7-2. No other unusual conditions were encountered at the site. Depth

to rock at the site was relatively uniform with 7-1 refusing at 42.2 feet and 7-2 refusing at 43.8 feet.

Site Number 8

Site Number 8 is a closed phossy water pond solids storage area. Solids from the Number 3 phossy water pond were placed at the site from 1973 until early 1985. The pond solids have not been capped, although the area has been diked and graded.

Borings were drilled at two locations (see Figure 2.1) and only clayey soils were found. Depth to rock in the area appears to be variable from a high of 3.3 feet below land surface on the western portion of the fill area to 17.9 feet on the eastern portion of the site. No unusual conditions were noted from the borings.

Site Number 11

Site Number 11 also contains solids from the No. 3 phossy water pond. This site has been in use since 1973. Solids removed from pond No. 3 were being transferred here during the field investigation. Five borings were drilled in this area (see Figure 2.1) and only clayey soils were found. Boring 11-1 was located near the center of the area, and borings 11-2 through 11-5 were located with 11-2 being south, 11-3 west, 11-4 north, and 11-5 east of the center point. Depth to rock in the area was variable, ranging between 3.3 feet and 49 feet below land surface. No unusual conditions were noted from the borings.

Site Number 12

Site Number 12 is located in the plant area and is on the western side of the phosphorus storage and shipping area. The remains of twelve concrete (Gunnite) storage tanks are located in the area. The tanks were partially below grade and were used to store phosphorus and phossy water from 1948 to 1955.

Four borings (12-1 to 12-4) were drilled along the abandoned railroad track adjacent to the phosphorus loading station. These borings were sampled and then completed as wells. Borings were drilled at eight locations in this area. Two borings were drilled on the downhill side of two tank locations which were identified by the geophysics investigation. Two additional borings were drilled on the uphill side of an old phosphorus "spring." The boring locations near the abandoned tanks were numbered 12-5 and 12-6. The borings at the phosphorus spring site were

numbered 12-7 and 12-8. Phosphorus containing soil was apparently encountered in holes 12-6, 12-7, and 12-8 based upon "smoking" noted in the cuttings. Depth to rock at site 12 varied between 13.1 feet and 21.0 feet.

Site Number 13

Site Number 13 is a closed coke dust and dust collector dust disposal site. Coke fines and dust collector dust were deposited here from 1940 to 1982. The site is divided by a road into a north and south area. The north area has been revegetated. The south area still has coke fines exposed.

One boring was drilled in the south area (13-1) and one in the north area (13-2) (see Figure 2.1). The boring at site 13-1 was terminated at a depth of 49.5 feet and boring 13-2 was terminated 10 feet below the waste (coke fines) at a depth of 26.5 feet. No obvious phosphorus containing material was encountered at either location.

Site Number 17

Borings for site number 17 were located along the in-plant road which separates the furnace area from the phosphorus storage and shipping area. The area has been in use since the plant began operations in 1936. Underground phosphorus transfer lines are located in the area as well as below grade bulk storage tanks for phosphorus. The area is covered with asphalt.

Borings were drilled at five locations to aid in determining if phosphorus is present in this area. One boring was completed as a well. The borings were drilled 20 feet into bedrock by coring. The coring was done in continuous 10-foot segments. Between 3 and 15 feet of unconsolidated material was encountered in the boreholes before reaching rock.

All of the boreholes had evidence of phosphorus in the unconsolidated material. Boring 17-3 apparently had a large amount of phosphorus present in these materials since burning occurred. This boring was located adjacent to the existing phosphorus bulk storage tanks.

Corings from boreholes 17-1 and 17-2 showed evidence of phosphorus in the rock. The cores retrived from both of these boreholes smoked and burned. The core from 17-2 exhibited no fractures or cavities in the entire core. Burning was observed at spots along the core length.

Site Number 18

Site Number 18 is a mined out area and was used from 1956 to 1973 to store phossy water pond solids from the No. 3 pond. It has also been used to store coke, coal and miscellaneous kiln feed materials since 1973. The surface of the site is presently covered with coke fines.

Borings were drilled at two locations in this area (see Figure 2.1). Boring 18-1 smoked and had phosphorus present. Boring 18-2 did not exhibit any obvious phosphorus presence. Boring 18-1 was terminated at 50.0 feet, and boring 18-2 was terminated at 46.5 feet.

Site Number 19

Site 19 is located between the Furnace Department and Greenlick Creek and includes the slag pot cooling and holding area, traffic areas and the furnace railyard. The site reportedly contains sanitary waste and ferrophos disposal areas.

Borings were drilled at eight locations. These borings were all completed as wells. Borings 19-1 through 19-4 were completed in a line between the railyard and furnace area. Borings 19-5 through 19-8 were completed in a line adjacent to Greenlick Creek.

Borings 19-1 through 19-4 encountered cinders, weathered rock fragments and slag covering bedrock from 2 to 7 feet. Bedrock was found to be highly fractured. Borings 19-5 through 19-8, located nearer the banks of Greenlick Creek, found about a foot of silt, sand and slag overlying about 10 feet of heavier slag, cinders and rock fragments. This was followed by a foot or two of clays and organic material overlying bedrock. Rock was generally encountered at 16 feet. No evidence of waste material other than slag and cinders was found in the borings.

Site Number 20

Site number 20 is also called the million gallon tank site and the Arkansas Steel Site. The site is suspected of being a mined out cutter 20 feet wide by 50 feet deep by 100 feet in length which reportedly may have been used for disposal of phosphorus containing materials in the 1930's and 1940's.

Borings were drilled at four locations on a line extending west from the million gallon tank (see Figure 2.1). Borings 20-1 and 20-2 were located east of the contractors gate and borings 20-3 and 20-4 were located west of the contractors gate. Coke fines cover the area west of

the contractors gate. One boring was drilled at each location except at 20-3, which had two borings. The first boring (20-3) was stopped at a depth of 15.2 feet when buried metal was encountered. When the drill rig was relocated 10 feet south and boring 20-3A was drilled, debris was encountered. Buried metal was encountered at a depth of 19.0 feet in boring 20-4. Depth to bedrock was variable at the site ranging from 3.7 feet below land surface to a depth greater than 46.5 feet.

No obvious phosphorus contamination was observed in any of these four borings.

MONITORING WELLS

The installation of monitoring wells at the Monsanto-Columbia plant was accomplished concurrently with the exploratory boring program and extended from June 27, 1985 to August 2, 1985. A total of 24 wells were installed at five sites. Table 2.3 provides depths for each of these wells. A detailed sketch of each well installation is included in Appendix D.

Site 4

Five wells were installed at Site 4 (see Figure 2.2). Wells numbered 4-5 and 4-6 were installed on the north side of the slurry dump area and are located where the results of the geophysical survey indicated low resistivity water was present. Well 4-5 is seated in bedrock and is shallow (27.5 feet), while well 4-6, also seated in bedrock, is relatively deep (52.5 feet). These wells were drilled to sample ground water in the immediate site vicinity. Well 4-9 (17.9 feet) is located halfway between the Duck River and wells 4-5 and 4-6. Well 4-9 was drilled to gain information about changes in water quality downgradient from the site.

Wells numbered 4-7 and 4-8 are located in secondary low resistivity areas identified by the geophysical survey. Well 4-7 (34.5 feet) is located northwest of the west slurry dump and well 4-8 (48.7 feet) is located south of the slurry dump.

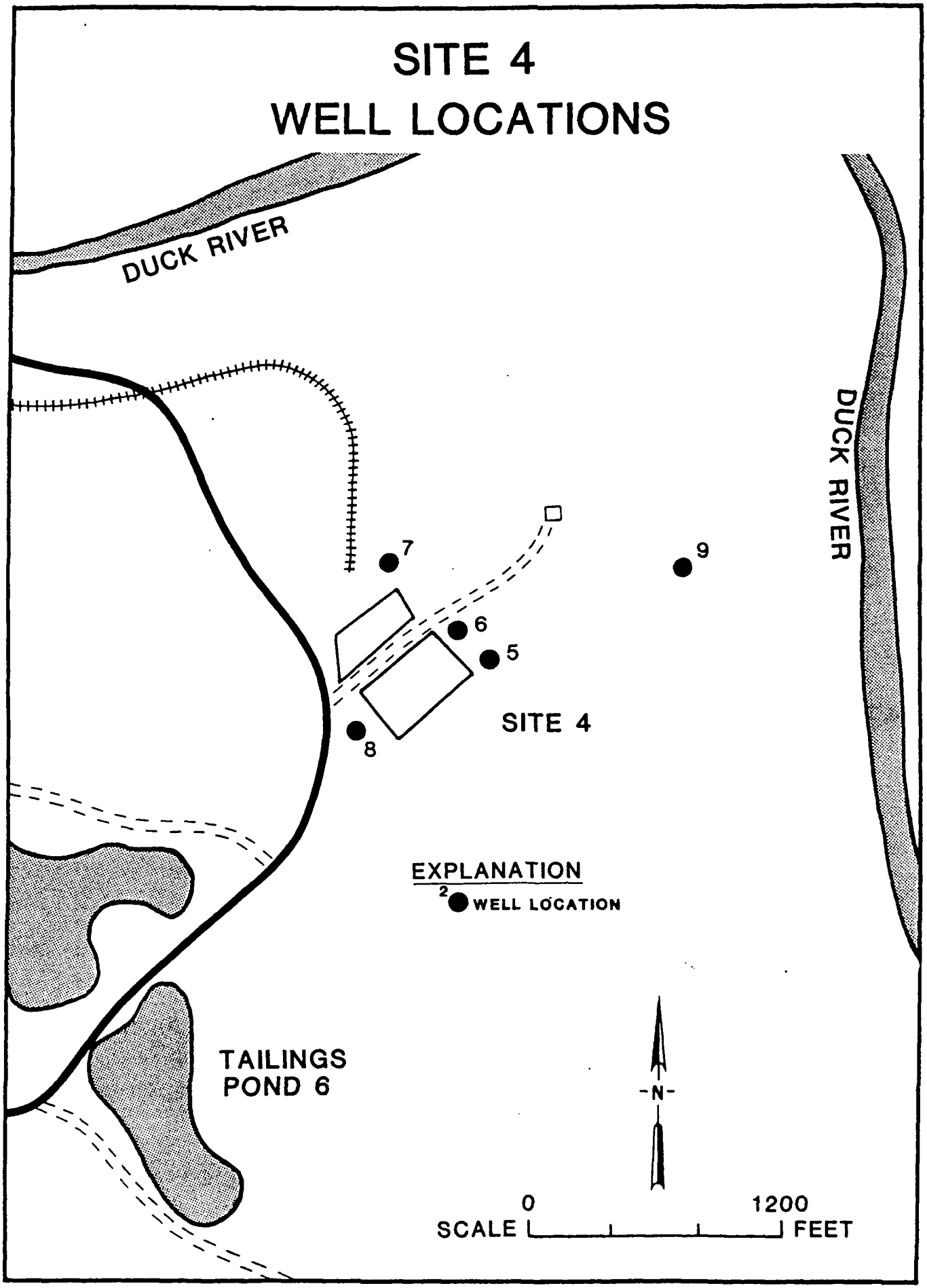
Site 9

Site 9 is also known as the No. 3 pond or the phossy water pond. Phossy water from the furnace and the phosphorus departments is routed to the pond for clarification after the bulk of the phosphorus has been

TABLE 2.3
MONITORING WELLS
COLUMBIA, TENNESSEE

| Well Number | Depth |
|---|---|
| 4-5 | 27.7 |
| 4-6 | 52.5 |
| 4-7 | 34.5 |
| 4-8 | 48.7 |
| 4-9 | 17.9 |
| 9-1 | 77.0 |
| 9-2 | 73.7 |
| 9-3 | 84.5 |
| 9-4 | 52.9 |
| 9-5 | 44.1 |
| 9-6 | 34.4 |
| 12-1 | 40.0 |
| 12-2 | 40.0 |
| 12-3 | 39.0 |
| 12-4 | 35.1 |
| 17-5 | 19.0 |
| 19-1 | 32.2 |
| 19-2 | 50.4 |
| 19-3 | 19.2 |
| 19-4 | 45.0 |
| 19-5 | 42.0 |
| 19-6 | 48.2 |
| 19-7 | 28.6 |
| 19-8 | 39.6 |

FIGURE 2.2






ES ENGINEERING-SCIENCE

removed. Lime is added to the water prior to its discharge to the pond to facilitate solids settling. Settled solids are removed by dragline and cast on the outside of the dike for additional dewatering. These solids are then removed to storage and disposal sites on the property.

Six wells were installed in the vicinity of the pond (Figure 2.3). Well 9-1 (71.5 feet) is located on the dike adjacent to the phossy water inlet pipe and was installed in unconsolidated material. Well 9-3 (84.5 feet) is located north of Well 9-1 and is at the toe of the dike. Well 9-3 is screened in bedrock. Wells 9-1 and 9-3 are a cluster well site for the purpose of sampling ground water at the pond site. Well 9-2 (73.6 feet) is located northwest of the pond inlet and is in an area of low resistivity water identified by the geophysical survey. Well 9-4 (49.1 feet) is located southeast of Well 9-1 and is also located in an area suspected of having low resistivity water based on the results of the geophysical survey. A buried abandoned pipe was encountered at a depth of 25 feet during the installation of Well 9-4. This may account for the apparent low resistivity reading obtained in the geophysical survey.

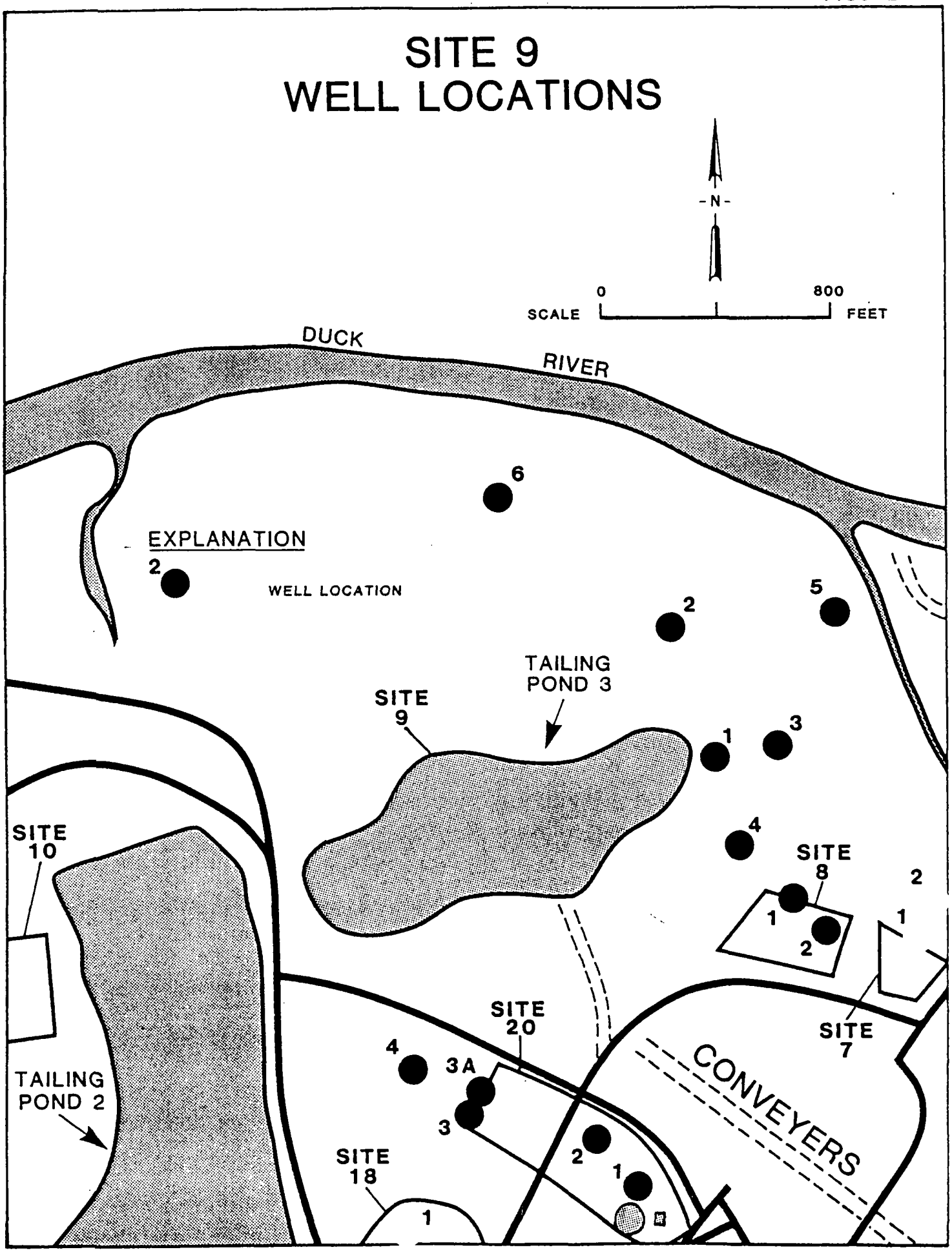
Wells numbered 9-5 (34.4 feet) and 9-6 (44.1 feet) are located north and northwest, respectively, of Well 9-1 and are in the floodplain of the Duck River. Both of these wells penetrated the Carter Limestone which is close to the surface in this area. These wells are for the purpose of gaining information about ground-water quality downgradient from the site.

Site 12

Four wells are located in this area (Figure 2.4). Wells numbered 12-1 (39.1 feet), 12-2 (40.0 feet), and 12-3 (39 feet) are located on the abandoned railroad track adjacent to the phosphorus tank car loading station. The soil in the area of Well 12-2 apparently contains phosphorus as evidenced by "smoking" being observed. Ground water from well 12-2 was observed to smoke as well. Well 12-4 (35.2 feet) is located north of the truck loading station.

These wells, together with wells at Sites 17 and 19, were drilled to determine if ground water has been impacted in the general area and to gain information about changes in ground-water quality that might occur in these areas.

FIGURE 2.3


SITE 9
WELL LOCATIONS
N
0
800
SCALE
FEET
DUCK
RIVER
EXPLANATION
2
WELL LOCATION
6
2
5
TAILING
POND 3
SITE
9
1
3
4
SITE
10
SITE
8
2
1
2
1
SITE
20
SITE
7
4
3A
CONVEYERS
TAILING
POND 2
3
2
1
SITE
18
1

Site 17

One well, 17-5 (19.0 feet) was installed at Site 17 (Figure 2.4). No evidence of elemental phosphorus was observed during the installation of the well.

Site 19

Site 19 includes the slag pot cooling and holding area and the furnace rail yard. No evidence of phosphorus was observed during the installation of the eight wells at this site. However, the holes drilled for the placement of guard pipe smoked at well 19-7.

The wells at this site are located in two lines (Figure 2.4). Wells 19-1 through 19-4 are located along a guard rail which separated the active slag hauler area from the rest of the rail yard. Wells 19-5 through 19-8 are located along the bank of Greenlick Creek. The middle two wells in each line are cluster wells with Wells 19-2 and 19-6 being the deep wells and 19-3 and 19-7 being the shallow wells in the cluster. Wells 19-1 through 19-4 range in depth from 19.2 feet to 50.4 feet, and wells 19-5 through 19-8 range in depth from 28.5 feet to 52.0 feet.

Well Development

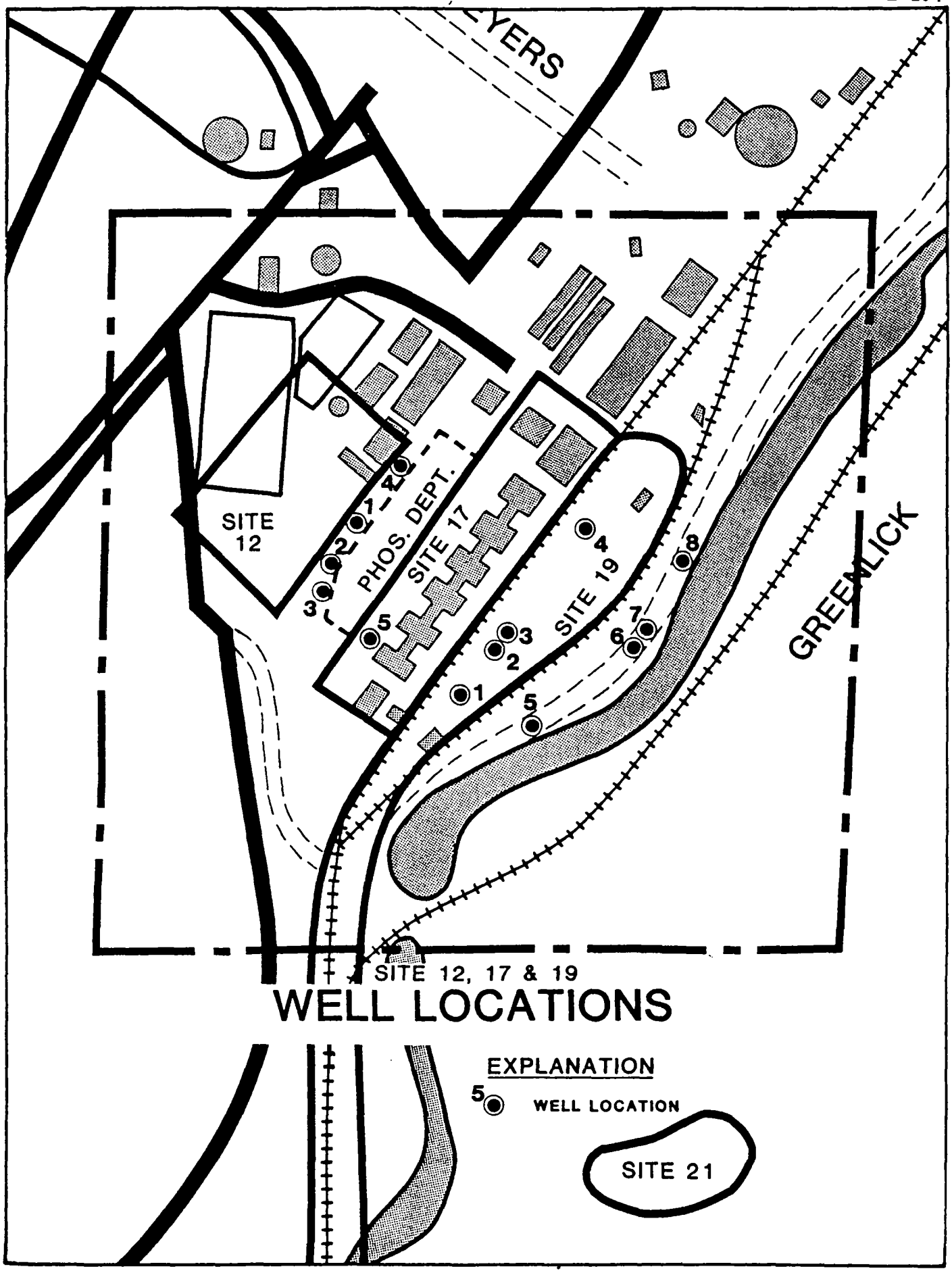
All wells except wells 19-1 to 19-5 were developed using a hand held piston pump. Wells 19-1 through 19-5 were developed using compressed air. A minimum of 10 casing volumes of water was removed from each well.

SUBSURFACE SOIL SAMPLING

Soil samples were taken from all of the exploratory borings. Soil sampling was generally begun at the surface. Exceptions to this practice occurred at sites 6, 17, and 19. Sites 6 and 19 had a slag cover and site 17 had an asphalt cover over the soil. Sampling at these sites was begun approximately one foot below land surface. Subsequent samples at each location were taken at five foot intervals. All soil samples were collected in accordance with the technical specifications given in Appendix B.

Before beginning drilling operations at each well or borehole location, the drill rig was washed according to the specifications set forth in Appendix B.

FIGURE 2.4


YERS
SITE 12
PHOS. DEPT.
SITE 17
SITE 19
GREENLICK
SITE 12, 17 & 19
WELL LOCATIONS
EXPLANATION
WELL LOCATION
SITE 21

Composite soil samples were made by Monsanto and subjected to elemental phosphorus analysis. The individual sample container and their contents were then delivered to ES personnel by Monsanto.

Composite samples for elemental phosphorus analysis were taken from four rock cores: 17-1, 17-2, 19-6, and 19-8. Two of these cores, 17-1 and 17-2, were observed burning. The two cores were judged to contain phosphorus by the geologist who performed the lithologic logging of the cores. Representative pieces of the cores were taken every 2.5 feet of core length and placed in two sample jars. One composite sample was given to Monsanto for elemental phosphorus analyses and one was retained by ES personnel. Analysis of the rock core samples for elemental phosphorus was not successful.

## WELL LOCATION AND ELEVATION SURVEY

A survey was conducted to ascertain the elevation and location of the exploratory borings and the monitoring wells. Boring and well locations were surveyed to an accuracy of plus or minus one foot while boring and well elevations were surveyed to plus or minus 0.01 foot. Results of surveyed locations and elevations are presented in Appendix E.

## STREAMFLOW MEASUREMENTS

A series of streamflow measurements were made on Greenlick Creek and tributaries in order to provide quantitative information on the flow in Greenlick Creek from its entry into the plant boundaries until its discharge into the Duck River. Particular attention was focused on the portion of Greenlick Creek flowing from the dammed area adjacent to the plant site proper to the confluence with the Duck River.

The intention was to determine the presence of ground water discharge to the creek or recharge from the creek in the plant property. This information would be used in the overall hydrologic assessment of the plant property, particularly in the vicinity of disposal sites located near Greenlick Creek.

### Measuring Point Selection

An evaluation was made of potential measuring points by noting the course of Greenlick Creek through the plant property in relation to

topographical features and the location of disposal sites. Fifteen stations were initially selected, seven on Greenlick Creek and eight located in drainage areas to Greenlick Creek or from Site 4 to the Duck River. Ground investigation revealed no flow in most of the drainage areas during this period of time, therefore, initially only stations 5, 6, 11, 12 and 13 on Greenlick Creek were selected for measurement (see Figure 2.1).

Station number 5 was just upstream of the rocks located at the confluence of Greenlick Creek and the Duck River. Water depth at this point varied up to about 4 feet and the stream width was about 32 feet.

Station number 6 was just upstream of the point where the creek enters the culvert under the railroad tracks at the ore loading station. This point was about 12 feet wide and varied from 1 to 2 feet deep.

Station number 11 was about 50 yards downstream of the dam on Greenlick Creek. The width here was about 25 feet and the depth varied up to about one foot.

Station numbers 12 and 13 were upstream of the plant site boundary. Number 12 was on Greenlick Creek at the point where the bridge for Hicks lane is located. The width of the creek at this station was about 15 feet and the depth varied from 6 inches to a foot. Station 13 was located on Gin Creek, upstream of the backwaters of the dammed area of Greenlick Creek. This stream was about 5 feet wide and 0.5 feet deep.

Following evaluation of the results for stations 5, 6, 11, 12 and 13, a second set of measurements were taken two weeks later at stations 5A, 6 and 11A.

Station number 5A was located downstream of these rocks at a point just before Greenlick Creek enters the Duck River. Depth at this location varied from about 6 inches to a foot. The width of the stream was about 19 feet. A second branch draining into the Duck River about 3 feet wide was also found and measured.

Station number 11A was about 75 yards downstream of the dam at a location where creek width was 11 feet and depth around one foot.

In addition to measurements on Greenlick Creek, the drainage area from the spring at Site 4 was investigated for flow measurements. The main spring was dry. However, flow existed downgradient towards the

Duck River. A station was selected between a ponded location and the Duck River, designated station 1. The very low flow at this point allowed measurement to be made by volumetric means.

Measurement Procedure

Measurements were made using either the Price AA or Price Pigmy current meters, depending upon stream conditions. These meters consist of an impeller and an electric circuit for counting revolutions induced by flow past the impeller. A basic relationship is used to convert revolutions per second to a measured water flow rate of feet per second.

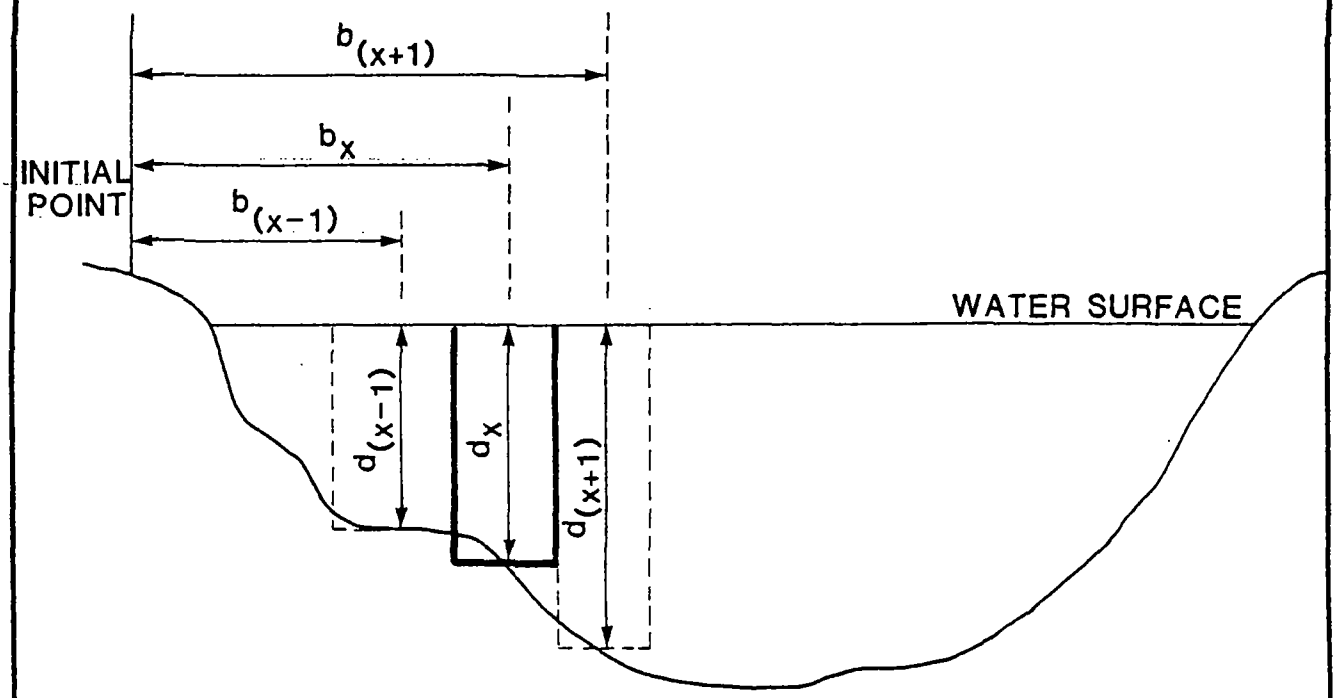
A section of stream was selected that was fairly straight and generally uniform, which offers the best results for this measurement method. The cross section of a stretch of creek was subdivided into a number of rectangular areas whose centerline extends from the surface of the water to the sounded depth at that point in the creek (Figure 2.5). Measurements of stream velocity at various depths down the centerline of the rectangle were used to estimate mean velocity through that rectangular area. Flow rate is then determined for that rectangle and summed with flow rates likewise determined for the other rectangles across the creek to determine overall creek flow.

The depths selected for measurement of stream flow were either based on the six-tenths depth method or the two-point method. In the 0.6-depth method, an observation of velocity made at 0.6 of the depth below the surface in the vertical is used as the mean velocity in the vertical. This method was generally used for creek depths below 2.5 feet. In the two-point method, observations are made at 0.2 and 0.8 of the depth below the surface and the mean velocity is the average of these two measurements. This method was used for depths greater than 2.5 feet. Most depths in Greenlick Creek were less than 2.5 feet.

The horizontal distance between measuring points across the stream, which determines the width of the rectangle, is chosen based upon the depth of the stream. For shallow portions of the creek the distance between measuring points was generally chosen to be greater than for deeper portions of the creek.

FIGURE 2.5

# STREAM FLOW MEASUREMENT




b: distance from initial point to stream velocity measuring point

d: depth of creek at stream velocity measuring point

Figure 2.5 depicts examples of measurements. Discharge through a partial section is computed by:

$$q_x = Vx \; \frac{b_{(x+1)} - b_{(x-1)}}{2} \; dx$$

Where: $q_x$ = discharge through partial section x

Vx = mean velocity at location x

bx = distance from initial point to location x

$b_{(x-1)}$ = distance from initial point to preceding location

$b_{(x+1)}$ = distance from initial point to next location

dx = depth of water at location x

Streamflow Results

Initial streamflow measurements were taken July 17 at Station 5, July 18 at Stations 6 and 11, and July 19 at Stations 12 and 13. Results of these measurements are shown in Table 2.4.

Net discharge to the impounded area of Greenlick Creek was found to have varied over the time of these measurements so a second set of measurements on Greenlick Creek was taken August 1 between the dam and the confluence with the Duck River. These measurements were taken at Stations 5A, 6 and 11A. Measurements were also taken of the discharge to Greenlick Creek downstream of Station 11A coming from Tailings Pond #4. Measurements were made at the point of pipe discharge. Results of these measurements are also shown in Table 2.4.

SURFACE WATER AND SEDIMENT SAMPLING

Surface water and stream sediment samples were obtained at various locations in Greenlick Creek and other unnamed tributaries to the Duck River in order to determine stream water quality and depositional impacts to the sediments within these areas.

Surface water and sediment samples were collected at the same time and location that stream flow measurements were made in July 1985. These locations include Stations 1, 5, 6, 11, 12 and 13 discussed previously. In addition, water and sediment samples were obtained from

TABLE 2.4
STREAMFLOW MEASUREMENTS

| Station No. | Date of Measurement | Area ($ft^2$) | Mean Velocity (ft/sec) | Discharge (cfs) |
|---|---|---|---|---|
| 5 | 17 July | 89.07 | 0.19 | 16.94 |
| 6 | 18 July | 13.39 | 1.59 | 21.37 |
| 11 | 18 July | 17.56 | 1.72 | 30.26 |
| 12 | 19 July | 6.05 | 0.63 | 3.84 |
| 13 | 19 July | 1.55 | 0.37 | 0.57 |
| 1 | 18 July | | | 0.007 |
| 5A | 1 August | 9.75 | 2.32 | 22.63 |
| 6 | 1 August | 9.39 | 1.90 | 17.87 |
| 11A | 1 August | 9.32 | 2.01 | 18.78 |
| Tailings Pond #4 | 1 August | | | 0.52 |

within the ponded area of the drainage from the Site 4 spring. This location was upstream of Station 1 and was designated Station 2A. Surface water samples were also obtained from a possible spring located along the slope on the northeast side of Pond No. 3. This location is designated Station 3A. All of these sampling locations were depicted on Figure 2.1.

Procedure

Water samples collected from the creek or springs were obtained by immersing the prepared sample bottle with the open neck facing upstream. Samples were collected at various undisturbed locations within the flow, starting at stations located downstream and proceeding to stations upstream.

Sediment samples were obtained by either of two methods. For sandy or clayey sediments, samples were collected using a stainless steel hand auger soil sampler. For rocky and mixed sediments in which penetration was not possible or sediments were easily lost, a small hand trowel was used for collection. Where practical, sediments were sampled across the stream bed and combined to form a composite.

Sample bottles prepared with iso-octane for elemental phosphorus analysis were shaken for a minimum of one minute immediately after being filled, then returned to the Columbia Plant environmental laboratory for analysis. All other sample bottles were packed with ice in chests until brought to the ES laboratory in Atlanta.

Surface water and sediment samples were analyzed for the parameters shown on Table 2.5.

GROUND-WATER SAMPLING

Ground-water samples were obtained from all 24 newly installed monitoring wells. Five wells were located near Site 4, six near Site 9, four near Site 12, one in Site 17 and eight in Site 19.

Ground-water quality parameters measured in the field included temperature, pH and specific conductance. Parameters measured in the laboratory were as indicated in Table 2.5. These parameters were selected by ES since, in our opinion, they would be indicative of environmental degradation associated with an elemental phosphorus processing plant.

TABLE 2.5
ANALYTICAL PARAMETERS

| Analysis/Procedure | Sample Type | | | | |
|---|---|---|---|---|---|
| | SW | GW | SED | SS | Extract |
| pH | X | X | | | X |
| Specific Conductance | X | X | | | |
| Total Dissolved Solids | X | X | | | |
| Total Organic Carbon | X | X | | | |
| Total Phosphate | X | X | X | X | |
| Soluble Phosphate | X | X | | | X |
| Total Fluoride | X | X | X | X | |
| Soluble Fluoride | X | X | | | X |
| Elemental Phosphorus | X | X | | X | |
| Cyanide | X | X | X | X | X |
| Lead | X | X | X | X | X |
| Chromium | X | X | X | X | X |
| Arsenic | X | X | X | X | X |
| Cadmium | X | X | X | X | X |
| ASTM Extraction | | | | X | |

SW = Surface Water
GW = Ground Water
SED = Sediments
SS = Split Spoon Composites
Extract = ASTM Part 31 D3987 Procedure

Procedures

Individual PVC bailers were cleaned and dedicated to each monitoring well. Bailers were secured to each well using new, twisted plastic rope. The potential for contamination during bailing was minimized by wearing of clean rubber gloves and taking care to ensure the slack line did not touch the ground or in any other way become contaminated. The procedures for sampling of monitoring wells were generally as follows:

- *Open protector casing and PVC cap*
- Measure static water level
- Compute length of water column based upon known depth of well
- Evacuate a minimum of three volumes of water using dedicated bailer
- Bail a sufficient volume of water to fill all prepared sample bottles
- Measure temperature, specific conductance and pH of the well water
- Secure the well

Sample bottles prepared with iso-octane for elemental phosphorus analysis were shaken for a minimum of one minute immediately after being filled, then returned to the Columbia Plant environmental laboratory for analyses. All other sample bottles were packed with ice in chests until brought to the ES laboratory in Atlanta.

GROUND-WATER LEVEL MEASUREMENTS

Ground-water static levels were measured for all of the newly installed monitoring wells. Water levels were measured for all wells once at the time of sampling. Water levels in all wells were measured a second time coincidental with sampling of wells at Sites 4 and 9 so that water levels at all wells would be obtained on the same day. Results of these measurements are provided in Table 2.6.

Procedure

Static water levels in all wells were measured prior to bailing to ensure an equilibrium level was measured. Measurement was accomplished

TABLE 2.6
GROUND-WATER LEVEL MEASUREMENTS

| Well No. | Date | Elevation of Measuring Point (MSL) | Measured Depth(ft) | Ground-water Elevation |
|---|---|---|---|---|
| 4-5W | 8-9-85 | 667.82 | 21.11 | 646.71 |
| 4-6W | 8-9-85 | 665.81 | 44.77 | 621.04 |
| 4-7W | 8-9-85 | 665.47 | 35.48 | 629.99 |
| 4-8W | 8-9-85 | 638.22 | 36.28 | 601.94 |
| 4-9W | 8-9-85 | 580.19 | 6.33 | 573.86 |
| 9-1W | 8-9-85 | 653.82 | 68.67 | 585.15 |
| 9-2W | 8-9-85 | 627.39 | 64.06 | 563.33 |
| 9-3W | 8-9-85 | 627.36 | 61.33 | 566.03 |
| 9-4BW | 8-9-85 | 629.14 | 42.00 | 587.14 |
| 9-5W | 8-9-85 | 560.18 | 23.16 | 537.02 |
| 9-6W | 8-9-85 | 563.78 | 18.27 | 545.51 |
| 12-1W | 8-1-85 | 593.83 | 5.00 | 588.83 |
| 12-2W | 8-1-85 | 596.01 | 3.83 | 592.18 |
| 12-3AW | 8-1-85 | 591.81 | 2.17 | 589.64 |
| 12-4W | 8-1-85 | 596.47 | 4.67 | 591.80 |
| 17-5W | 8-1-85 | 591.39 | 7.35 | 584.04 |
| 19-1W | 8-9-85 | 584.60 | 16.05 | 568.55 |
| 19-2W | 8-9-85 | 584.52 | 20.69 | 563.83 |
| 19-3W | 8-9-85 | 583.85 | 13.29 | 570.56 |
| 19-4W | 8-9-85 | 584.73 | 18.75 | 565.98 |
| 19-5W | 8-9-85 | 576.53 | 12.71 | 563.82 |
| 19-6AW | 8-9-85 | 571.65 | 7.81 | 563.84 |
| 19-7W | 8-9-85 | 572.35 | 8.52 | 563.83 |
| 19-8W | 8-9-85 | 572.94 | 7.50 | 565.44 |

by lowering an electric sensor down the well casing. The sensor provides an audio and visual signal when the water surface is touched. By careful manipulation, an accurate level can be measured by marking the sensor line at the edge of the PVC casing when the sensor is just at the water surface.

Static water measurements from the top of the PVC casing were then compared to surveyed elevations at that point to determine static water level elevations referenced to mean sea level.

ANALYTICAL PROCEDURES

Analysis was conducted on soil boring composite, sediment, ground water and surface water samples for those parameters shown in Table 2.5. Elemental phosphorus analysis was conducted by the Monsanto Plant Environmental Laboratory. All others were conducted by Engineering-Science.

Evaluation of the applicability of available leachate test methods was conducted to select an appropriate test to determine the leachability of constituents from samples of soils and waste materials. Two methods were considered. The first was the acetic acid extraction procedure used for the determination of EP Toxicity. The second was a water extraction procedure proposed as an ASTM method.

The EP toxicity extraction procedure utilizes an acetic acid extraction to assess leachability. This procedure simulates conditions in municipal type sanitary landfills in which weak acids are produced from organic decay of waste materials. This procedure was considered to not be representative of site conditions at the Monsanto Plant.

An ASTM procedure was selected which utilizes water as the sole extraction medium. This method would best represent natural occurrences of water infiltration and contact with the soils and waste materials in the site. Acid conditions, which would increase the potential for release of metals, would exist only if such a reaction occurred between water and the soils and waste materials in-situ. Acidic conditions during this leachate procedure were created in many cases. This was particularly true for leachate tests on soils and waste materials high in elemental phosphorus.

## SECTION 3

## SITE CONDITIONS

### GENERAL HYDROGEOLOGY AT THE PLANT SITE

The subsurface at the plant site consists of bedrock generally overlain by unconsolidated material. The unconsolidated material is either residual silty clay that has been weathered from the bedock or slag material from plant operations that has been used as fill. The bedrock is Ordovician age limestone. Bedrock is exposed in the Greenlick Creek and Duck River valleys while the unconsolidated material is over 20 feet thick along the ridges overlooking the streams.

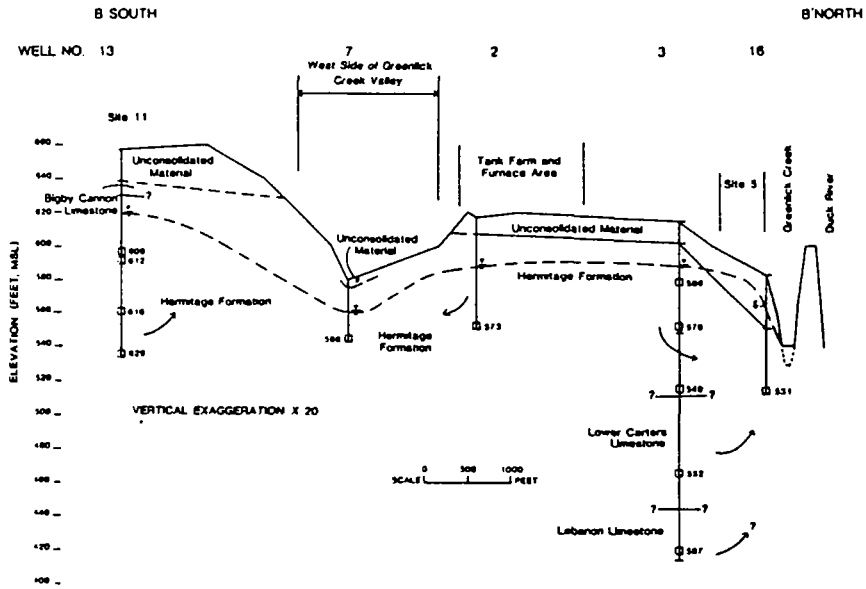
The rocks that have been investigated at the plant site include, in descending order, the Bigby-Cannon Limestone, Hermitage Formation, Carters Limestone and Lebanon Limestone. The Bigby-Cannon is found along the ridge tops. The Hermitage underlies the Bigby-Cannon and is about 90 feet thick in the vicinity of the Environmental Well Site (Site OB-3 on Figure 1.1). Underlying the Hermitage is the Carters Limestone which is 67 feet thick at Well Site OB-3. The Lebanon Limestone underlies the Carters. Its thickness was not determined. Generalized geologic cross-sections through the plant site are shown on Figure 3.1. Locations of cross-sections are shown on Figure 3.2.

The Carters Limestone is the oldest rock unit exposed in the plant vicinity. The Duck River has cut into the Carters just south of where the unnamed tributary that drains much of Site No. 4 discharges into the river. The Duck River has also cut into the Carters in the vicinity of the confluence with Greenlick Creek.

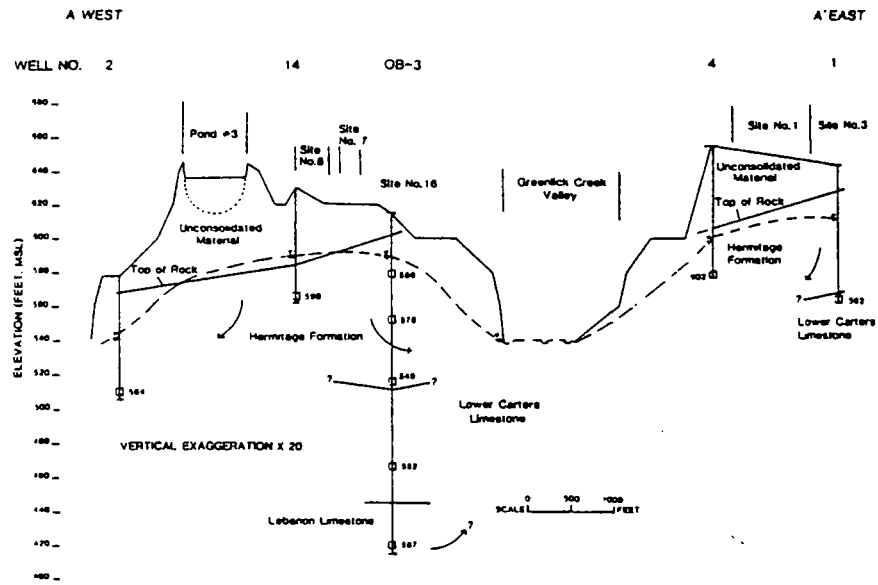
The water table at the plant site generally occurs in the Hermitage Formation. Water is found in this formation in secondary openings that include fractures, joints, and solution channels. Water is also found in secondary openings in the underlying Carters Limestone and Lebanon Limestone.

FIGURE 3.1

# GENERALIZED GEOLOGIC CROSS-SECTIONS THROUGH PLANT SITE.




A. Generalized south to north cross-section.




B. Generalized west to east cross-section.
See Figure 3.2 for cross-section locations.

EXPLANATION

ESTIMATED WATER-TABLE. SHOWS APPROXIMATE POSITION OF WATER TABLE DURING 1983-1985. DASHED WHERE INFERRED.

GENERALIZED GROUND-WATER FLOW DIRECTION..

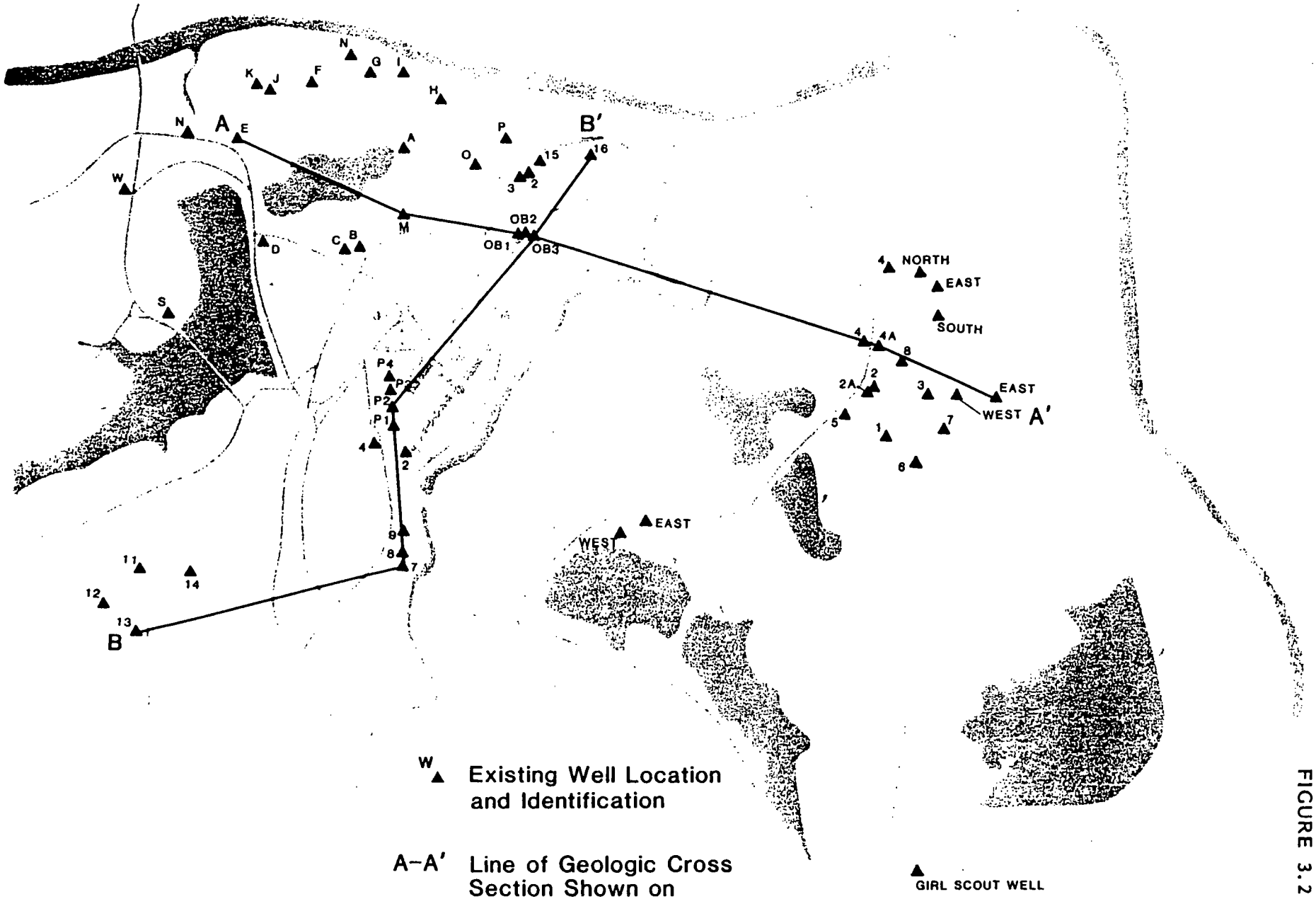
GEOLOGIC CONTACT. DASHED WHERE INFERRED.

PIEZOMETER USED FOR CONTROL POINT. APPROXIMATE WATER-LEVEL ELEVATION DURING 1983-1985 SHOWN NEXT TO PIEZOMETER.

602 Piezometer

Bottom of Borehole

# GEOLOGIC CROSS SECTION LOCATION




W ▲ Existing Well Location and Identification

A–A' Line of Geologic Cross Section Shown on Figure 3.1

FIGURE 3.2

Shallow ground-water movement at the plant site is generally from areas of high topographic relief to Greenlick Creek and the Duck river. Water enters the Hermitage Formation as infiltration, or recharge, on the ridge tops. This water moves vertically into the Hermitage and horizontally toward discharge points in the river and the creek.

Shallow ground-water movement was estimated from the shape of the water table (Figure 3.3). Water table contours were drawn using the altitudes of streams and water levels in monitoring wells. Ground water flows from areas of higher water levels, or hydraulic heads, to areas of lower water levels. This analysis assumed that the fractures, joints and solution channels are interconnected, at least in the rock units that are exposed in the plant site vicinity.

Based on the available data, water from the Carters Limestone probably discharges to the Duck River in the plant site vicinity. The Duck River cuts into the Carters in the plant site vicinity indicating that this rock unit is in hydraulic communication with the river in the area. Also, the water level observed in the Carters at Well Site OB-3 near the river is higher than the river level.

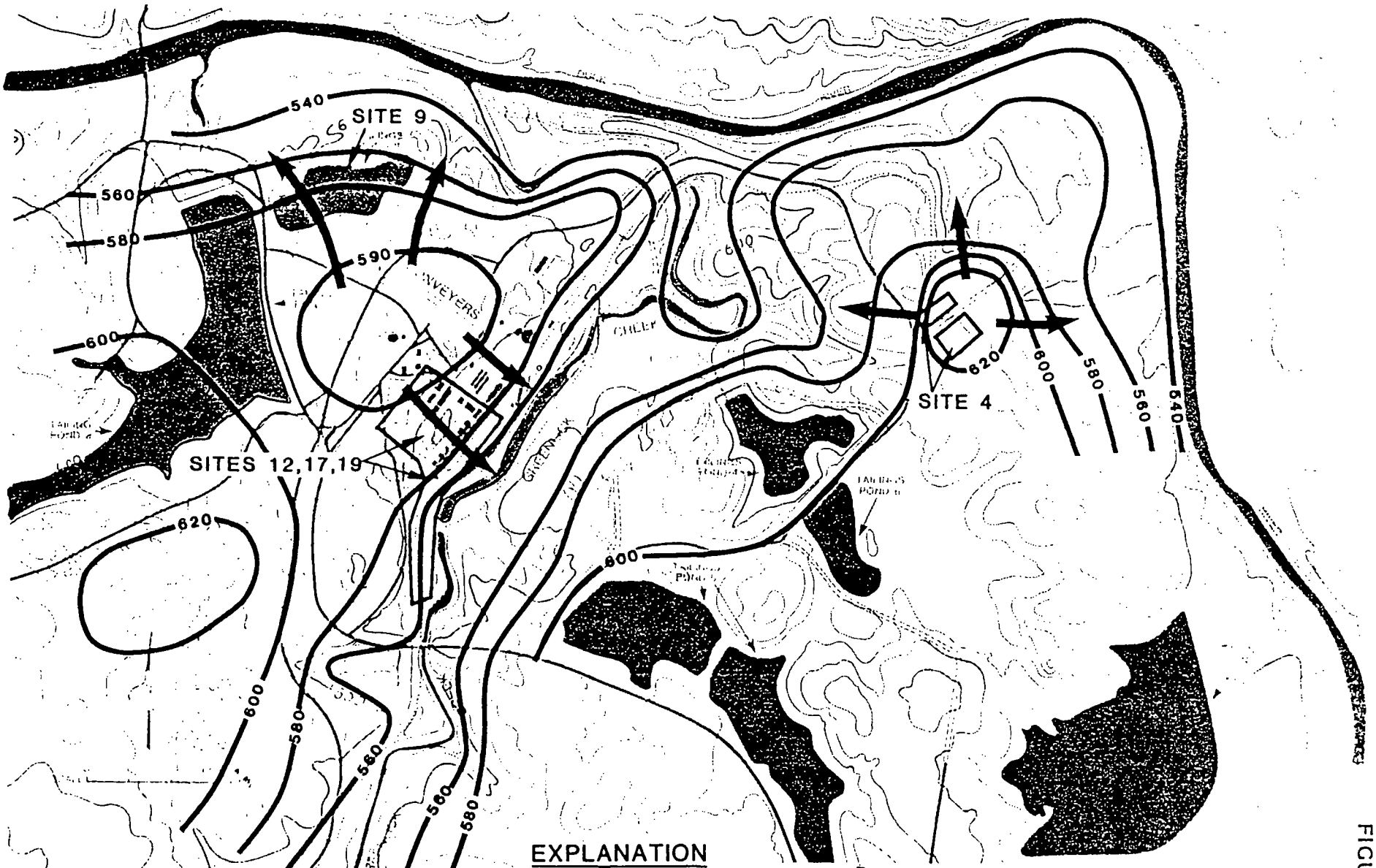
Water from the Lebanon Limestone may discharge into overlying rock units or into the Duck River in the plant site vicinity. The water level observed in the Lebanon Limestone at Well Site OB-3 is considerably higher than water levels in overlying formations and in the level of the river at the plant site.

## HYDROGEOLOGY AND WASTE CHARACTERIZATION AT THE PHOSPHORUS SLURRY DUMP (SITE NO.4)

### Geologic Setting

Unconsolidated materials consisting of silty and sandy clay and waste materials overlies limestone bedrock in this area (Figure 3.4). The source of the unconsolidated materials is waste materials from plant operations and weathered rock of the Bigby-Cannon Limestone. The waste materials include various industrial wastes generated at the plant. The thickness of the unconsolidated materials varies from about six feet to more than 66 feet across the site, with the bulk of this material being waste.

# GENERALIZED WATER-TABLE MAP




## EXPLANATION

—580— WATER LEVEL CONTOUR. SHOWS APPROXIMATE POSITION OF WATER TABLE DURING 1983-1985. CONTOUR INTERVAL 20 FEET. DATUM IS MEAN SEA LEVEL.

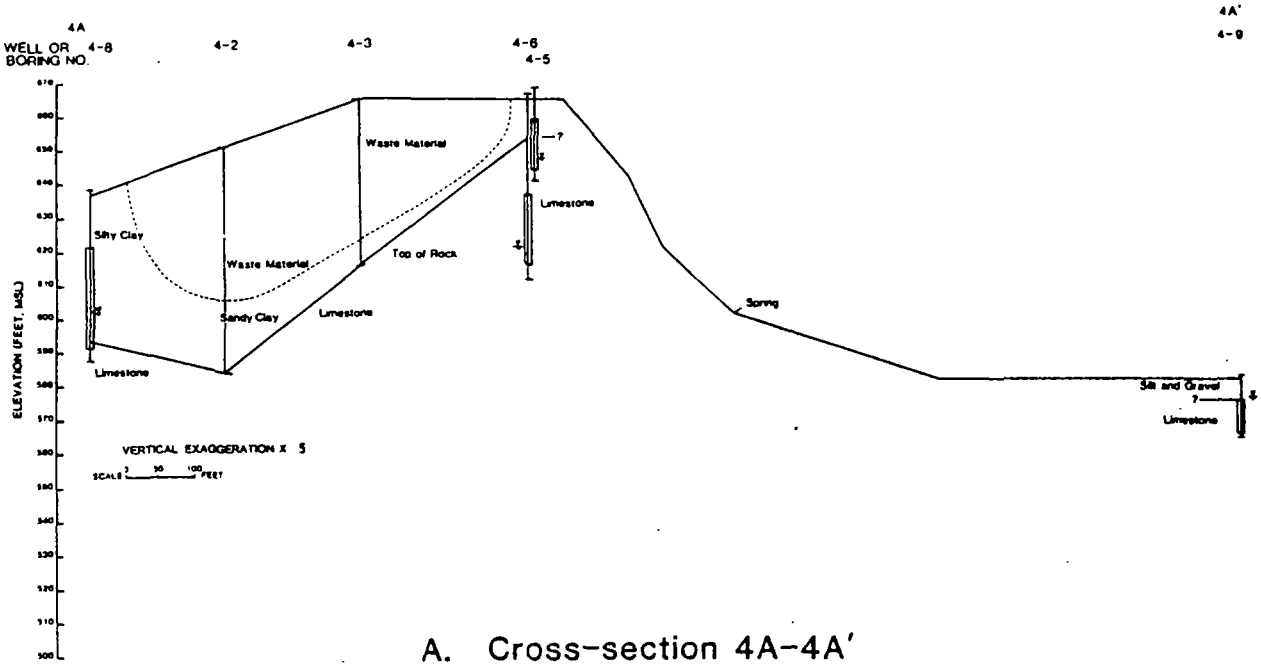
GENERALIZED GROUND-WATER FLOW DIRECTION

SITE 4 DISPOSAL SITE AND IDENTIFICATION

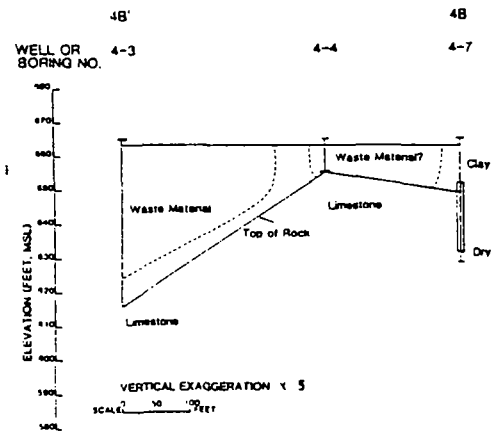
FIGURE 3.3

FIGURE 3.4

# GEOLOGIC CROSS-SECTIONS IN THE PHOSPHORUS SLURRY DUMP AREA




A. Cross-section 4A-4A'




EXPLANATION

MEASURED WATER LEVEL ON AUGUST 9, 1985, IN FEET MEAN SEA LEVEL.

GEOLOGIC CONTACT

BOREHOLE OR WELL USED FOR CONTROL.

Well Screen

B. Cross section 4B-4B'

See FIGURE 3.7 for cross-section locations.

The Bigby-Cannon Limestone is the formation which immediately underlies the unconsolidated materials and is the bedrock unit in the area. At depth the Bigby-Cannon is underlain by the Hermitage Limestone and older rocks. Geologic cross-sections are shown on Figure 3.4.

Waste Characterization

Site No. 4 generally consists of three disposal areas (Figure 3.5). Two of these areas occur to the southeast of a dirt road that bisects the site. The third area occurs northwest of this road.

The section to the southeast of the road, referred to mainly as the north and south slurry dump site, is separated into the two portions by a ridge tending northwest to southeast. Various phosphorus containing materials were reportedly placed in this site. These wastes included coke dust and slurry waste from the phosphorus still and centrifuge, treater oil sludge and large metallic structural debris. The possibility exists that barrels of waste were also deposited in the site. Generally, it is believed that slurry waste was deposited on both sides of the ridge. Treater oil waste was probably deposited on the southwest side of the ridge, as were most of the metallic structures. Metal was detected in the southwest side of the ridge by magnetometry.

Three borings were drilled in the southwest portion of the slurry dump site to aid in characterizing the waste material in that area. Boring 4-1 was placed at the presumed location of the treater oil operation. Boring samples showed a phosphorus containing clayey material at about 18 feet below the surface, with damp or wet clays and silt continuing to bedrock at 28 feet. Chemical analysis of a composite of this boring did not indicate significant levels for the parameters that were measured (see Appendix G). An ASTM water leachate test was conducted to determine the leachability of components of the soil and waste samples. Chromium in the leachate was found to be 0.2 mg/l.

Two borings were placed closer to the ridge on the southwest side, toward the center of the site. The first (4-2) encountered a boulder or cutter at about 41 feet, so a second boring (4-2A) was placed approximately 20 feet to the southwest to continue to the expected depth of bedrock, which was about 66 feet. These borings showed a smoking black material existed at about 10 feet. Clay, sands, silt and gravel mixtures that smoked continued down to about 45 feet. The remaining 20

FIGURE 3.5

ES ENGINEERING-SCIENCE

feet of material consisted of nonsmoking clay and sands with occasional gravel and rock fragments. These results would indicate that a 35-foot lens of slurry or similar wastes was encountered at this location. Chemical analysis of a composite of this lens showed 0.1 percent elemental phosphorus by weight and 111 mg/kg of lead. Analysis of samples from the lower clay material did not reveal any significant concentrations of measured parameters. This would indicate that at this location the waste material overlies about 10 feet of natural soil and gravel mixtures before encountering bedrock.

A third boring (4-3) was drilled northeast of the ridge to characterize waste materials in that area of the slurry dump site. This part of the site was expected to contain most of the waste slurry. Smoking black material was identified at about four feet. Smoking gray material described by the on-site geologist as sandy chemical waste continued to about 25 feet. This material was mixed with thin layers of slag. An additional 15 feet of material that smoked slightly and was composed of clay, sandy lenses and some gravel was found under the apparent slurry waste. About six feet of non-smoking silty sands were found overlying the bedrock. Chemical analyses on a composite of this boring showed almost three percent elemental phosphorus by weight, 7,169 mg/kg of phosphate, 15,324 mg/kg of fluoride, 97 mg/kg of lead, 4.4 mg/kg of arsenic and 50 mg/kg of cyanide. Results of the leachate analysis showed release of 623 mg/l phosphates, 234 mg/l fluoride and 0.134 mg/l arsenic (see Appendix G).

Based on the sampling at this location, it would appear there are about 20 feet of concentrated slurry wastes containing elemental phosphorus, fluorides and some metals. Under the slurry waste are about 15 feet of waste materials similar to that found on the other side of the ridge. At the bottom are about six feet of possibly natural silty sands above the bedrock.

The other section of Site No. 4 is located to the northwest across the dirt road. This section was reported by Monsanto personnel to contain phosphorus containing asbestos wastes, slurry wastes and possibly other materials that were buried in slit trenches. One of four borings drilled in this area (4-4) encountered materials containing elemental phosphorus. About six feet of clay and rock fragments covered about

four feet of this waste material. Bedrock was found at 10 feet and no layer existed between the waste material and bedrock. Samples of this boring were not obtained. Chemical analysis of a composite of the first boring in this section showed phosphate levels at 10,264 mg/kg. This material was not believed to represent the waste in this site, however. It can also be noted in the results that 422 mg/l of chromium were shown to be released in the leachate test (See Appendix G).

Based on results of sampling, the waste area may be composed of trenches containing about four feet of waste with some elemental phosphorus. Trenches are covered over with about six feet of slightly sandy clay.

Estimates were made of the volume of waste material and associated soils contained in the sites by assuming an average depth of soils and waste and estimating a site surface area (Table 3.1). Depth of soils and waste was estimated based upon the borings completed in the site. Surface area was estimated based upon Columbia plant personnel estimates and evaluation of aerial photography from a number of years of the plant's history. These volumes include the soil covers on the sites and assume a uniform horizontal distribution throughout the estimated site boundaries.

Ground-Water Occurrence and Movement

Ground-water occurs at a depth of about 40 feet in this area and is associated in part with the base of the unconsolidated materials and the Bigby-Cannon Limestone. The variation in depth at which the water table is encountered appears to relate to topographic variations in the area.

Ground-water flow directions in the shallow bedrock are downward and radially away from the site toward the east, west and north (see Figure 3.3). Wells completed between Site 4 and the Duck River indicate that the water table slopes away from the site. Also, water levels in two closely spaced wells that are completed at different elevations indicate that ground-water flow is also downward in the vicinity of the site.

Ground-water flow is usually fairly rapid in a solution channel/-fractured hydrogeologic system. Water quality data that have been collected at a spring located about 400 feet east of the site show fluctuation in response to recharge from precipitation. Recharge to the

TABLE 3.1
SITE CHARACTERISTICS

| Site No. | Surface Area[1] (Acres) | Mean Depth[2] (ft) | Volume[3] (cubic yards) | Waste Type | Years of Use |
|---|---|---|---|---|---|
| 1 | 8 | 25 | 60,000 | Phos. containing waste | 1980-1985 |
| 3 | 0.3 | 21 | 9,000 | Barrels | 1950-1978 |
| 4 (West) | 2.8 | 10 | 45,000 | Asbestos/Slurry | 1955-1978 |
| (North & South) | 5.8 | 45 | 420,000 | Slurry/Various | |
| 5 | 1.8 | 30 | 87,000 | Solids | 1950-1978 |
| 6 | 0.1 | 12 | 1,900 | Treater Oil | 1950-1965 |
| 7 | 1.4 | 43 | 97,000 | Collector Dust<br>Treater Oil | 1981-1985 |
| 8 | 2.1 | 18 | 61,000 | Pond No. 3 Solids | 1973-1985 |
| 9 | 13.1 | 35 | 740,000 | Sediments | 1949-1985 |
| 10 | 2 | 20 | 40,000 | Sanitary | 1979-1985 |
| 11 | 14.5 | 26 | 608,000 | Pond No. 3 Solids | 1973-1985 |
| 12 | 1.2 | 18 | 35,000 | Tank Farm | 1940-1955 |
| 13 | 6.5 | 38 | 400,000 | Coke dust | 1940-1982 |
| 17 | 4 | 9 | 58,000 | Phosphorus | 1936-1985 |
| 18 | 1.4 | 48 | 108,000 | Pond No. 3 Solids | 1956-1973 |
| 19 | 5.4 | 8 | 69,000 | Solids | 1936-1985 |
| 20 | 9.0 | 50 | 726,000 | Phos. Waste, Steel<br>Treater Oil | 1940-1950 |

[1] Surface areas estimated from aerial photographs and information provided from the field investigation.

[2] Mean depth is estimated from exploratory boring results and historic information provided from the plant.

[3] Volume was estimated as actual trench volume for sites 1 and 10 and as whole site volumes for other sites. The estimate included unconsolidated soils and waste materials.

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ground-water system generally occurs during the early spring when evapotranspiration losses are minimal and precipitation is greatest. Shortly following this recharge period, spring water generally experiences an increase in the content of various chemical constituents. The concentration of these constituents in the spring water will continue to increase until mid-summer and then begin to decrease. The decrease in concentration of the constituents in the water will continue until the next spring recharge period. An example of this reaction for one water quality parameter is shown in Figure 3.6

Water Quality

Ground-water samples were collected from the five monitoring wells installed at Site No. 4 (see Figure 3.7). Analysis results are presented in Appendix G. The results show that 0.125 mg/l of lead (Pb), 119.9 mg/l of soluble phosphate ($PO_4$) and 0.047 mg/l arsenic (As) were detected at monitoring well 4-8. In well 4-7, 0.20 mg/l of chromium (Cr) and 0.72 mg/l of lead were found. Lead, chromium and fluoride were found downgradient from the site in monitoring well 4-9 at concentrations of 0.145 mg/l, 0.126 mg/l, and 6.3 mg/l respectively. Concentrations of the remaining parameters of interest at Site 4 were considered generally to be at background levels.

Water samples taken at two locations along the unnamed tributary to Duck River that is adjacent to the site (See Figure 2.1) showed up to 20 mg/l of phosphate. The other parameters tested at those locations appeared to be similar in concentration to that generally expected in surface water in the area.

Historical water quality data are available for ground water and the spring at Site No. 4 from previous sampling of the spring and previously installed monitoring wells (See Figure 1.1). Parameters of interest that were historically measured include pH, phosphate, fluoride and elemental phosphorus ($P_4$). Metals were generally not analyzed from these pre-existing wells but were measured at least once at the spring.

Levels of phosphate over 3,000 mg/l, fluoride over 24 mg/l and some elemental phosphorus (20 ppt) have been measured in the ground-water at Site 4 within the past five years. However, there has been a tendency

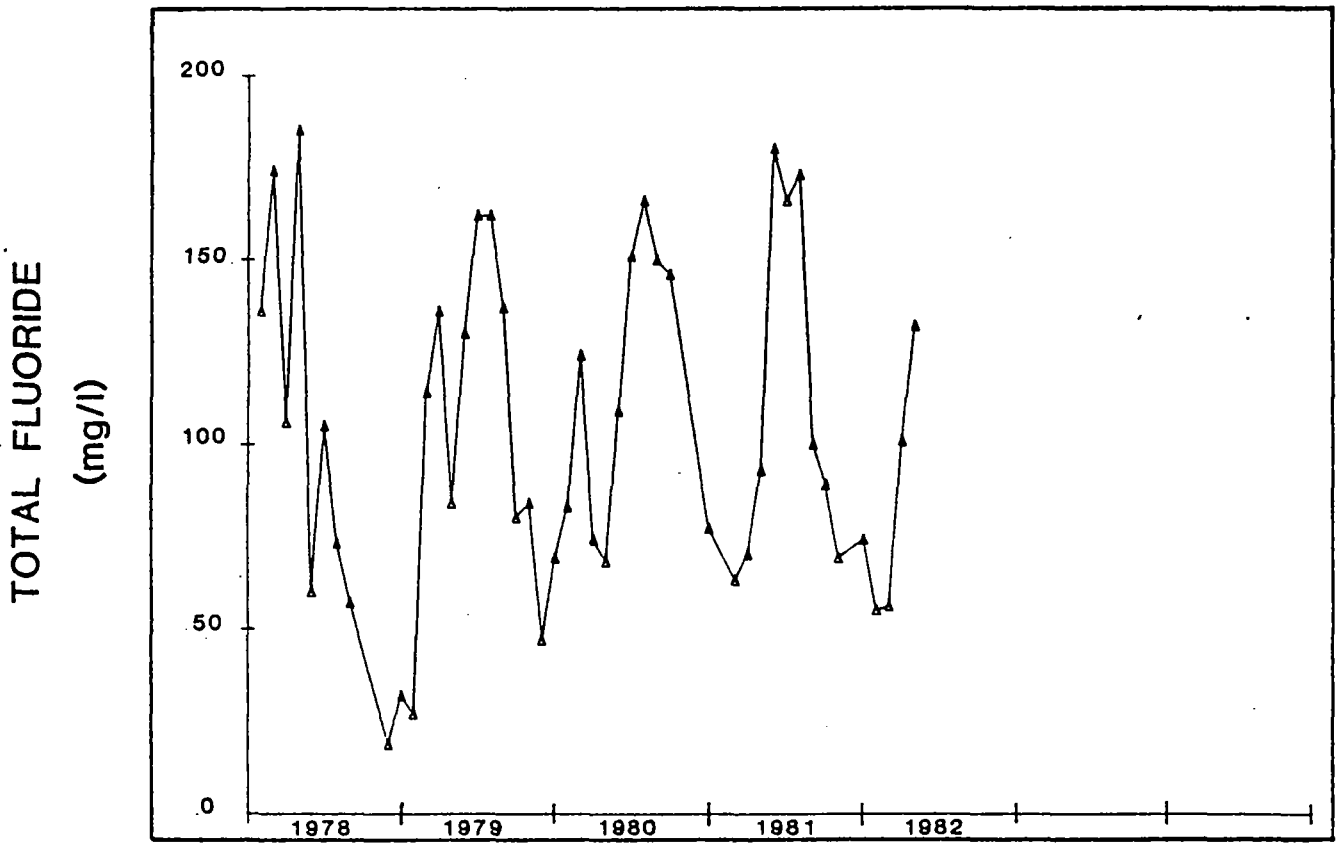
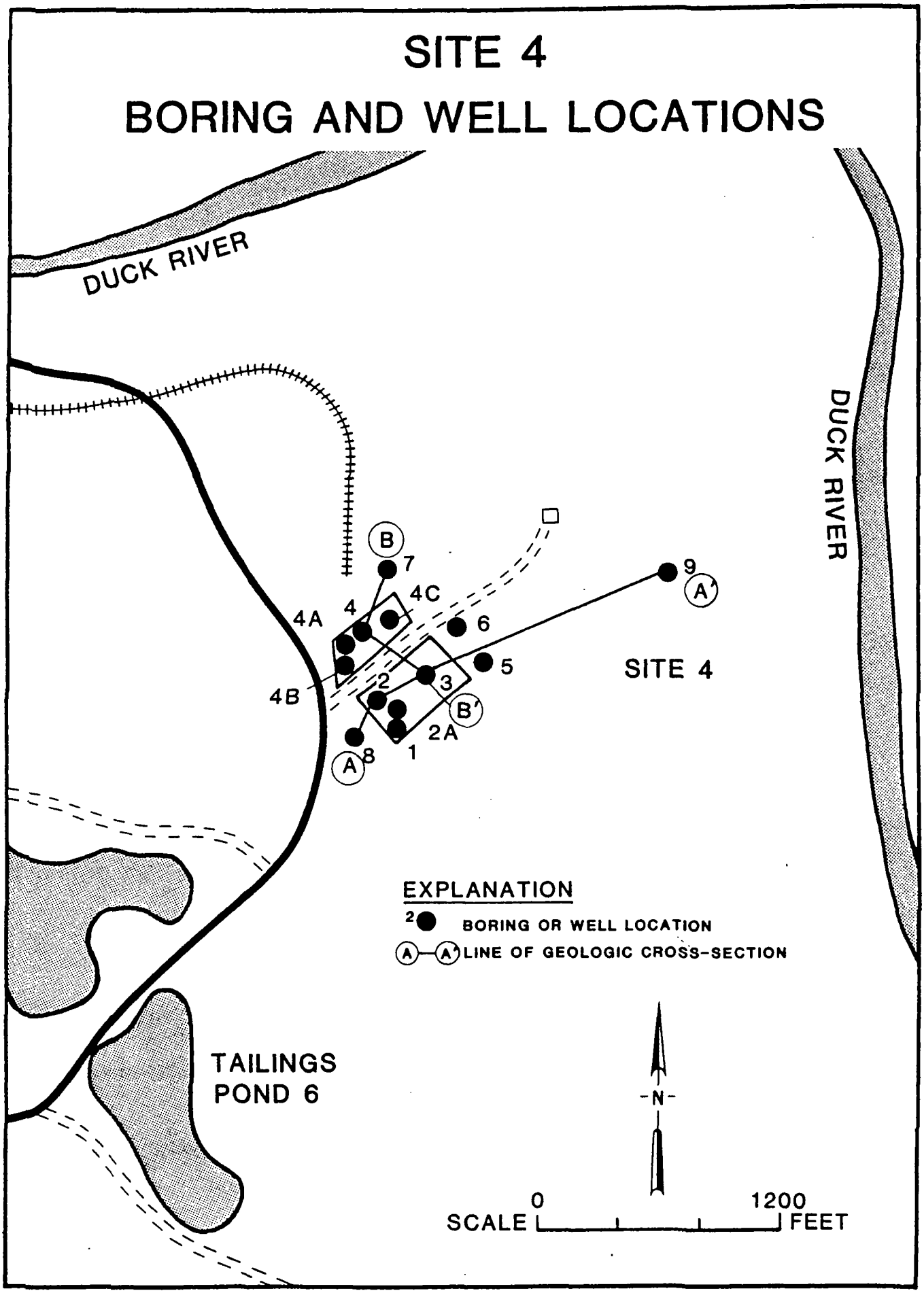



FIGURE 3.6 Flouride in water from the spring at Site No.4.
(Seasonal Variation)

FIGURE 3.7



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toward decreasing concentration of these parameters in water in the site vicinity (see Appendix H). In a study conducted in 1978, 0.016 mg/l of lead and 0.018 mg/l of chromium were measured in the spring.

## HYDROGEOLOGY AND WASTE CHARACTERIZATION AT POND NO. 3 (SITE NO. 9)

### Geologic Setting

The unconsolidated materials in this area consist of an upper zone of waste materials overlying a lower zone of silty and sandy clay, sand and rock fragments. The thickness of the wastes ranges from 12 to 40 feet in the immediate vicinity of Pond No. 3. The lower zone is generally mine tailings and ranges in thickness from 10 to 48 feet and in depth to about 85 feet below ground surface. The unconsolidated materials directly overlie the Hermitage Formation.

The Hermitage Formation is the bedrock unit in this area. The limestone is laminated and fossiliferrous and exhibits partings which are filled with clayey materials. At depth this formation is underlain by the Carters Limestone and Lebanon Limestone, respectively. A geologic cross section of this site showing the generalized state to bedrock is presented in Figure 3.8.

### Waste Characterization Site 9 (Pond #3)

Site No. 9 consists of Pond Number 3, which is a phossy process water pond. The waste material at this site is estimated to include about 90 million gallons of phossy water underlain by about 750,000 cubic yards of sediment.

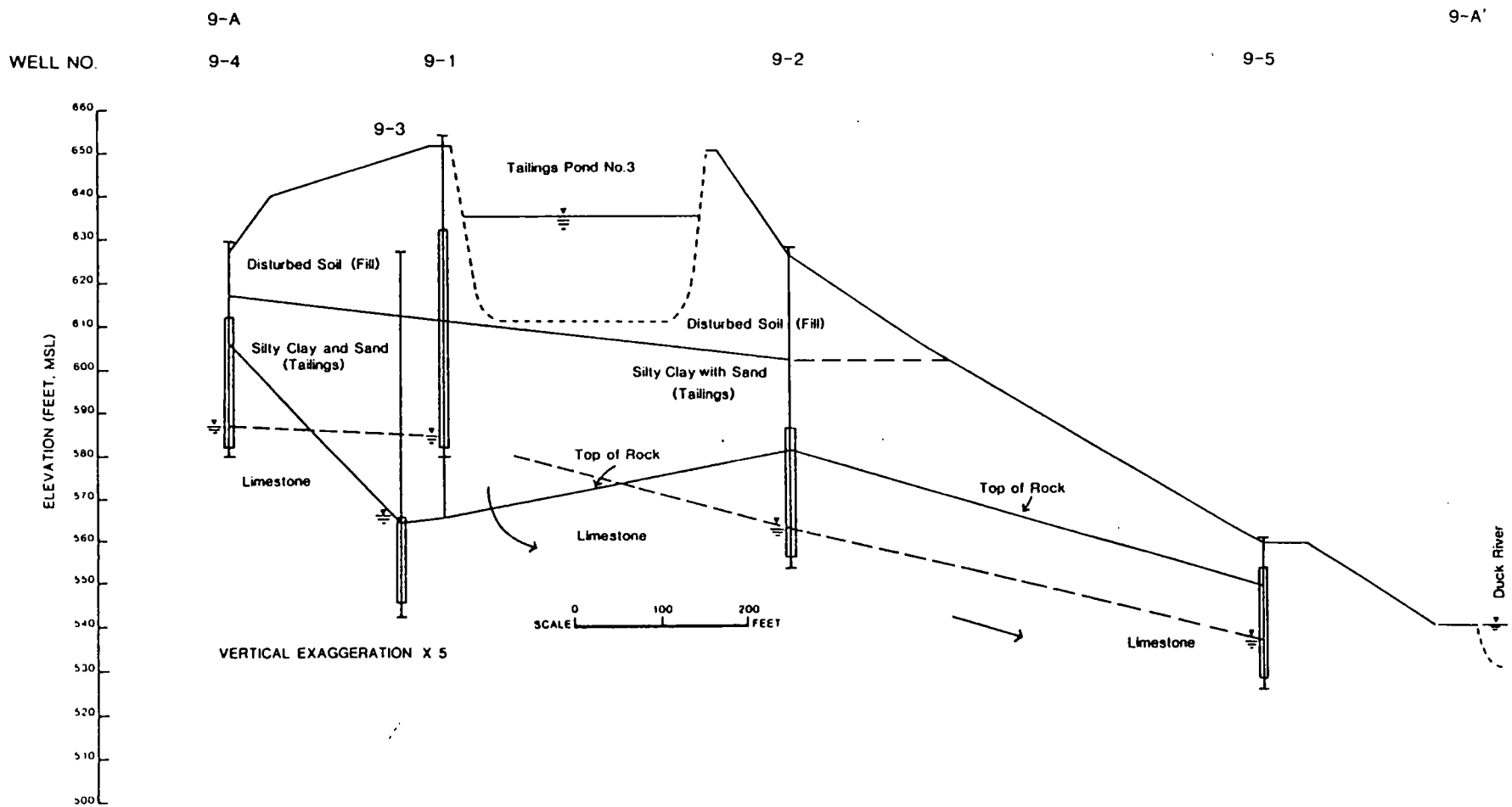
Some information is available for waste characterization from studies conducted previously. However, no samples were taken of the phossy water or the pond sediments as part of this study.

As shown in Table 3.2, the phossy water contains fluorides (523 mg/l), lead (0.27 mg/l), arsenic (1.8 mg/l), cyanide (0.6 mg/l), and total dissolved solids (3,011 mg/l). It also contains elemental phosphorus, up to at least 1.1 mg/l, for some samples analyzed.

The sediments from Pond No. 3 have been analyzed previously for the parameters shown on Table 3.3 as well as other metals and priority pollutants. A review of these analyses show fluorides (73,000 mg/kg) and lead (170 mg/kg), and some arsenic (14.5 mg/kg). Analysis of FP

FIGURE 3.8

# GEOLOGIC CROSS-SECTION IN THE POND NO.3 AREA




See FIGURE 3.9 for cross-section location.

EXPLANATION

MEASURED WATER LEVEL ON AUGUST 9, 1985, IN FEET MEAN SEA LEVEL.

GENERALIZED GROUND-WATER FLOW DIRECTION.

GEOLOGIC CONTACT

BOREHOLE USED FOR CONTROL

Well Screen

Bottom of Well

Bottom of borehole if different than bottom of well.

TABLE 3.2

POND NO. 3 PROCESS WATER

| Report Source | $P_4$ (ppb) | $PO_4$ (mg/l) | $F^-$ (mg/l) | Cd (ug/l) | Cr (ug/l) | Pb (ug/l) | As (ug/l) | CN (mg/l) | TOC (mg/l) | pH | Sp. Cond. | TDS (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | -- | -- | 99 | 2.4 | 25 | 270 | 1,180 | 0.6 | -- | 5.5 | -- | -- |
| 2 | 1,140 | -- | -- | -- | -- | -- | -- | - | -- | -- | -- | --- |
| 3 | -- | 64.3 | 523 | <2 | <1 | 3 | 1,860 | -- | 11 | 6.3 | 5200 | 3011 |

Source Identification

1. Monsanto MDA-001 September 15, 1978 (#3 Pond Return)
2. Columbia Plant measurements, February 1982 (#3 Pond Overflow)
3. PEDCO Environmental, Inc. Report dated November 28, 1983

TABLE 3.3

POND NO. 3 SEDIMENTS

| Report Source | $P_4$ % | $PO_4$ (mg/kg) T/E | $F^-$ (mg/kg) T/E | Cd (mg/kg) T/E | Cr (mg/kg) T/E | Pb (mg/kg) T/E | As (mg/kg) T/E | CN (mg/kg) T/E |
|---|---|---|---|---|---|---|---|---|
| 1 | -- | --/-- | 10/-- | <0.005/-- | <0.005/-- | <0.03/-- | 0.102/-- | <0.02/-- |
| 2 | -- | 28/7.88 | 73000/11.2 | 2.4/0.022 | 39/0.017 | 170/<0.84 | 14.5/0.19 | --/-- |
| 3 | 0.015 | | | | | | | |

T = Totals
E = EP Toxicity (mg/L)

Source Identification

1. Monsanto MDA-107 August 20, 1980 (#3 Pond Solids)
2. PEDCo Environmental, Inc. report dated November 28, 1983
3. Monsanto Report on No. 3 Pond Sampling July 9, 1985

Use "total" values only to evaluate this waste source

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toxicity extractions on this material showed relatively low concentrations of these same parameters. Elemental phosphorus was generally found to be present in low amounts.

Ground Water Occurrence and Movement

Ground-water occurs under water-table conditions in the unconsolidated materials and the Hermitage Formation in this area. The depth to water in the site vicinity varies from 18 to 68 feet below ground surface and generally follows the topography.

Ground water flow from the site is generally downward and toward the Duck River (See Figure 3.3). Wells completed between Pond No. 3 and the Duck River indicate that the water table slopes toward the river in this area. Also, for two wells completed in the pond vicinity, one at a low elevation and one at a higher elevation, water level data shows that elevations or pressure heads are lower with depth of measurement, which indicates downward flow.

The water quality in Well H, located between Pond No. 3 and the Duck River, fluctuates in response to recharge in a manner similar to that observed for the spring at Site No. 4.

Water Quality (Site 9)

Ground-water samples were collected from the six monitoring wells installed at the site (Figure 3.9). Results of the analyses are presented in Appendix G. A review of these results shows lead (1.78 mg/l), chromium (0.753 mg/l) and arsenic (0.860 mg/l) as well as cadmium (0.50 mg/l), phosphate (229 mg/l) and fluoride (7 mg/l) in water from monitoring well 9-4. The total dissolved solids content in water from monitoring wells 9-1 through 9-4 range between 1,800-3,700 mg/l.

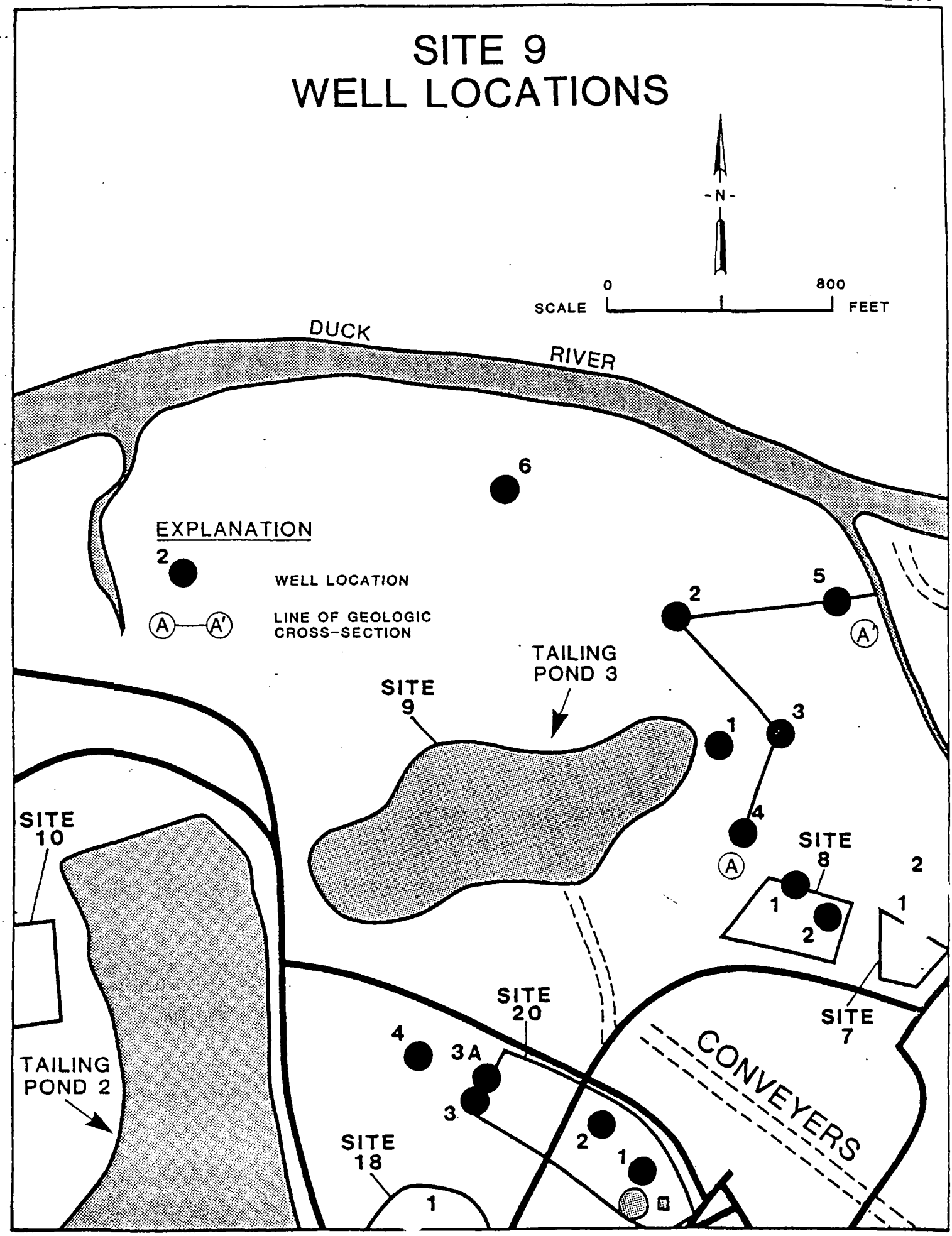
Some analytical data from existing wells were available for evaluation. This data generally shows background levels for most parameters measured. However, the elemental phosphorus and fluoride content in water from well A has been as much as 0.003 and 1,135 mg/l respectively.

HYDROGEOLOGY AND WASTE CHARACTERIZATION AT THE TANK FARM, FURNACE DEPARTMENT AND RAILROAD YARD (SITE NOS. 12, 17 AND 19)

Geologic Setting

Surficial materials at the Tank Farm, Furnace Department and Railroad Yard areas consist of residual unconsolidated materials and fill.

FIGURE 3.9


SITE 9
WELL LOCATIONS
N
SCALE
0
800
FEET
DUCK
RIVER
EXPLANATION
WELL LOCATION
LINE OF GEOLOGIC CROSS-SECTION
A
A'
TAILING POND 3
SITE 9
SITE 10
TAILING POND 2
SITE 8
SITE 7
SITE 20
SITE 18
CONVEYERS
6
2
5
3
1
4
3A

The residual unconsolidated materials are sandy and silty clays, clayey and sandy silts, sands and rock fragments. The fill materials include slag, brick, concrete, and metals. These surficial deposits vary in thickness from approximately 2 to 21 feet.

The bedrock underlying the surficial materials is the Hermitage Formation. The bedrock is a shaly limestone with solution cavities, joints, and fractures in the area. The Hermitage is exposed in Greenlick Creek near Site 19.

Geologic cross-sections through the area are shown in Figure 3.10.

Waste Characterization

Three sites, 12, 17 and 19 are characterized together at this location. Sites 12 and 19 contain buried waste material. Site 17 is an area where elemental phosphorus has been observed.

The waste material in Site 12 includes the remnants of 12 gunnite tanks that contained elemental phosphorus, phossy water and phos mud. These tanks apparently leaked materials into the underlying rock and soils. The tanks were filled in with slag and covered over with soil.

Two exploratory borings were placed in the vicinity of the buried tanks (Figure 3.11). The first boring, 12-5, showed bedrock at 21 feet. The rock was overlain with silt, clay, sands and rock fragments. Smoking material was found at about 20 feet. A second boring, 12-6, showed bedrock at about 13 feet overlain by about three feet of a tan, clayey material showing evidence of phosphorus by smoking. This was covered with about 10 feet of silt and clayey material. ~~Analyses of composites of samples from these borings showed levels of phosphate ranging from 48,000 to 58,000 mg/kg. Additionally, fluoride at 51 mg/l and lead at 0.376 mg/l were shown to be released during the leachate test (see Appendix G).~~ NO

Two exploratory borings were placed in the location of the historic seepage of phosphorus materials (Figure 3.11). Boring 12-7 showed bedrock at about 14 feet covered over with about 12 feet of gravel fill and a two-foot cover of silt and rock fragments. Bedrock was found at about 8.5 feet in boring 12-8. The bedrock was covered with about 3.5 feet of silt, clay and sand that showed indications of elemental phosphorus. This was covered by about 5 feet of silt and gravel fill. Analysis of the boring sample just above the bedrock showed 2.8 percent by weight of

FIGURE 3.11

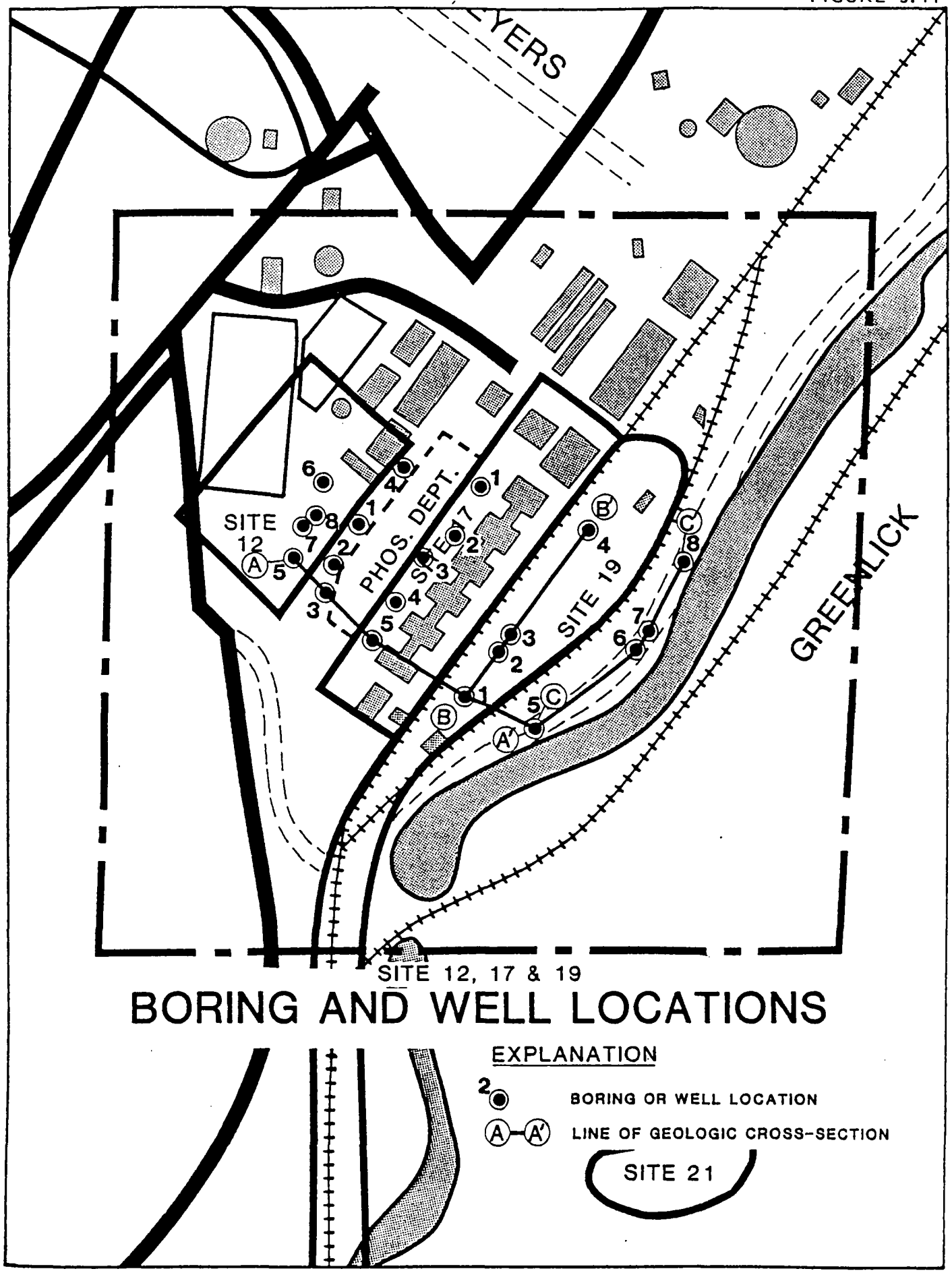
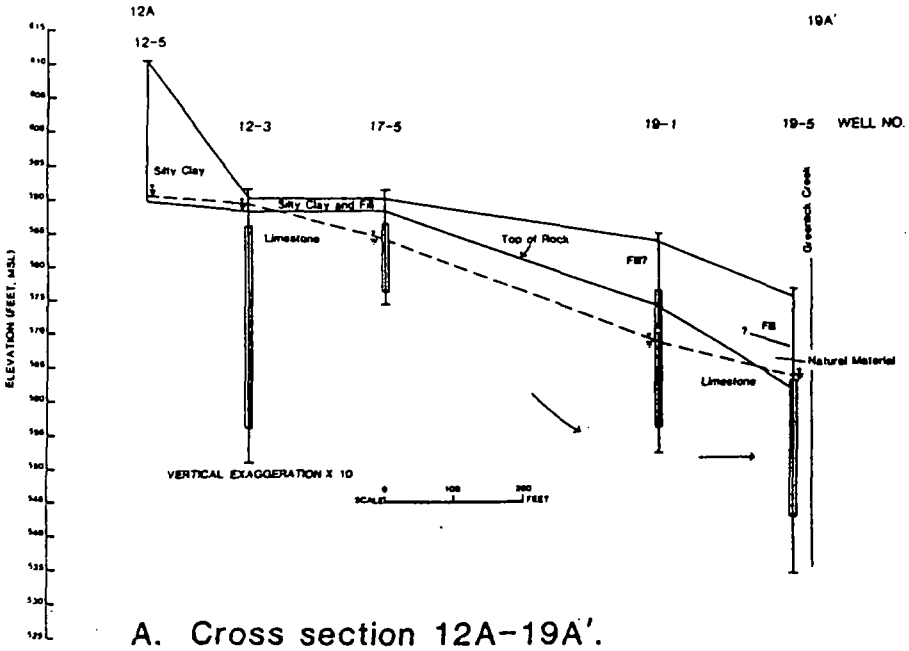
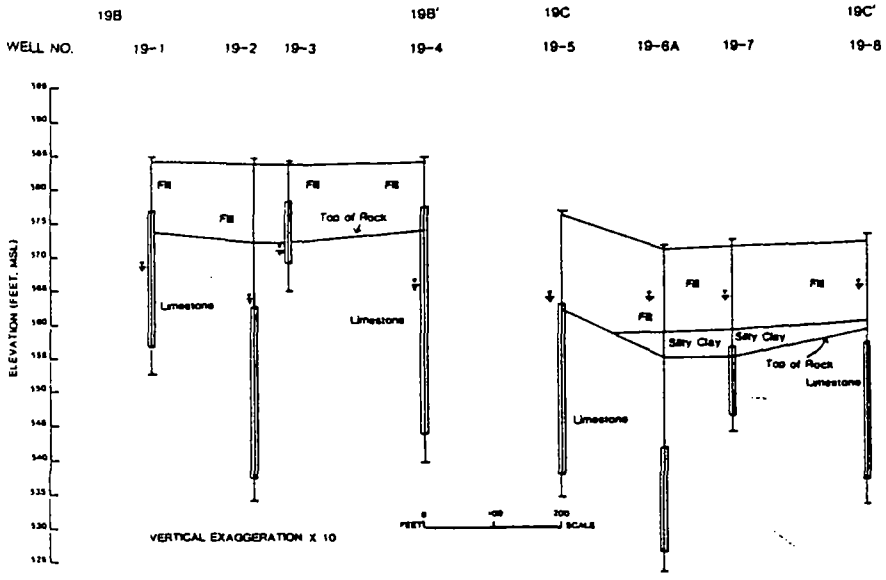

YERS
SITE 12
PHOS. DEPT.
SITE 17
SITE 19
GREENLICK
A
A'
B
B'
C
C'
SITE 12, 17 & 19
BORING AND WELL LOCATIONS
EXPLANATION
BORING OR WELL LOCATION
LINE OF GEOLOGIC CROSS-SECTION
SITE 21

FIGURE 3.10

# GEOLOGIC CROSS-SECTIONS IN THE FURNACE DEPARTMENT, TANK FARM AND RAILROAD YARD AREA




A. Cross section 12A-19A'.




B. Cross section 19B-19B' C. Cross-section 19C-19C'.
See FIGURE 3.11 for cross-section locations.

EXPLANATION

MEASURED WATER LEVEL ON AUGUST 9, 1985, IN FEET MEAN SEA LEVEL.

GENERALIZED GROUND WATER FLOW DIRECTION.

GEOLOGIC CONTACT.

BOREHOLE OR WELL USED FOR CONTROL.

Well Screen

Bottom of Well

elemental phosphorus. Analyses for other parameters showed phosphate at 116,667 mg/kg and arsenic at 4.3 mg/kg. Release of arsenic was found to occur during the leachate test at 0.164 mg/l, phosphate at 588 mg/1 and fluoride at 68 mg/l (see Appendix G).

Based upon historic information on elemental phosphorus seepage from the hillside, water quality in downgradient wells, and evaluation of these exploratory borings, some of the waste in this site has seeped down and flowed through the weathered limestone bedrock. The bedrock under Site 12 is 10 to 15 feet higher than surface grade at the railroad tracks near the Phosphorus Department loading area. Assuming a total of 18 feet of soil and rock that may contain phosphorus, the total volume would be about 35,000 cubic yards of material at Site 12.

Site 17 includes approximately 4 acres over which the Furnace Department has existed in one form or another for the entire history of the plant. Based on interviews with plant personnel, leaks and spills from pipelines and tanks have apparently contributed elemental phosphorus to the underlying soils and bedrock.

Five borings were placed along "Phos Avenue" in order to characterize the soils and bedrock below the site. Figure 3.11 showed the locations of these borings. Analysis of samples from three of the borings, 17-1, 17-2A and 17-3 showed levels of elemental phosphorus at 0.94, 5.28 and 4.88 percent by weight in the unconsolidated materials overlying the bedrock. Depth to bedrock below surface ranged up to 14 feet. Unconsolidated sediments were composed generally of sandy clay, silt and gravel. Rock cores extracted at borings 17-1 and 17-2 showed that elemental phosphorus existed in the limestone bedrock down to about 35 feet below ground surface. Analyses of unconsolidated soils from these 5 borings showed levels of phosphate from 14,000 to 109,000 mg/kg and fluoride from 29 to 311 mg/kg, but relatively low levels of other parameters measured. The leachate test for some of the borings showed release of chromium up to 0.95 mg/l and lead up to 0.47 mg/l (see Appendix G).

Assuming an average of about 9 feet of unconsolidated deposits and 35 feet of rock over the area of the Furnace and Phosphate Departments are impacted by elemental phosphorus, then the volume of soils and rock

at this site which may contain phosphorus would be about 60,000 cubic yards of unconsolidated soils and about 170,000 cubic yards of bedrock.

Site 19 consists of the area east of the Furnace Department to Greenlick Creek. Monsanto personnel report that this area has been a storage area for ferrophos, slag, coke, tanks of diesel oil, and treater dust. Portions of the site were also used as a general landfill for the plant, containing primarily sanitary rather than industrial wastes. Plant personnel reported that old underground concrete storage tanks, possibly lined with lead, may still exist close to the furnace area. Eight monitoring wells were installed in this site and samples were obtained from these boring locations (see Figure 3.11). Borings for wells 19-1 through 19-4 showed a few feet of unconsolidated slag and cinders overlying highly fractured rock. Analysis of composites from these borings showed levels of elemental phosphorus less than 0.13 percent by weight, although phosphates were found at levels up to 26,144 mg/kg. Some lead and chromium were also found to exist, generally below 50 mg/kg. However, the leachate test showed release of 0.896 and 0.235 mg/l of chromium from borings 19-3 and 19-4 respectively and lead from 19-2 at 0.630 mg/l. Borings for wells 19-5 through 19-8 were conducted closer to Greenlick Creek. These borings showed about 15 feet of slag, cinders, gravelly waste and some organics over the fractured base rock. Analysis of composites of these borings showed levels of phosphates up to 63,637 mg/kg and fluorides up to 465 mg/kg. Chromium was shown to be released in leachate tests on samples from borings 19-7 and 19-8 at 0.196 and 0.208 mg/l respectively.

Ground-Water Occurrence and Movement

Ground water at this site occurs under water table conditions in the loose surface materials and in the Hermitage formation. The water table varies in depth from approximately 2 to 21 feet below ground surface. Evaluation of measured water elevations shows that ground-water flow in the shallow bedrock is generally downward and toward Greenlick Creek (see Figure 3.3). The basis for this determination is that wells completed between the Tank Farm area and the Railroad Yard area indicate that the water table slopes toward the creek. Wells completed at lower elevations in the area between the Furnace Department

and Railroad yard had lower water levels than water levels observed in wells completed at higher elevations. This indicates flow is downward.

Ground water in this area occurs as a result of infiltration into and through the unconsolidated materials to the bedrock. Precipitation is the source for this ground water recharge. During wet seasons water levels rise and consequently levels decline during dry periods. Ground water generally moves vertically at a rapid rate through the type of loose, unconsolidated materials found at this site. In the Hermitage Formation ground water moves through fractures, joints, and solution channels.

Ground water at this site moves horizontally toward Greenlick Creek. This movement generally follows the topographic and geologic gradient of the site. Greenlick Creek is a ground water discharge area.

Water Quality

A total of 13 monitoring wells were constructed at Site Nos. 12, 17 and 19 (see Figure 3.11). Analytical results for water samples taken from these wells are included in Appendix G. A review of these results shows that there is an elevated level of elemental phosphorus at monitoring wells 12-1, 12-2, 12-3 and 12-4 (0.07, 1.43, 0.001 and 0.008 mg/l respectively) compared to low levels in other wells in the area (below 0.00007 mg/l). Phosphate concentrations for all wells at these sites were at 6.2 mg/l or less. Elevated fluoride concentrations were found in monitoring well 17-5 (44 mg/l) and most wells at Site No. 19 (2 to 14 mg/l). Chromium was detected at levels in wells up to 0.32 mg/l. Lead was found in well 12-2 (0.13 mg/l) and many of the wells at site 19. Wells 19-3, 19-4 and 19-5 had 0.68, 0.74 and 0.30 mg/l lead respectively. The levels of total dissolved solids (TDS) ranged from 300 to 1800 mg/l in these areas.

## WASTE CHARACTERIZATION AND WATER QUALITY AT REMAINING SITES

### Site No. 3

This site consists of an inactive phosphorus barrel dump. Drums of phosphorus containing materials were reported by plant personnel to have been brought here for disposal from the 1950's until 1978 when the area was closed and capped.

A magnetometer survey of the area identified a trench 240 feet long by 30 feet wide. Four exploratory borings were drilled at the site (See Figure 2.1). Borings within the confines of this trench encountered smoking soil and buried metal. Boring 3-4 was advanced through the trench area to a depth of 21.6 feet. The results of the analysis of a composite of the boring samples showed relatively high levels of phosphate (19,144 mg/kg), fluoride (1,035 mg/kg), cyanide (259 mg/kg) and lead (206 mg/kg). The leachate test on this sample showed release of 85 mg/l phosphate, 56 mg/l fluoride, and 0.057 mg/l cyanide (See Appendix G). A review of the results of the past monitoring of existing wells at this site has shown relatively low levels of phosphates, generally below 2 mg/l, fluorides below 1 mg/l and trace amounts of elemental phosphorus.

The trench is approximately 10 feet deep based on the sampling at this location. There are 10 to 11 feet of natural clayey silts under the waste which may contain some phosphorus. An estimated volume of 9000 cubic yards of soils and phosphorus containing material is present at this site.

Site No. 5

Site No. 5 was originally a tailings pond used for disposal of waste products from the phosphate ore benefication process. After the tailings pond was closed, the site was used as a sanitary landfill and solid waste disposal site from the 1950's until 1978 when it was closed. The site has been graded and has a grass cover. Coke fines were used as part of the final cover over the site. Phosphorus containing material, metal, cable and other plant generated debris were encountered during exploratory boring at the site.

Two borings were drilled in the area (See Figure 2.1). Boring 5-2 refused on rock at a depth of 57.5 feet. Boring 5-1 was terminated at 58.9 feet without encountering bedrock. The actual waste depth at the site is 25 feet at site 5-1 and 35 feet at site 5-2. Based on an estimate of surface area and an assumption of uniform waste distribution, the estimated volume of soils and waste material in the site is 87,000 cubic yards.

The results of the chemical analyses of the composite soil samples taken at Site No. 5 showed up to 64 mg/kg of chromium and 108 mg/kg of lead. Results of the leachate tests on these samples showed the release of chromium at 0.233 mg/l (See Appendix G). Past results of monitoring existing wells for phosphate and fluoride have shown both to generally be less than 2 mg/l.

Site No. 6

Site No. 6 is a closed treater oil site which was used to store and clean treater oil from the treater explosion seals. The oily sludge resulting from removing phosphorous from the treater oil was dumped on the ground in the area.

Five borings were made at this site to define subsurface conditions (See Figure 2.1). Bedrock was found to be relatively close to the surface, ranging from a depth of 2.5 feet to a depth of 13.5 feet. Oily residue was encountered in a relatively confined area. This oily material was found at the top of bedrock, which was at a depth of 11.9 feet in the center of the area. Based on this depth and an estimated surface area, a volume of 1900 cubic yards of oily soils and material may be present at this site. Results of the chemical analysis of the composite soil samples showed phosphate up to 46,078 mg/kg, fluoride up to 282 mg/kg, and lead up to 72 mg/kg. The results of the leachate test showed that chromium was released at 0.26 mg/l (see Appendix G). Monitoring for phosphate and fluoride at previously existing wells has shown phosphate generally less than 65 mg/l and fluoride less than 2 mg/l.

Site No. 7

Site No. 7 is an active dust collector dust storage pile. Dust collector dust and treater dust have been stored at this location since 1981. The material is recycled back into the manufacturing process. A treater oil site was also located here. The area was observed to be smoking several times during the field investigation.

Two borings were installed in this area (See Figure 2.1). Boring 7-1 refused on rock at a depth of 42.2 feet. The soil samples obtained during boring indicate that no natural soils were found at this location. Boring 7-2 encountered oily material at a depth of 35.0 feet. The boring refused at a depth of 43.8. The oily material was present at the rock interface. Based on an estimate of surface area and assuming a

uniform distribution to depth, the total amount of soil and waste materials in this site may be as much as 97,000 cubic yards.

Chemical analysis results of the soil samples taken from the two borings showed phosphate up to 87,581 mg/kg, fluoride up to 478 mg/kg and chromium up to 98 mg/kg. The leachate test showed that some of the chromium was released during the procedure (0.275 mg/l) (see Appendix G).

Site No. 8

Site No. 8 is a closed phossy water pond solids storage area. Solids from the Number 3 phossy water pond were placed at the site from 1973 until early 1985. The area has not been capped, although it has been diked and graded.

Two borings were drilled at the site (See Figure 2.1). Boring 8-1 located bedrock at about 3.3 feet below grade. Sampling of this boring showed slightly sandy silt and clay. Boring 8-2 showed bedrock at about 18 feet overlain by dark brown silt with clay, believed to represent Pond No. 3 solids. Total soil and waste material volume at this site may be 61,000 cubic yards based on an estimate of surface area and these boring depths.

Chemical analyses were conducted on samples from boring 8-2. The results show elevated phosphate at 57,843 mg/kg, fluoride at 2,141 mg/kg, and lead at 132 mg/kg. The ASTM leachate test showed leaching of chromium at 377 mg/l and arsenic at 24 mg/l (See Appendix G).

Site No. 11

Site No. 11 is an active disposal area for Pond No. 3 solids. This site has been receiving these solids since 1973. Five borings were drilled in this site to determine the site characteristics (See Figure 2.1). Bedrock was found at depths varying from about three feet to over 49 feet. The predominant material overlying the bedrock appeared to be a dark brown silty clay, sometimes containing organics or rock fragments. This material extends from the surface to the bedrock. The areal extent of this site was estimated from aerial photographs to be about 14 acres. Based upon this area, the volume of materials in this site may be as much as 608,000 cubic yards.

Chemical analysis of composite samples from the borings showed levels of phosphates up to 63,725 mg/kg, fluorides up to 1,103 mg/kg and lead up to 162 mg/kg. Results of the leachate test show a release of fluoride at 30 mg/l (See Appendix G).

A review of previous results of analyses for phosphate and fluoride at existing monitoring wells at Site No. 11 shows low (less than 2 mg/l) but generally increasing levels of phosphate and fluoride (See Appendix H).

Site No. 13

Site No. 13 is a closed site that was used from 1940 to 1982 for disposal of coke fines and dust collector dust. The site is separated into two parts by a dirt road.

Two borings were drilled in the site, one on each side of the road (See Figure 2.1). Boring 13-1, placed south of the road, was drilled down to about 49 feet and did not encounter bedrock. Sampling of this boring showed a black-brown very silty clay to about 36 feet, followed by sandy materials and weathered rock fragments. Boring 13-2 was placed north of the dirt road. Samples from this boring showed a combination of black and brown silty sandy clay materials present from the surface to a depth of at least 26 feet. Bedrock was not encountered at this boring. Based on an estimate of surface area and the depth of these soils, up to 400,000 cubic yards of soil and waste materials may be present in this site.

Chemical analyses conducted on composite samples from these borings show phosphate up to 63,725 mg/kg. Results of the leachate test indicate a release of elevated levels of chromium at 0.391 (see Appendix G).

A review of historic data for phosphates and fluorides from existing wells in the area shows phosphate generally less than 28 mg/l and fluoride less than 2 mg/l.

Site No. 18

Site No. 18 is a closed disposal site for Pond No. 3 solids. These solids were deposited in this mined out area from 1956 to 1973. The area has been used for surface storage of coke, coal and miscellaneous kiln feed materials since 1973.

Two borings were drilled in this site in order to aid in characterization (See Figure 2.1). Boring 18-1 was drilled to 50 feet without encountering bedrock. Brown, slightly sandy silty clay was found to about 50 feet where weathered rock was then encountered. This material appeared to represent pond solids and had a phosphorus odor. Boring 18-1 was drilled to about 46 feet. Pond solids existed down to about 40 feet followed by yellowish clay with silt and sand. The volume of soils and pond solids in this site is estimated to be 108,000 cubic yards.

Chemical analysis on composite samples from these borings showed levels of phosphate up to 62,091 mg/kg, fluoride up to 2,052 mg/kg, lead up to 92 mg/kg and chromium up to 91 mg/kg. The leachate test showed 90 mg/l fluoride and 0.082 mg/l of arsenic released from samples from boring 18-1 (See Appendix G).

Site No. 20

Site No. 20 is a mined out area that may have received phosphorus contaminated material as well as scrap structural steel from the 1930's to about 1950. It is also reported that the site may have included a location for treater oil waste disposal.

Five exploratory borings were drilled at the Site (See Figure 2.1). Four borings were sampled. Boring 20-1 showed clay, sand and rock fragments to 36 feet. Boring 20-3 encountered mostly coke waste with some gravel down to the point of refusal at about 15 feet. The on-site geologist reported that they probably refused on scrap metal at that depth. Some phosphorus smoke was evident in this boring. Boring 20-3A continued characterization in the same general vicinity of 20-3 down to a depth of about 46 feet. Sampling revealed that black coke waste, clay and silt continued down to about 30 feet followed by yellowish brown and gray clay with silt. Boring 20-4 showed coke waste down to about 19 feet at which point one-half inch steel cable and other metallic objects were encountered and the boring was terminated. Bedrock was not encountered in the borings at this site.

Chemical analysis of composites from these borings showed levels of phosphate up to 40,850 mg/kg, and fluoride up to 1,706 mg/kg. Lead (479 mg/kg) was found in boring 20-4. The leachate test showed that fluoride at 20 mg/l and chromium at 0.163 mg/l was released (See Appendix G).

# SECTION 4

# IMPACTS OF DISPOSAL SITES ON THE HYDROLOGIC ENVIRONMENT

## SECTION 4

## IMPACTS OF DISPOSAL SITES ON THE HYDROLOGIC ENVIRONMENT

The impacts of selected disposal sites on the hydrologic environment were investigated. Test borings and monitoring wells were drilled in the areas of the Phosphorus Slurry Dump, Pond No. 3, and Furnace Department, Tank Farm and Railroad Yard. The data collected from these borings and wells, together with historical data from existing wells, were used to aid in defining the impacts of these sites on the hydrologic environment. In addition, streamflow and stream water quality were investigated along Greenlick Creek to aid in defining the overall impact of the plant site on the hydrologic environment.

### HYDROLOGIC IMPACTS OF THE PHOSPHORUS SLURRY DUMP

Ground-water sampling, together with the results of the geophysical survey, indicates that there has been some degradation of the subsurface in the vicinity of the Phosphorus Slurry Dump.

The results of analyses on water samples taken from wells recently completed on the north, west and south sides of the waste material (see Appendix G) indicate that the waste materials are having some impact on ground-water quality in the site vicinity. The lead contents in water from wells numbered 4-7, 4-8 and 4-9 are 0.720, 0.125 and 0.145 milligrams per liter (mg/l), respectively, which is higher than the lead content found in water from other wells sampled at the site (0.035 and 0.042 at wells 4-5 and 4-6 respectively). The chromium levels in wells 4-7 and 4-9 were higher at 0.200 and 0.126 mg/l then levels measured at the other wells (less than 0.010 mg/l each). Also, the elemental phosphorus contents in water from wells number 4-7 and 4-8 are .086 and .042 micrograms per liter (ug/l) respectively, which is high when compared to the trace levels of elemental phosphorus in water from other wells sampled at the site. The total dissolved solids content in water from

wells at the site ranges between 590 and 1530 milligrams per liter (mg/l), which is slightly higher then total dissolved solids content in water from other wells around the Columbia region, which vary from 200 to 700 mg/l.

The lead content in the ground water does not appear to be attenuated as the water migrates away from the area. The lead content in water from Well 4-9, completed mid-way between the buried waste material and the Duck River, is about the same as that in water from the well 4-8 completed at the dump site (see Appendix G).

The total dissolved solids content in the ground water is attenuated with distance from the site. Wells 4-5 through 4-8, completed in the site vicinity, have water with an average total dissolved solids content of 965 mg/l. The total dissolved solids content downgradient in water from well 4-9, however, is 593 mg/l. The background total dissolved solids concentration for ground water at the plant site is estimated to be about 250 mg/l based on the total dissolved solids content observed in water from Greenlick Creek above the plant site and spring water in the vicinity of the Duck River at Sampling Station 1.

Constituents examined in water and sediment samples from the unnamed tributary to the Duck River, located between the site and the river, appeared to be at background levels. The phosphate, fluoride, cadmium, chromium, lead, arsenic, cyanide, total organic carbon, pH and total dissolved solids contents in the water and sediments were similar to those found in water and sediments from Greenlick Creek above the plant site.

Historical data from pre-existing wells at the site indicates that the concentration of phosphate and fluoride has generally decreased in recent years for the East well but showed little overall change for other wells at the site and Greg's Spring (slurry dump spring) at least through 1983 (Figures 4.1 to 4.3).

The historical data also indicate that there is little or no attenuation of some constituents in the ground water as the water moves toward the slurry spring. The total phosphate and total fluoride contents observed in wells near the waste materials were similar to the contents of these constituents observed in the water at the spring.

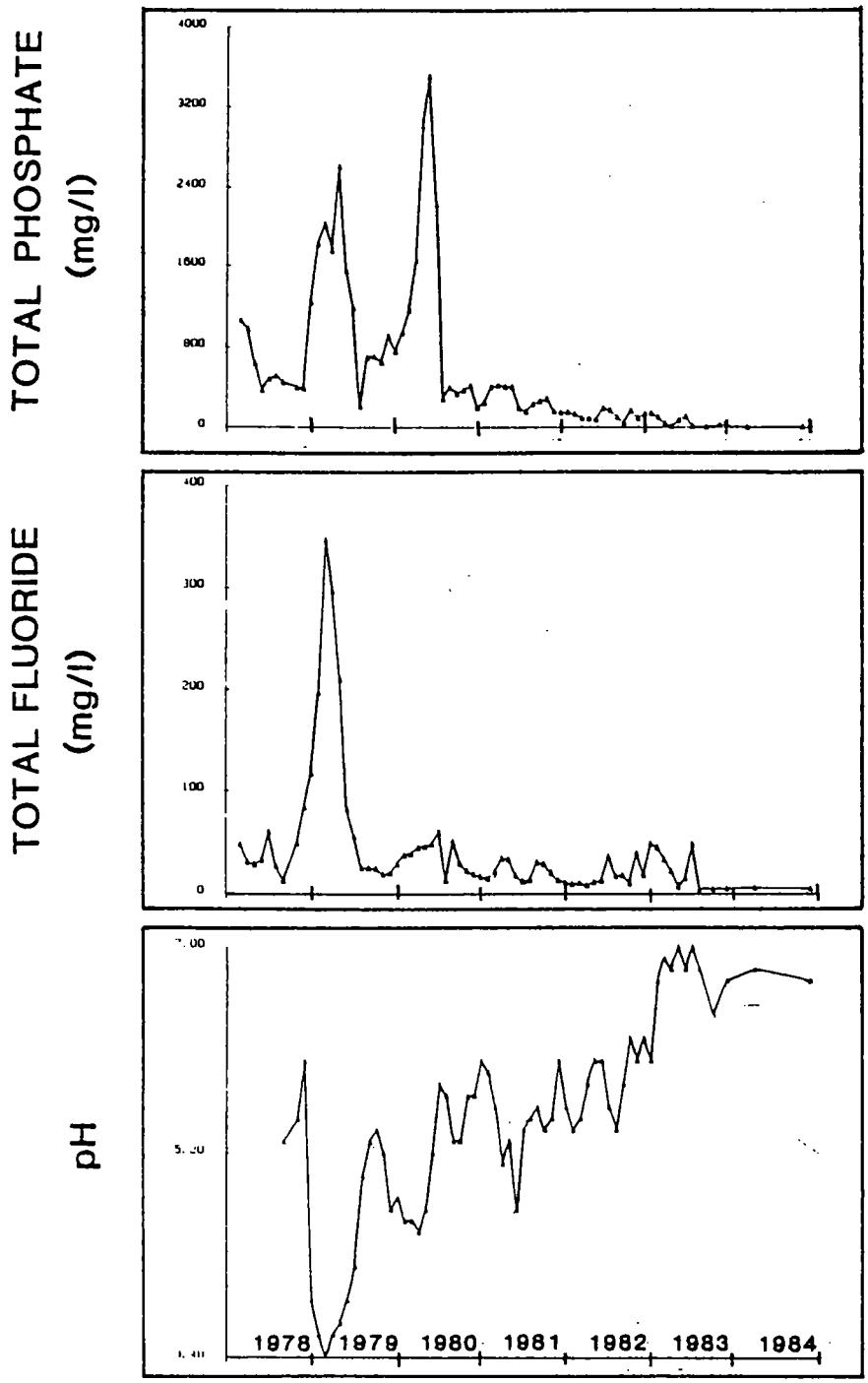



FIGURE 4.1 Variation in concentration of selected parameters in water from Site No. 4 East Well.

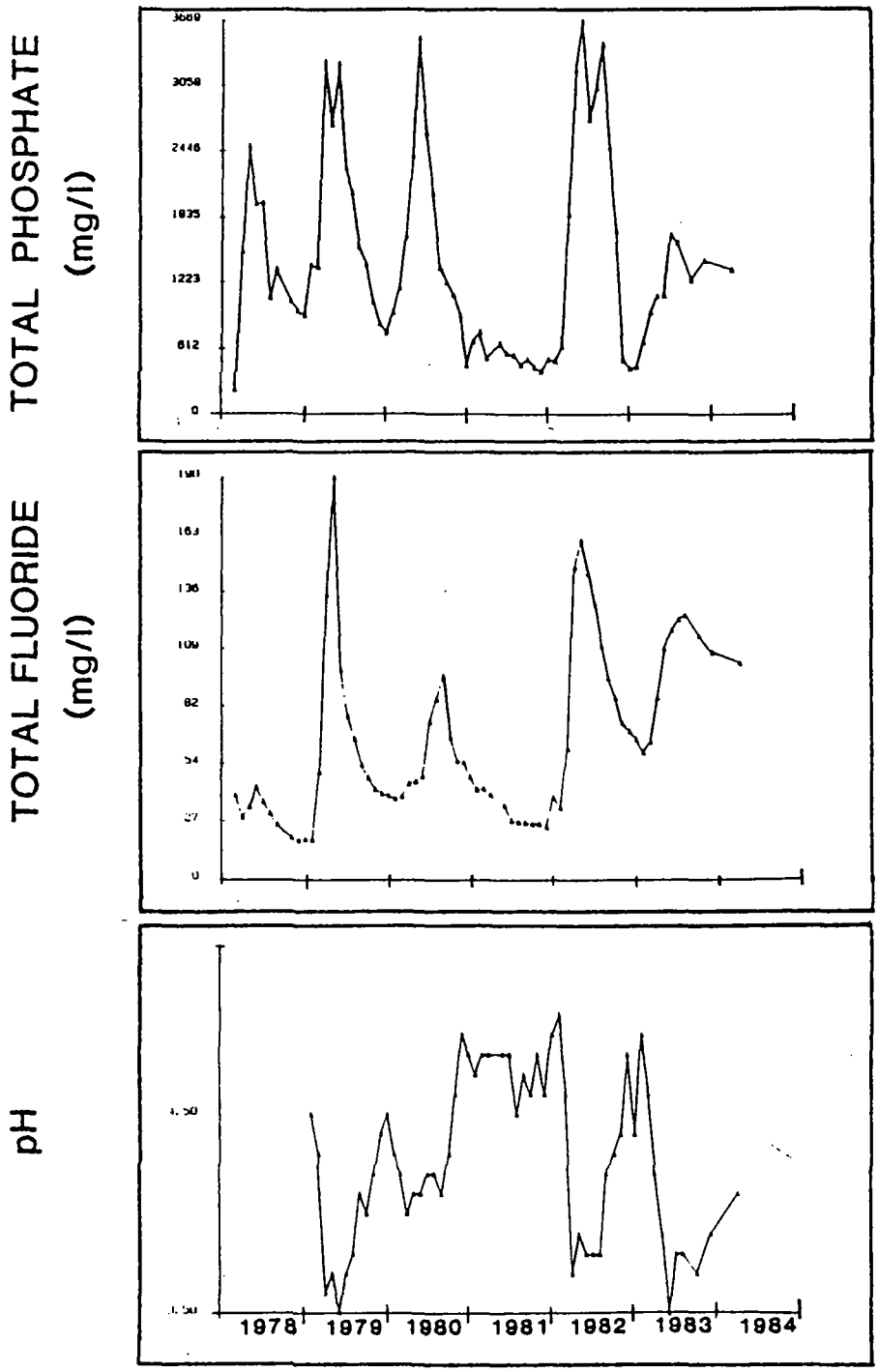



FIGURE 4.2 *Variation in concentration of selected* parameters in water from Site No. 4 South Well.

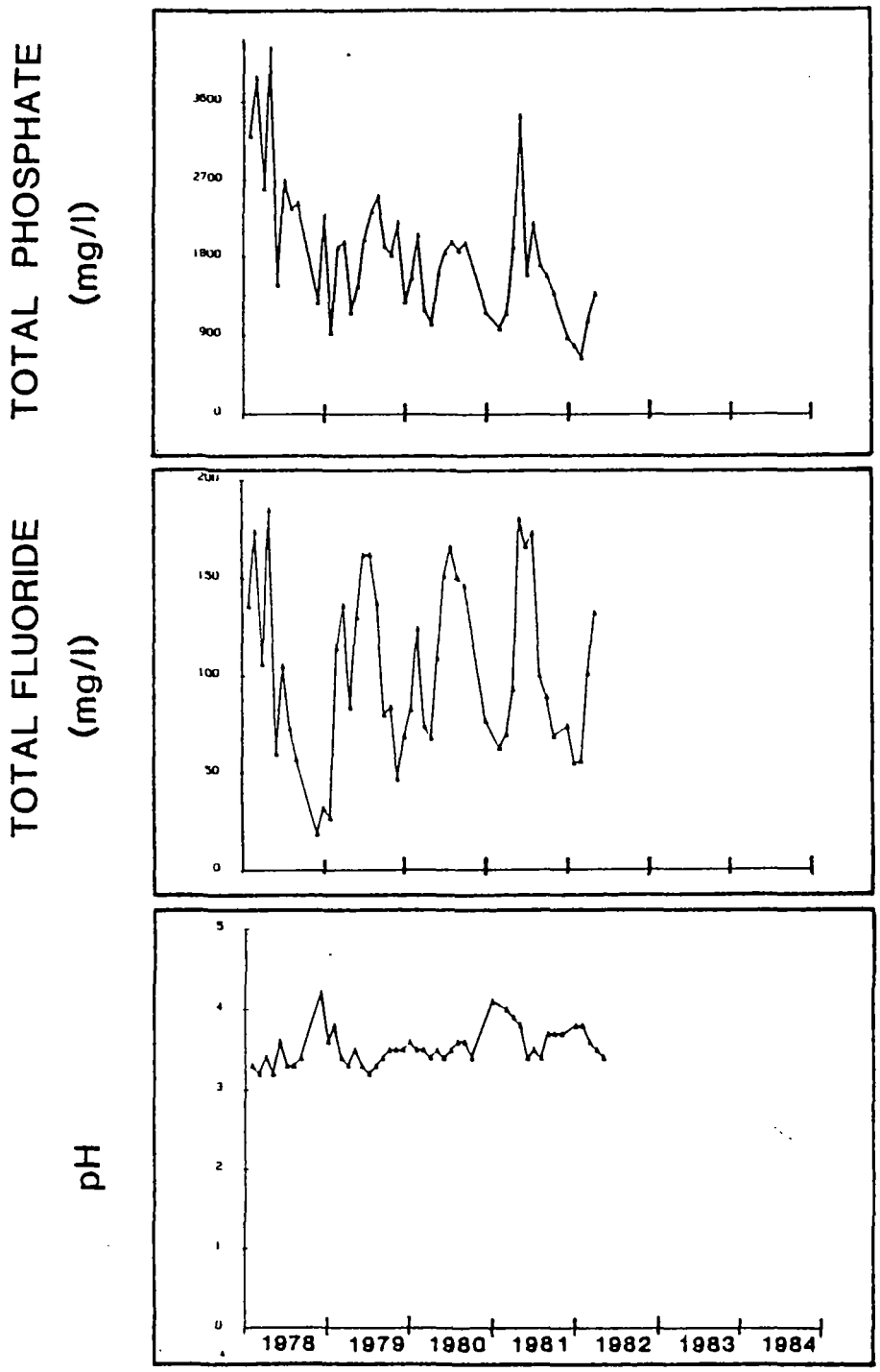



FIGURE 4.3 Variation in concentration of selected parameters in water from Site No. 4 Spring.

However, the total phosphate and total fluoride contents observed in ground water in 1985 are considerably less than those observed between 1978 and 1983. The total phosphate content in the water commonly exceeded 1,000 mg/l and the total fluoride content commonly exceeded 50 mg/l between 1978 and 1983. With the exception of well 4-8, the total phosphate content in the water generally was less than 15 mg/l in 1985. Well 4-8 had phosphate at 120 mg/l. Fluoride concentrations were found at less than 1 mg/l in the site.

In summary, the phosphorus slurry dump appears to be impacting the ground water in the vicinity by leaching of some constituents. The impacts are seasonal and are probably functions of both infiltration and rising water table levels contacting the disposed materials. During periods of time when water levels were high enough to create what is called the slurry dump spring, historic impacts were seen in the spring water in the form of pH less than 4, phosphate greater than 1,000 mg/l and fluoride greater than 50 mg/l. Similar impacts are seen in wells located near the waste site. During drier periods of time, the concentrations generally decrease in the ground water, but concentrations of phosphate above 100 mg/l and metals above 0.10 mg/l are found, and these concentrations do not attenuate to any great extent downgradient toward the Duck River.

HYDROLOGIC IMPACTS OF POND NO. 3

Ground-water sampling, together with the results of the geophysical survey, indicates that there has been some impact to the subsurface in the vicinity of Pond No. 3.

Elevated levels of some constituents were identified in water samples taken from recently completed wells at the site. The total organic carbon and lead contents in water from Well 9-4 are 168 mg/l and 1.78 mg/l, respectively. Values of TOC range from 26 to 60 mg/l and values of lead range from 0.005 to 0.022 mg/l for other wells in the vicinity. Also, the chromium and arsenic contents in water from Well 9-4, at 0.753 and 0.860 respectively, are high in comparison to that found in water from other wells, which generally are less than 0.10 mg/l for chromium and less than 0.035 mg/l for arsenic. Finally, the total dissolved solids content in water from wells 9-1 through 9-4 range from 1800 to

3700 mg/l, which is high when compared to the total dissolved solids content in other wells, generally under 1000 mg/l.

The total dissolved solids content in the ground water is attenuated as measured downgradient from the site. Wells 9-1 through 9-4, completed in the pond vicinity, have water with a total dissolved solids content higher than water from wells 9-5 and 9-6, located between the pond and the Duck River.

The historical data also indicate that ground water was impacted by the pond. The fluoride and elemental phosphorus contents in water from Well A have consistently been above those levels that were found in other nearby wells. Fluoride in Well A has usually been measured above 15 mg/l and elemental phosphorus has been measured as high as 0.003 mg/l. Other wells in the vicinity have shown fluoride to be generally less than 10 mg/l and elemental phosphorus to be negligible.

The geophysical survey identified two areas in the pond vicinity where low resistivity ground water exists. A localized area occurs to the southeast of the pond between the pond and a small sinkhole. Well 9-4 is located in this area. A broad area occurs between the pond and the Duck River.

In summary, Pond #3 has impacted the ground water below the site to some extent. Notable impacts include the presence of metals, organic carbon and phosphate in the immediate vicinity of the pond. Interpretation of the results of the geophysical survey would be that impacts to ground water may extend in the direction of the Duck River. Water quality analyses in wells completed downgradient from the pond show attenuation of those parameters measured.

## HYDROLOGIC IMPACTS OF THE FURNACE DEPARTMENT, TANK FARM AND RAILROAD YARD AREA

Ground-water sampling and an analysis of borehole samples in the Furnace Department, Tank Farm and Railroad Yard area indicates that there has been some impact to the subsurface in this area.

Elevated levels of some constituents were identified in water samples taken from wells completed in the area as a part of this study (see Appendix G). The elemental phosphorus content in water from wells 12-1 through 12-4 ranged from 0.001 to 1.43 mg/l. Fluoride levels were

found to be high in wells at Sites 17 and 19, at 44 and 14 mg/l respectively. Chromium levels in Site 12 ranged up to 0.320 mg/l. In Site 17 it was found at 0.123 mg/l and at Site 19 up to 0.320 mg/l. Lead was found at a concentration of 0.130 mg/l at well 12-2 and at 0.680, 0.740 and 0.300 mg/l at wells 19-3, 19-4 and 19-5 respectively. Arsenic was found at 0.070 mg/l in Site 19. All of these values were relatively high compared to other wells around the site. The total dissolved solids content ranged up to 1,840 mg/l for water from wells in this area. This total dissolved solids content is high when compared to that in water from other wells around the plant, generally under 500 mg/l.

The total dissolved solids content in the ground water appears to increase downgradient from Site 12 to Site 19 and then attenuates as the water moves toward Greenlick Creek. The total dissolved solids content in water from wells 12-1 through 12-4 averaged 597 mg/l. These wells are located approximately 900 feet upgradient from Greenlick Creek. In well 17-5, the TDS value was 846 mg/l. The average total dissolved solids content in water from wells 19-1 through 19-4 and wells 19-5 through 19-8 are respectively, 1,115 mg/l and 531 mg/l. Wells 19-1 through 19-4 are about 300 feet upgradient from Greenlick Creek and wells 19-5 through 19-8 are located in the vicinity of the creek.

The elemental phosphorus in ground water at wells 12-1 through 12-4 is much higher than that in water at wells 19-1 through 19-8. The reduction in elemental phosphorus content between these wells may be due to attenuation of the phosphorus as it moves downgradient. The elemental phosphorus content in water from wells 12-1 to 12-4 ranged between .0013 mg/l and 1.43 mg/l while that in water from wells 19-1 through 19-8 was .000018 mg/l or less. Well 17-5, located between the two groups of wells, had water with an elemental phosphorus content of .000070 mg/l.

The results of the boring program also indicated that the subsurface was being impacted by plant operations. Elemental phosphorus was detected in the bedrock and in the overlying unconsolidated deposits in the vicinity of both the Tank Farm and Furnace Department.

## OVERALL HYDROLOGIC IMPACTS OF THE PLANT SITE

Streamflow was measured and sediment and water samples were collected at selected points along Greenlick Creek to aid in determining the overall impact of plant operations on the hydrologic environment. Streamflow measurements and sampling were done at five sites (see Figure 2.1). The results of the measurements and sampling were presented in Section 3.

### Current Impacts

Plant operations have impacted Greenlick Creek to some extent. Water in Greenlick Creek has elevated levels of elemental phosphorus. The elemental phosphorus content in the water was about 0.0001 mg/l in the area between the dam and the confluence with the Duck River. The elemental phosphorus content in water from the creek above the plant site was about 0.000002 mg/l. Also, the sediments in the creek at the railroad culvert contained 1,149 mg/kg of phosphate and those at the dam contained 183 mg/kg. The concentration of fluoride in sediments at the dam was 30 mg/kg. The concentrations of phosphate and fluoride in sediments from Greenlick Creek above the plant site are about 100 mg/kg and 6 mg/kg, respectively.

Background levels of phosphate (about 100 mg/kg) were observed in sediments at the confluence of the Duck River with Greenlick Creek, while background levels of fluoride (about 6 mg/kg) were observed everywhere except at the dam.

Other constituents examined in water and sediments from Greenlick Creek were at about background levels (see Appendix G). The cadmium, chromium, lead, arsenic, cyanide and total organic carbon contents in the water and sediments at the dam, the railroad culvert and the confluence with Duck River were similar to those found in the creek above the plant site.

The total dissolved solids concentration in Greenlick Creek as the creek runs through the plant site decreases from about 250 mg/l upstream of the plant to about 160 mg/l at the discharge to the Duck River. This is due mainly to the addition of water to the dammed up area under current operational conditions.

Impacts Associated with Plant Closure

The dissolved constituents in water from Greenlick Creek may increase by a factor of about 1.3 in the plant vicinity if operations cease and the creek returns to natural flow conditions. A simple mass balance model was used to estimate this increase by evaluating total dissolved solids content and stream flow measurements made in Greenlick Creek. The background total dissolved solids was assumed to be 250 mg/l, or equivalent to that observed in the creek above the plant site. The total dissolved solids content in ground water entering the creek in areas other than the Railroad Yard was estimated to be 370 mg/l. The dissolved solids content of ground water entering the creek in the vicinity of the Railroad Yard was assumed to be 530 mg/l, or the average of TDS values measured in the ground water in that area (wells 19-5 to 19-8). The procedure used to arrive at this factor is shown in Appendix I.

POTENTIAL RECEPTORS ASSOCIATED WITH ENVIRONMENTAL IMPACTS

A preliminary review was made of ground-water receptors located in the vicinity of the Monsanto property. Nine possible well locations were identified in the plant vicinity. General locations of these wells are shown in Figure 4.4. Table 4.1 provides a brief description of the ground-water usage locations identified on Figure 4.4.

Three wells, due to their proximity to the plant site, have some potential for being impacted by plant operations. These wells are wells G, H and I. None of these wells, however, have any potential for being impacted by disposal sites that were studied in detail.

Water quality data collected from well H in the past shows the elemental phosphorus content was .005 ug/l in March, 1983 and .014 ug/l in September, 1983. These values are higher than the .001 ug/l commonly found in other wells around the plant site. However, these values are still very low and generally at or below the confidence level reported by the Monsanto Laboratory for phosphorus analysis (about 0.015 ug/l). The total phosphorus and total fluoride contents in these water samples averaged 0.24 and 0.65 mg/l, respectively, which was in the background range.

FIGURE 4.4

MONSANTO

# POSSIBLE GROUNDWATER RECEPTORS

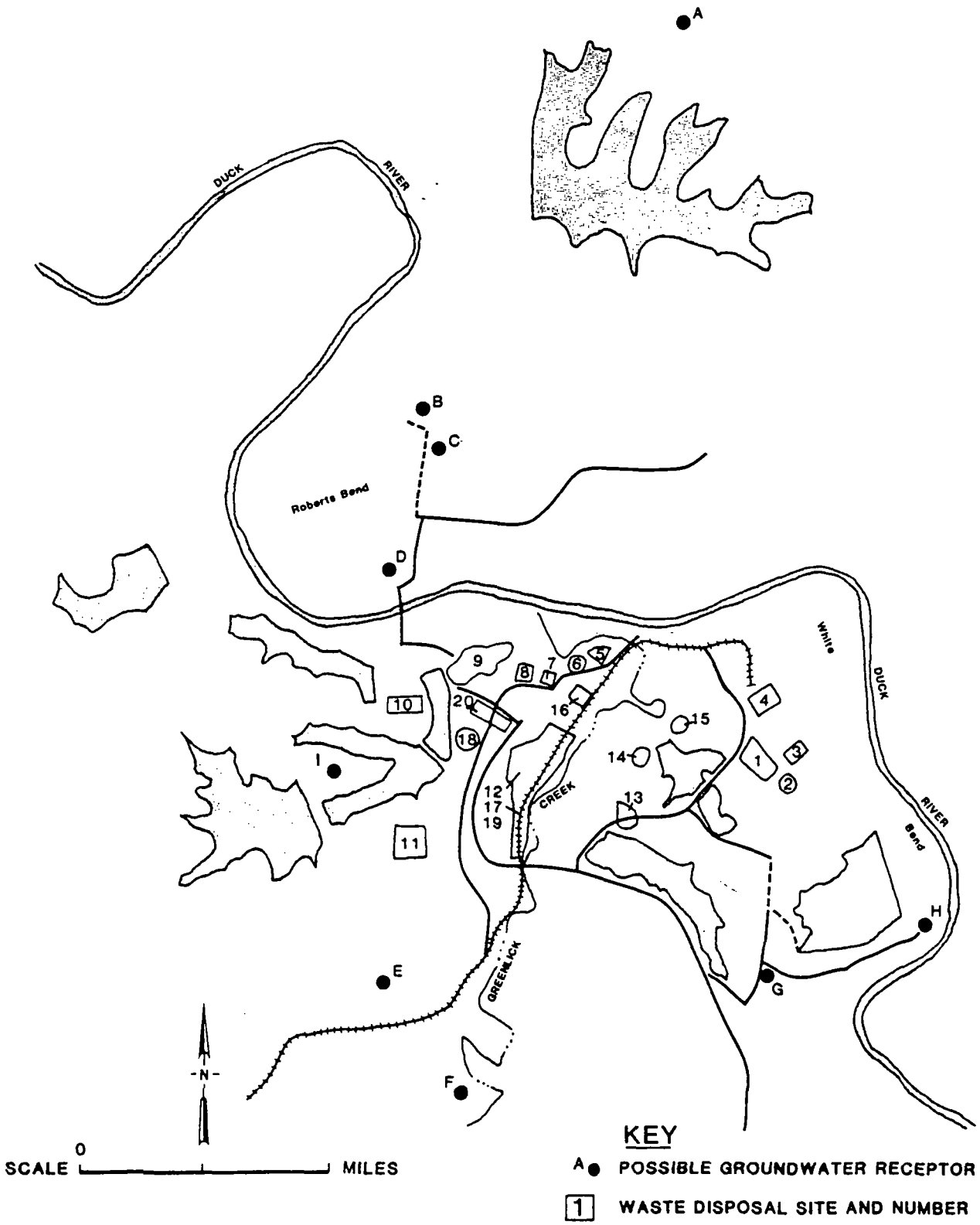


TABLE 4.1
POSSIBLE GROUND-WATER RECEPTORS

| Letter (from Figure 4.1) | Description |
|---|---|
| A | Previous water source for pond #15 construction crews |
| B | Possible well site at a residence |
| C | Possible well site at "repair building" |
| D | Possible well site at a residence |
| E | Possible commercial facility well site (Uptane Construction Co.) |
| F | Numerous residences on wells |
| G | Girl Scout Camp gate well (electric pump) |
| H | Girl Scout Camp hand pump well |
| I | Possible well site at trailer residence |

## HYDROLOGIC IMPACTS OF PLANT OPERATIONS RELATED TO WATER QUALITY CRITERIA

### Ground Water

Metals in concentrations above drinking water standards have been detected in ground water from each of the three areas that were studied in detail. Chromium and lead were detected in the water in levels significantly above standards in some wells in each area. Chromium was detected at 0.126 and 0.200 mg/l in Site 4, at 0.094 and 0.753 mg/l in Site 9, at 0.210, 0.250 and 0.320 mg/l in Site 12, at 0.123 ppb in Site 17 and at 0.190, 0.240 and 0.320 mg/l in Site 19. Lead was detected at 0.125, 0.145 and 0.720 mg/l in Site 4, at 1.780 mg/l in Site 9, at 0.130 mg/l in Site 12 and at 0.300, 0.680 and 0.740 mg/l in Site 19. The drinking water standard for both metals is 0.050 mg/l. Arsenic was detected in the water in levels slightly above standards in two wells in the Railroad Yard area. These levels were each 0.070 mg/l. The drinking water standard is 0.050 mg/l. Arsenic above standards was also detected in water from one well in the Pond No. 3 area, with the level being 0.860 mg/l.

The total dissolved solids content in water from all wells in the Phosphorus Slurry Dump area and Pond No. 3 area exceeded recommended drinking water standards of 500 mg/l, as did most wells in the Furnace Department, Tank Farm and Railroad Yard area.

Metals concentrations and total dissolved solids content in ground water at the plant site that are above recommended drinking water standards may be attributed to operations at the plant site. Results of leachate tests conducted on boring samples from the sites show that some metals are leachable (see Appendix G). Additionally, past analysis of the process water and sediments in Pond No. 3, discussed previously in Section 3 of this report, show the presence of many of these same constituents (see Tables 3.2 and 3.3). Water standards for selected parameters are presented in Table 4.2.

### Surface Water

Water from Greenlick Creek meets ambient water quality criteria and generally meets drinking water standards for those parameters tested in the plant site vicinity. The lead content in the water slightly exceeded drinking water standards at the dam (0.081 mg/l), but so did the water in the creek above the plant site (0.065 mg/l).

TABLE 4.2

COMPARISON OF FEDERAL AMBIENT WATER QUALITY CRITERIA, DRINKING WATER STANDARDS AND PROPOSED BAT GUIDELINES FOR ORGANIC CHEMICALS (ALL CONCENTRATIONS IN UG/L)

| Parameter | Ambient Water Quality Criteria: Short Term[1] Acute | Ambient Water Quality Criteria: Long Term[2] Chronic | Drinking Water Standards | Selected Effluent Guidelines for BAT (Monthly Average) |
|---|---|---|---|---|
| Arsenic | 360 | 190 | 50 | 30 - 50[6] |
| Cadmium | 3.89[3]<br>6.19[4] | 1.13[3]<br>1.56[4] | 10 | 70[5] |
| Lead | 83[3]<br>138[4] | 3.2[3]<br>5.4[4] | 50 | 230 - 860[6] |
| Cyanide | 22 | 5.2 | -- | 120[6] |
| Chromium ($^{+}3$) | 1734[3]<br>2414[4] | 207[3]<br>288[4] | --<br>-- | --<br>-- |
| Chromium ($^{+}6$) | 16 | 11 | -- | -- |
| Total Chromium | -- | -- | 50 | 80 - 120[6] |
| Total Dissolved Solids | -- | -- | 500,000 | -- |

(1) One hour average concentration not to be exceeded more than once every 3 years.

(2) Four day average concentration not to be exceeded more than once every 3 years.

(3) Total hardness of 100 mg/l as $CaCO_3$.

(4) Total hardness of 150 mg/l as $CaCO_3$.

(5) New Source Performance Standards for Metal Finishing Industry FR July 15, 1983, pg. 32487.

(6) BAT Standards For Organic Chemicals (PROPOSED) FR July 17, 1985, pg. 29082.

The total dissolved solids content in water from Greenlick Creek may increase in the plant site vicinity when the creek is returned to natural flow conditions, but the level will still be below 500 mg/l. Other constituents in the creek may also increase slightly based upon a reduction in flow volume.

Concentrations of the various metals and inorganic constituents have been measured in past studies (1978) on the Duck River. Those results show no impact to the Duck River from the plant site areas.

SUMMARY OF HYDROLOGIC IMPACTS

Plant operations have impacted the hydrologic environment at the plant site. These impacts can be summarized as follows:

- Elevated concentrations of lead (up to 0.72 mg/l), chromium (up to 0.20 mg/l), and total dissolved solids (up to 1500 mg/l) were identified in ground water around the Phosphorus Slurry Dump.
- Elevated concentrations of lead (up to 1.78 mg/l), chromium (up to 0.75 mg/l), arsenic (up to 0.86 mg/l), fluoride (up to 5.7 mg/l), total organic carbon (up to 168 mg/l) and total dissolved solids (up to 3,776 mg/l) were identified in ground water in the vicinity of Pond No. 3.
- Elevated concentrations of elemental phosphorus (up to 1.43 mg/l), chromium (up to 0.32 mg/l), lead (up to 0.74 mg/l), and total dissolved solids were identified in ground water around the Furnace Department, Tank Farm and Railroad Yard area. Total dissolved solids content in the water was generally greater than 500 mg/L.
- Historical data indicated that ground water at the plant site may have been impacted to a greater extent in the past.
- Some constituents in the ground water are attenuated as water moves away from disposal sites while other constituents are not attenuated. The same constituents may be attenuated at one site and not attenuated at another site.

- The water in Greenlick Creek has been impacted by plant operations. Increases in levels of elemental phosphorus (up to 0.0001 mg/L) and lead (up to 0.08 mg/L) were observed in the portion of the creek flowing by the plant.
- Returning Greenlick Creek to natural flow conditions may result in a small increase in the total dissolved solids content as well as other constituents in the water.
- No impacts to the Duck River from plant operations have been noted based upon historic analytical data upstream and downstream of the plant site.

APPENDIX G

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CHEMISTRY ANALYTICAL RESULTS


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# TABLE G.1
## SEDIMENT AND SOIL ANALYSES

EDSOL

| Location | Date | ID | SEDIMENT AND SOIL ANALYSIS: (1) P4 % | PO4 Total (mg/kg) | F⁻ Total (mg/kg) | Cd (mg/kg) | Cr (mg/kg) | Pb (mg/kg) | As (mg/kg) | CN (mg/kg) | ASTM Extract: pH | PO4 Tot. Sol. (mg/l) | F⁻ Tot. Sol. (mg/l) | Cd (mg/l) | Cr (mg/l) | Pb (mg/l) | As (mg/l) | CN (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEDIMENT | | | | | | | | | | | | | | | | | | |
| Greenlick Cr | 7-17-85 | STA 5 | N/A | 98 | 4 | 2.4 | 27 | 41 | 2.6 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 7-18-85 | STA 6 | N/A | 1149 | 1.5 | 2.4 | 37 | 38 | 3.4 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 7-18-85 | STA 11 | N/A | 183 | 30 | 2.7 | 49 | 32 | 3.8 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 7-19-85 | STA 12 | N/A | 90 | 5 | 1.8 | 42 | 24 | 2.7 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 7-19-85 | STA 13 | N/A | 119 | 6.4 | 1.9 | 43 | 32 | 2.1 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| Near Site 4 | 7-18-85 | STA 1 | N/A | 262 | 1.7 | 9 | 22 | 26 | (2 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| | 7-18-85 | STA 2A | N/A | 100 | 3.4 | 7.7 | 27 | 23 | (2 | (0.1 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | N/A |
| SOIL SAMPLES | | | | | | | | | | | | | | | | | | |
| Site 3 | 8-2-85 | 3-4 | 0.07 | 19144 | 1035 | 6.9 | 25 | 206 | 1.2 | 259 | 5 | 85 | 56 | (0.05 | (0.15 | (0.20 | 0.011 | 0.057 |
| Site 4 | 6-27-85 | 4-1 | 0 | 32 | 7.9 | 2.7 | 35 | 41 | 2.9 | 2.1 | 6 | 2 | 1 | (0.05 | 0.2 | (0.20 | 0.002 | (0.005 |
| | 6-27-85 | 4-2 | 0.12 | 445 | 14 | 2.1 | 53 | 111 | 2.2 | 2.7 | 4.5 | 45 | 5 | (0.05 | (0.15 | (0.20 | 0.017 | 0.005 |
| | 6-29-85 | 4-2A | 0 | 162 | 51 | 1.6 | 30 | 14 | (2 | (0.1 | 5 | 3 | 1 | (0.05 | (0.15 | (0.20 | (0.002 | (0.005 |
| | 6-29-85 | 4-3 | 2.74 | 7169 | 15324 | 4 | 45 | 97 | 4.4 | 50 | 3.6 | 623 | 234 | (0.05 | (0.15 | (0.20 | 0.134 | 0.04 |
| | 7-3-85 | 4-4 | 0 | 10264 | 6 | (5 | (15 | (20 | (1 | 0.5 | 7.7 | 1 | 3 | (0.05 | 0.422 | (0.20 | (0.002 | (0.005 |
| Site 5 | 6-29-85 | 5-1A | 0 | 4093 | 21 | 1.6 | 44 | 48 | (2 | 2.1 | 6.9 | 3 | 3 | (0.05 | 0.204 | (0.20 | (0.002 | 0.006 |
| | 7-3-85 | 5-2 | 0 | 444 | 44 | 2.2 | 64 | 108 | (2 | 2.1 | 6.6 | 10 | 7 | (0.05 | 0.233 | (0.20 | (0.002 | 0.008 |
| Site 6 | 7-26-85 | 6-1 | 0.05 | 27492 | 147 | (5 | 33 | (20 | 2 | (0.1 | 6.8 | 7 | 9 | (0.05 | (0.15 | (0.20 | 0.002 | 0.008 |
| | 7-26-85 | 6-2 | 0 | 46078 | 225 | (5 | 53 | 72 | 3.1 | 2.8 | 6.6 | 13 | 4 | (0.05 | (0.15 | (0.20 | (0.002 | 0.076 |
| | 8-1-85 | 6-4 | 0 | 23707 | 239 | (5 | 44 | (20 | 2 | 0.8 | 7 | 37 | 7 | (0.05 | 0.26 | (0.20 | (0.002 | (0.005 |
| | 8-1-85 | 6-5 | 0 | 23398 | 282 | (5 | 48 | (20 | 2.2 | 1.7 | N/A | N/A | N/A | (0.05 | (0.15 | (0.20 | 0.015 | N/A |
| Site 7 | 7-26-85 | 7-1 | 0.12 | 87581 | 174 | (5 | 77 | (20 | 3.8 | (0.1 | 7 | 1 | 3 | (0.05 | 0.275 | (0.20 | 0.002 | 0.009 |
| | 8-2-85 | 7-2 | 0 | 63072 | 478 | (5 | 98 | 28 | 5.2 | 0.5 | 6.9 | 3 | 6 | (0.05 | (0.15 | (0.20 | (0.002 | 0.025 |
| Site 8 | 7-27-85 | 8-2 | 0 | 57843 | 2141 | (5 | 57 | 132 | 4.9 | 4.3 | 6.2 | 1 | 27 | (0.05 | 0.377 | (0.20 | 0.024 | 0.009 |
| Site 11 | 7-24-85 | 11-1 | 0.15 | 63725 | 1103 | (5 | 49 | 162 | 4.9 | 3.9 | 6.4 | 9 | 30 | (0.05 | (0.15 | (0.20 | 0.021 | 0.006 |
| | 7-24-85 | 11-2 | 0.18 | 27778 | 38 | (5 | 61 | 29 | 5.4 | (0.1 | 5.8 | 4 | 2 | (0.05 | (0.15 | (0.20 | (0.002 | 0.007 |
| | 7-24-85 | 11-3 | 0.14 | 13072 | 100 | (5 | 41 | 26 | 4.3 | 1.3 | 7.4 | 3 | 3 | (0.05 | (0.15 | (0.20 | (0.002 | 0.006 |
| | 7-25-85 | 11-5 | 0 | 42157 | 1046 | (5 | 51 | 81 | 4.7 | 1.1 | 6.5 | 4 | 4 | (0.05 | (0.15 | (0.20 | (0.002 | 0.013 |

TABLE G.1
(CONTINUED)
SEDIMENT AND SOIL ANALYSES

EDSOL

| Location | Date | ID | (1) P4 % | PO4 Total (mg/kg) | F⁻ Total (mg/kg) | Cd (mg/kg) | Cr (mg/kg) | Pb (mg/kg) | As (mg/kg) | CN (mg/kg) | ASTM Extract pH | PO4 Tot. (mg/l) | PO4 Sol. (mg/l) | F⁻ Tot. (mg/l) | F⁻ Sol. (mg/l) | Cd (mg/l) | Cr (mg/l) | Pb (mg/l) | As (mg/l) | CN (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SEDIMENT | | | | | | | | | | | | | | | | | | | | |
| Site 12 | 7-11-85 | 12-1W | 1.01 | 171 | 88 | <5 | 40 | 33 | <2 | 4.9 | 8.6 | <0.1 | 4 | <0.05 | 0.226 | <0.20 | <0.002 | 0.007 | | |
| | 7-12-85 | 12-2W | 0 | 84 | 44 | <5 | 62 | 21 | 2.6 | 2.2 | 6.3 | 4 | 2 | <0.05 | 0.4 | 0.539 | <0.002 | <0.005 | | |
| | 7-12-85 | 12-3AW | 0 | 43572 | <5 | <5 | 44 | 24 | 5 | 0.3 | 7.7 | 1 | 0 | <0.05 | 0.447 | <0.20 | 0.003 | <0.005 | | |
| | 7-12-85 | 12-4W | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 7.3 | 5 | 4 | <0.05 | <0.15 | <0.20 | <0.002 | 0.009 | | |
| | 7-29-85 | 12-5 | 0 | 48921 | 70 | <5 | 24 | <20 | 3.6 | <0.1 | 6.4 | 5 | 1 | <0.05 | <0.15 | 0.376 | <0.002 | <0.005 | | |
| | 7-29-85 | 12-6 | 0.14 | 58170 | 56 | <5 | 34 | <20 | 6 | <0.1 | 5.8 | 29 | 51 | <0.05 | <0.15 | <0.20 | 0.02 | <0.005 | | |
| | 7-29-85 | 12-7 | 0 | 1180 | N/A | <5 | 29 | <20 | 2 | N/A | 6.4 | 3 | 8 | <0.05 | <0.15 | <0.20 | <0.002 | <0.005 | | |
| | 7-29-85 | 12-8 | 2.83 | 116667 | N/A | <5 | 28 | <20 | 4.3 | N/A | 4.6 | 588 | 68 | <0.05 | <0.15 | <0.20 | 0.164 | <0.005 | | |
| Site 13 | 7-23-85 | 13-1 | 0.12 | 40196 | 149 | <5 | 23 | 49 | 7.5 | <0.1 | 5.2 | 1 | 4 | <0.05 | 0.391 | <0.20 | <0.002 | 0.005 | | |
| | 7-23-85 | 13-2 | 0.12 | 63725 | 24 | <5 | 44 | 21 | 14 | <0.1 | 6.5 | 3 | 2 | <0.05 | 0.343 | <0.20 | <0.002 | 0.006 | | |
| Site 17 | 7-8-85 | 17-1 | 0.94 | 77778 | 69 | <5 | 26 | <20 | <1 | 1.4 | 7.4 | 12 | 3 | <0.05 | <0.15 | 0.43 | 0.011 | 0.008 | | |
| | 7-8-85 | 17-2A | 5.28 | 109382 | 311 | <5 | 28 | <20 | 3.3 | 1.1 | 4.4 | 253 | 2 | 0.053 | <0.15 | <0.20 | 0.041 | 0.033 | | |
| | 7-10-85 | 17-3 | 4.88 | 40500 | 29 | <5 | 36 | <20 | 3.6 | 0.9 | 5 | 139 | 1 | <0.05 | 0.198 | <0.20 | 0.009 | 0.008 | | |
| | 7-9-85 | 17-4 | 0.15 | 30168 | 74 | <5 | <15 | <20 | <1 | 0.9 | 5.8 | 1 | 3 | <0.05 | 0.949 | <0.20 | <0.002 | 0.016 | | |
| | 7-10-85 | 17-5W | 0 | 14640 | 285 | <5 | 31 | <20 | <1 | 3.2 | 7.2 | 67 | 13 | <0.05 | 0.343 | 0.475 | <0.002 | <0.005 | | |
| Site 18 | 8-1-85 | 18-1 | 0 | 62031 | 2052 | <5 | 37 | 27 | 28 | 4.6 | 5.2 | 11 | 90 | <0.05 | <0.15 | <0.20 | 0.082 | <0.005 | | |
| | 8-2-85 | 18-2 | 0 | 55229 | 1835 | <5 | 91 | 92 | 5.8 | 6.8 | 6.6 | 6 | 25 | <0.05 | <0.15 | <0.20 | 0.008 | 0.008 | | |
| Site 19 | 7-10-85 | 19-1W | 0 | 15815 | 577 | <5 | <15 | 35 | 1.3 | 1.2 | 8.6 | <0.1 | 10 | <0.05 | <0.15 | <0.20 | <0.002 | 0.006 | | |
| | 7-16-85 | 19-2W | 0 | N/A | N/A | N/A | N/A | N/A | N/A | N/A | 8.6 | 4 | 10 | <0.05 | <0.15 | 0.63 | <0.002 | <0.005 | | |
| | 7-17-85 | 19-3W | 0 | 26144 | 24 | <5 | 86 | 32 | 2.2 | N/A | 7.7 | 2 | 1 | <0.05 | 0.896 | <0.20 | 0.006 | <0.005 | | |
| | 7-16-85 | 19-4W | 0.13 | 22070 | 178 | <5 | 36 | 30 | 3.2 | 1.1 | 7.2 | 1 | 5 | <0.05 | 0.235 | <0.20 | 0.002 | 0.006 | | |
| | 7-16-85 | 19-5W | 0.11 | 9149 | 340 | <5 | 20 | <20 | <1 | 1.9 | 7.2 | 1 | 10 | <0.05 | <0.15 | <0.20 | <0.002 | <0.005 | | |
| | 7-22-85 | 19-6W | 0.07 | 8751 | 326 | <5 | 34 | <20 | 1.2 | 3.2 | 8.9 | <0.1 | 9 | <0.05 | <0.15 | <0.20 | <0.002 | <0.005 | | |
| | 7-23-85 | 19-7W | 0.09 | 63637 | 183 | <5 | 29 | <20 | <1 | 1.9 | 6.4 | 1 | 10 | <0.05 | 0.196 | <0.20 | <0.002 | 0.009 | | |
| | 7-19-85 | 19-8W | 0.1 | 8724 | 465 | <5 | <15 | <20 | <1 | 1.2 | 8.9 | <0.1 | 6 | <0.05 | 0.208 | <0.20 | <0.002 | 0.006 | | |
| Site 20 | 7-29-85 | 20-1 | 0 | 30490 | 36 | <5 | 22 | 20 | 7.1 | 1.2 | 6.5 | 4 | 16 | <0.05 | <0.15 | <0.20 | <0.002 | 0.011 | | |
| | 7-30-85 | 20-3 | 0 | 40850 | 252 | <5 | 23 | 35 | 6.3 | 1.6 | 6 | 2 | 8 | <0.05 | <0.15 | <0.20 | <0.002 | <0.005 | | |
| | 8-1-85 | 20-3A | 0 | 31797 | 20 | <5 | 45 | 32 | <1 | <0.1 | 7.2 | 3 | 4 | <0.05 | <0.15 | <0.20 | <0.002 | <0.005 | | |
| | 8-1-85 | 20-4 | 0 | 35294 | 1706 | <5 | 26 | 479 | 4.6 | 0.8 | 6 | 7 | 20 | <0.05 | 0.163 | <0.20 | 0.002 | <0.005 | | |

EDSOL

# TABLE G.2
## SURFACE AND GROUND-WATER ANALYSIS

| Location | Date | ID | Field Measurement pH | Sp.Cond. (umhos) | Temp. C | P4 (mg/l) | PO4 Total (mg/l) | PO4 Totl Sol. (mg/l) | $F^-$ Total (mg/l) | $F^-$ Totl Sol. (mg/l) | Cd (mg/l) | Cr (mg/l) | Pb (mg/l) | As (mg/l) | CN (mg/l) | TOC (mg/l) | pH | Sp.Cond. (umhos) | TDS (mg/l) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SURFACE WATER | | | | | | | | | | | | | | | | | |
| Greenlick,Cr. | 7-17-85 | STA 5 | 7.4 | 350 | 29 | 0.000086 | 0.8 | 1.2 | 0.8 | 0.7 | 0.0004 | (0.010 | 0.015 | 0.004 | (0.005 | 22 | 7.2 | 235 | 195 |
| | 7-18-85 | STA 6 | 6.7 | 290 | 29 | 0.000086 | 0.7 | 0.9 | 0.8 | 0.7 | 0.0006 | (0.010 | 0.026 | 0.003 | (0.005 | 20 | 7 | 285 | 169 |
| | 7-18-85 | STA 11 | 7.5 | 310 | 31 | 0.00011 | 0.6 | 0.6 | 0.6 | 0.5 | 0.0003 | (0.010 | 0.081 | (0.002 | (0.005 | 19 | 7.5 | 280 | 160 |
| | 7-19-85 | STA 12 | 7.9 | 400 | 26 | 0.000002 | 0.5 | 1.3 | 0.3 | 0.2 | 0.0003 | (0.010 | 0.065 | 0.003 | 0.005 | 20 | 7.5 | 439 | 251 |
| | 7-19-85 | STA 13 | 8.1 | 600 | 26 | 0.000001 | 0.9 | 0.9 | 0.6 | 0.5 | 0.0004 | (0.010 | 0.05 | 0.002 | (0.005 | 21 | 7.3 | 640 | 422 |
| Near Site 4 | 7-18-85 | STA 1 | 6.3 | 400 | 21 | N/A | 21.9 | 20.6 | 0.4 | 0.4 | 0.0004 | (0.010 | 0.043 | 0.002 | 0.008 | 12 | 6.8 | 382 | 275 |
| | 7-18-85 | STA2A | 6.9 | 380 | 29 | N/A | 5.2 | 5.2 | 1.1 | 1.2 | 0.0007 | (0.010 | 0.014 | 0.003 | (0.005 | 18 | 7 | 380 | 239 |
| Spring Near Site 9 | 7-18-85 | STA3A | 6.8 | 370 | 22 | 0.000004 | (0.1 | 2.2 | 0.6 | 0.4 | 0.0005 | (0.010 | 0.035 | 0.006 | (0.005 | 16 | 7.2 | 262 | 147 |
| | | GROUND WATER | | | | | | | | | | | | | | | | | |
| Site 4 | 8-9-85 | 4-5W | 6.9 | 1000 | 18 | 0.000002 | 1.4 | 1 | 0.9 | 0.6 | (0.0002 | (0.010 | 0.026 | 0.001 | (0.005 | 28 | 6.7 | 950 | 590 |
| | 8-9-85 | 4-6W | 7.4 | 1575 | 17 | 0.000002 | 6.5 | 1.4 | 0.6 | 0.4 | (0.0002 | (0.010 | 0.042 | 0.015 | 0.005 | 55 | 6.4 | 1600 | 1533 |
| | 8-9-85 | 4-7W | 6.8 | 1500 | 15 | 0.000086 | 19.3 | 15.3 | 1 | 0.6 | (0.0002 | 0.2 | 0.72 | 0.023 | 0.006 | 75 | 6.2 | 1250 | 962 |
| | 8-9-85 | 4-8W | 6.5 | 800 | 23 | 0.000042 | 196 | 119.9 | 0.9 | 0.7 | (0.0002 | (0.010 | 0.125 | 0.047 | (0.005 | 90 | 7 | 768 | 774 |
| | 8-9-85 | 4-9W | 8.5 | 525 | 19 | 0.000003 | 1.9 | 1.1 | 7.5 | 6.3 | (0.0002 | 0.126 | 0.145 | 0.003 | 0.003 | 35 | 8.2 | 485 | 593 |
| Site 9 | 8-8-85 | 9-1W | 6.9 | 4100 | 34 | 0.000001 | 41.2 | 40.2 | 5.3 | 3.9 | (0.0002 | 0.094 | 0.022 | 0.035 | (0.005 | 26 | 6.6 | 3777 | 2466 |
| | 8-8-85 | 9-2W | 7.7 | 4300 | 20 | 0.000002 | 1 | 1 | 1.2 | 1 | (0.0002 | 0.012 | 0.005 | 0.001 | (0.005 | 50 | 7.2 | 4145 | 3776 |
| | 8-8-85 | 9-3W | 7.3 | 4100 | 25 | 0.000001 | 0.8 | 1.2 | 1.3 | 1 | (0.0002 | (0.010 | 0.016 | 0.006 | (0.005 | 52 | 7 | 4239 | 2765 |
| | 8-9-85 | 9-4W | 7.1 | 2500 | 20 | 0.000001 | 276.1 | 229.7 | 7 | 5.7 | 0.05 | 0.753 | 1.78 | 0.86 | (0.005 | 168 | 7 | 2167 | 1874 |
| | 8-9-85 | 9-5W | 7.2 | 740 | 17 | 0.000001 | 6.5 | 3.2 | 0.8 | 0.5 | (0.0002 | 0.011 | 0.022 | 0.006 | 0.005 | 60 | 7.2 | 716 | 514 |
| | 8-9-85 | 9-6W | 7.6 | 1050 | 17 | 0.000001 | 0.7 | 0.6 | 1.5 | 1.6 | (0.0002 | (0.010 | 0.015 | (0.001 | (0.005 | 37 | 7.3 | 1319 | 966 |
| Site 12 | 8-1-85 | 12-1W | 7.2 | 1040 | 20 | 0.07 | 4.6 | 2.8 | 2.3 | 2.4 | (0.0002 | (0.030 | (0.005 | 0.007 | 0.005 | 24 | 7.3 | 989 | 586 |
| | 8-1-85 | 12-2W | 7 | 830 | 20 | 1.43 | 6.9 | 4.6 | 1.4 | 1.3 | (0.0002 | 0.21 | 0.13 | 0.004 | (0.005 | 22 | 6.7 | 767 | 453 |
| | 8-1-85 | 12-3AW | 7.3 | 1050 | 18 | 0.00127 | 1.4 | 0.9 | 1.8 | 1.6 | (0.0002 | 0.25 | (0.005 | (0.001 | (0.005 | 22 | 7.3 | 1009 | 609 |
| | 8-1-85 | 12-4W | 7.1 | 1250 | 24 | 0.00818 | 8.2 | 6.2 | 2.4 | 2 | (0.0002 | 0.32 | (0.005 | 0.003 | 0.015 | 26 | 6.9 | 1312 | 740 |
| Site 17 | 8-1-85 | 17-5 | 7.4 | 1320 | 20 | 0.0007 | 4.9 | 4.6 | 48 | 44 | (0.0002 | 0.123 | 0.006 | 0.008 | 0.013 | 26 | 7.2 | 1312 | 846 |
| Site 19 | 8-2-85 | 19-1W | 7.6 | 500 | 19 | 0.000001 | 1.3 | 1.3 | 12 | 10 | 0.007 | (0.030 | 0.016 | 0.002 | (0.005 | 9 | 6.9 | 616 | 430 |
| | 8-2-85 | 19-2W | 7.4 | 2060 | 20 | 0.000001 | 1.4 | 1.4 | 2.1 | 2 | 0.01 | (0.030 | 0.005 | 0.002 | 0.01 | 84 | 7.2 | 2013 | 1271 |
| | 8-2-85 | 19-3W | 8.5 | 1300 | 21 | 0.000001 | 2.7 | 2.5 | 14 | 14 | 0.035 | 0.32 | 0.68 | 0.07 | (0.005 | 22 | 8.2 | 1514 | 918 |
| | 8-2-85 | 19-4W | 7.8 | 2300 | 20 | 0.000002 | 1.4 | 1.5 | 4.6 | 4.4 | 0.015 | 0.24 | 0.74 | 0.07 | (0.005 | 10 | 7.4 | 2573 | 1840 |
| | 8-2-85 | 19-5W | 7.7 | 700 | 19 | 0.000002 | 1.2 | 0.7 | 7.8 | 7.2 | 0.015 | 0.19 | 0.3 | 0.014 | (0.005 | 18 | 7.5 | 713 | 413 |
| | 8-2-85 | 19-6AW | 8.3 | 680 | 24 | 0.000018 | (0.1 | (0.1 | 7.5 | 7.5 | 0.002 | (0.030 | (0.005 | 0.005 | (0.005 | 18 | 7.7 | 696 | 391 |
| | 8-2-85 | 19-7W | 7.9 | 960 | 20 | 0.000006 | 1.1 | 1.3 | 6.5 | 6.2 | 0.007 | (0.030 | (0.005 | 0.005 | 0.009 | 33 | 7.5 | 868 | 528 |
| | 8-2-85 | 19-8W | 7.5 | 1250 | 20 | 0.000001 | 1.4 | 0.7 | 6.2 | 5.1 | (0.0002 | (0.030 | 0.05 | 0.01 | 0.007 | 10 | 7.6 | 1261 | 792 |

TABLE G.3

QA/QC SAMPLE SETS

MONSANTO

Columbia, Tennessee

| Set | Type Sample | | Description |
|---|---|---|---|
| A | GW | Wells | 19-1 to 19-8, 12-1 to 12-4, 17-5 |
| B | GW | Wells | 9-1 to 9-6, 4-5 to 4-9 |
| C | SW | Stations | 1 to 13 |
| D | SED | Stations | 1 to 13 |
| E | SS | Borings | 4-1 to 4-3, 5-1, 5-2, 12-1 to 12-3 |
| F | SS | Borings | 12-3, 17-1 to 17-4, 19-1, 19-4 to 19-8 |
| G | SS | Borings | 3-4, 4-4, 6-1, 6-2, 6-4, 6-5, 7-1, 7-2, 8-2, 11-1 to 11-3, 11-5, 18-2, 19-3, 20-4 |
| H | SS | Borings | 12-5 to 12-8, 13-1, 13-2, 17-5, 18-1, 20-1, 20-3, 20-3A |
| I | LE | Borings | 4-4, 5-2, 7-1, 8-2, 12-1, 12-3A, 13-1, 13-2, 17-4, 19-1, 19-4 to 19-8 |
| J | LE | Borings | 3-4, 4-1, 5-1, 6-1, 6-2, 6-4, 6-5, 7-2, 11-1 to 11-3, 11-5, 12-2, 12-4, 12-5, 12-7, 17-1, 17-3, 17-5, 18-2, 19-1, 19-2, 20-1, 20-3A, 20-4 |
| K | LE | Borings | 4-2, 4-2A, 4-3, 12-6, 12-8, 17-2A, 18-1, 20-3. |

TABLE G.4
MONSANTO, COLUMBIA, TN
PHOSPHATE QA/QC
August 1985

| QA Sample Description | | | Duplicates | | | Spikes | | | Sample Set |
|---|---|---|---|---|---|---|---|---|---|
| | | | V1 | V2 | % Rel. Error | Added | Recovered | % Recovery | |
| 19-5 | GW | T | 2.8 | 4.4 | 44 | 5 | <1 | NA | A |
| 9-6 | GW | T | 2.2 | 2.4 | 9 | - | - | - | B |
| STA 13 | SW | T | 2.7 | 2.7 | - | - | - | - | C |
| STA 5 | SW | T | - | - | - | 1.00 | .95 | 95 | C |
| STA 11 | SED | T | - | - | - | 1.00 | .80 | 80 | D |
| 12-3 | SS | T | - | - | - | 1.00 | 1.02 | 102 | E |
| 19-5 | SS | T | 29472 | 26521 | 10 | - | - | - | F |
| 6-2 | SS | T | 129000 | 153165 | 17 | 5 | 20 | 400 | G |
| 8-2 | SS | T | 175080 | 179111 | 2 | 5 | 20 | 400 | G |
| 12-5 | SS | T | 157100 | 142300 | 10 | 5.0 | 4.3 | 86 | H |
| 19-5 | GW | S | <1 | 3.6 | NA | 5 | <2 | NA | A |
| 9-6 | GW | S | 1.9 | 1.8 | 5 | - | - | - | B |
| STA 5 | SW | S | - | - | - | 1.00 | .93 | 93 | C |
| 7-1 | LE | S | - | - | - | 10.8 | 10.26 | 95 | I |
| 19-8 | LE | S | <1 | <1 | 0 | - | - | - | I |
| 8-2 | LE | S | 9.9 | 10 | 1 | - | - | - | I |
| 11-1 | LE | S | 29 | 28 | 4 | 5 | 4.8 | 96 | J |
| 12-2 | LE | S | 7.4 | 8.8 | 17 | - | - | - | J |
| 12-5 | LE | S | 13.1 | 13.3 | 1 | 5 | 7.6 | 152 | J |
| 18-1 | LE | S | 31 | 32 | 3 | 5 | 6 | 120 | K |

GW - Ground water
LE - Leachate
SED - Sediment
SS - Soil
SW - Surface water
S - Soluble
T - Total
NA - Not Applicable

8510J35

TABLE G.5
MONSANTO, COLUMBIA, TN
FLUORIDE QA/QC
August 1985

| QA Sample Description | | | Duplicates | | | Spikes | | | Sample Set |
|---|---|---|---|---|---|---|---|---|---|
| | | | V1 | V2 | % Rel. Error | Added | Recovered | % Recovery | |
| 19-5 | GW | T | 8.9 | 6.8 | 27 | - | - | - | A |
| 9-6 | GW | T | 1.5 | 1.5 | 0 | 2.00 | 1.78 | 89 | B |
| STA 1 | SW | T | 0.4 | 0.4 | 0 | 1.00 | 1.00 | 100 | C |
| STA 6 | SED | T | 1.5 | 1.5 | 0 | 1.00 | 0.70 | 70 | D |
| 4-3 | SS | T | 15581 | 15067 | 3 | 1.00 | 1.10 | 110 | E |
| 19-6 | SS | T | 330 | 322 | 2 | - | - | - | F |
| 4-4 | SS | T | 7.5 | 5.0 | 40 | - | - | - | G |
| 18-1 | SS | T | 2100 | 2005 | 5 | - | - | - | H |
| 19-5 | GW | S | 8.3 | 6.2 | 29 | 2.00 | 1.94 | 97 | A |
| 9-6 | GW | S | 1.6 | 1.6 | 0 | 2.00 | 2.10 | 105 | B |
| 9-4 | GW | S | - | - | - | 2.00 | 1.96 | 98 | B |

GW - Ground water
SED - Sediment
SS - Soil
SW - Surface water
S - Soluble
T - Total

TABLE G.6
MONSANTO, COLUMBIA, TN
CADMIUM QA/QC
August 1985

| QA Sample Description | | Duplicates V1 | Duplicates V2 | Duplicates % Rel. Error | Spikes Added | Spikes Recovered | Spikes % Recovery | Sample Set |
|---|---|---|---|---|---|---|---|---|
| 19-5 | GW | 19 | 11 | 53 | 20 | 15 | 75 | A |
| 0.5 ppb | STD | - | - | - | 5.0 | 4.4 | 88 | A |
| 9-6 | GW | .063 | .071 | 12 | .050 | .049 | 98 | B |
| 0.1 ppb | STD | - | - | - | .100 | .107 | 107 | B |
| Test Solution | - | - | - | - | .500 | .528 | 106 | B |
| 4-7 | GW | <.02 | <.02 | 0 | - | - | - | B |
| STA 6 | SW | .004 | .003 | 29 | .200 | .197 | 99 | C |
| STA 6 | SED | 2.4 | 2.4 | 0 | .200 | .189 | 95 | D |
| 4-3 | SS | 1.7 | 3.5 | 69 | .200 | .168 | 84 | E |
| 19-4 | SS | <5 | <5 | 0 | - | - | - | F |
| 19-5 | SS | <5 | <5 | 0 | - | - | - | F |
| Test Solution | - | - | - | - | .500 | .464 | 93 | F |
| Test Solution | - | - | - | - | .500 | .470 | 94 | F |
| 6-1 | SS | <.05 | <.05 | 0 | - | - | - | G |
| 11-3 | SS | <.05 | <.05 | 0 | - | - | - | G |
| Test Solution | - | - | - | - | .500 | .511 | 102 | G |
| 0.5 ppb | STD | - | - | - | .500 | .498 | 99 | G |
| 18-1 | SS | <.05 | <.05 | 0 | - | - | - | H |
| Test Solution | - | - | - | - | .500 | .486 | 97 | H |
| 0.5 ppb | STD | - | - | - | .500 | .512 | 102 | H |
| 17-4 | LE | <.05 | <.05 | 0 | - | - | - | I |
| 5-2 | LE | <.05 | <.05 | 0 | - | - | - | I |
| 12-5 | LE | <.05 | <.05 | 0 | - | - | - | J |
| 12-7 | LE | <.05 | <.05 | 0 | - | - | - | J |
| Test Solution | - | - | - | - | .500 | .518 | 104 | I,J |
| 0.5 ppb | STD | - | - | - | .500 | .547 | 109 | I,J |
| 18-1 | LE | <.05 | <.05 | 0 | - | - | - | K |

GW - Ground water
LE - Leachate
SW - Surface water
SED - Sediment
SS - Soil
STD - Standard

8510J35

TABLE G.7
MONSANTO, COLUMBIA, TN
CHROMIUM QA/QC
August 1985

| QA Sample Description | | Duplicates | | | Spikes | | | Sample Set |
|---|---|---|---|---|---|---|---|---|
| | | V1 | V2 | % Rel. Error | Added | Recovered | % Recovery | |
| 19-5 | GW | .18 | .20 | 11 | - | - | - | A |
| .3 PPB | STD | - | - | - | .30 | .26 | 87 | A |
| Test Solution | | - | - | - | 1.154 | 1.109 | 96 | A |
| 9-6 | GW | <.05 | .06 | NA | - | - | - | B |
| 4 ppb | STD | - | - | - | 4.000 | 4.179 | 105 | B |
| 4-7 | GW | .22 | .19 | 15 | - | - | - | B |
| STA 6 | SW | <.15 | <.15 | 0 | - | - | - | C |
| STA 6 | SW | 29 | 45 | 43 | - | - | - | D |
| 4-3 | SS | 58 | 33 | 55 | - | - | - | E |
| 19-4 | SS | 36 | <15 | NA | - | - | - | F |
| 19-5 | SS | 21 | 20 | 5 | - | - | - | F |
| 4 ppb | STD | - | - | - | 4.000 | 4.089 | 102 | F |
| 6-1 | SS | 34 | 32 | 6 | - | - | - | G |
| 11-3 | SS | 44 | 39 | 12 | - | - | - | G |
| 0.5 ppb | STD | - | - | - | .500 | .454 | 91 | G |
| Test Solution | | - | - | - | 4.000 | 3.963 | 99 | G |
| 18-1 | SS | 37 | 37 | 0 | - | - | - | H |
| 4 ppb | STD | - | - | - | 4.000 | 3.990 | 100 | H |
| 17-4 | LE | .47 | .47 | 0 | - | - | - | I |
| 5-2 | LE | .22 | .20 | 10 | - | - | - | I |
| .3 ppb | STD | - | - | - | .300 | .270 | 90 | I |
| 12-7 | LE | <.15 | <.15 | 0 | 1.5 | 1.5 | 100 | J |
| 12-7(Repeat) | LE | <.15 | <.15 | 0 | 1.000 | .787 | 79 | J |
| 1 ppb | STD | - | - | - | 1.000 | .975 | 98 | J |
| Test Solution | | - | - | - | 2.000 | 2.041 | 102 | J |
| 12-5 | LE | <.15 | <.15 | 0 | - | - | - | J |
| 2 ppb | STD | - | - | - | 2.000 | 1.959 | 98 | J |
| 18-1 | LE | <.15 | <.15 | 0 | - | - | - | K |

GW - Ground water
LE - Leachate
SW - Surface water
NA - Not Applicable
SED - Sediment
SS - Soil
STD - Standard

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TABLE G.8
MONSANTO, COLUMBIA, TN
LEAD QA/QC
August 1985

| QA Sample Description | | Duplicates | | | Spikes | | | Sample Set |
|---|---|---|---|---|---|---|---|---|
| | | V1 | V2 | % Rel. Error | Added | Recovered | % Recovery | |
| 19-5 | GW | .30 | .29 | 3 | - | - | - | A |
| 17-5 | GW | - | - | - | .200 | .159 | 80 | A |
| 4-7 | GW | .67 | .77 | 14 | - | - | - | B |
| 9-6 | GW | 13 | 18 | 32 | 10 | 11.5 | 115 | B |
| 20 ppb | STD | - | - | - | 20 | 20 | 100 | B |
| 10 ppb | STD | - | - | - | 10 | 11 | 110 | B |
| Test Solution | | - | - | - | 5.000 | 4.658 | 93 | B |
| STA 6 | SW | .027 | .023 | 16 | - | - | - | C |
| STA 13 | SW | - | - | - | .800 | .748 | 94 | C |
| STA 6 | SED | 36 | 41 | 13 | .500 | .560 | 112 | D |
| 4-2 | SS | - | - | - | 2.500 | 2.762 | 111 | E |
| 4-3 | SS | 13.9 | 63.4 | 127 | - | - | - | E |
| 4-2 | SS | - | - | - | 2.500 | 2.730 | 109 | E |
| 19-4 | SS | 30 | <20 | 40 | - | - | - | F |
| 2 ppb | STD | - | - | - | 2.000 | 2.116 | 106 | F |
| 19-5 | SS | <20 | <20 | 0 | - | - | - | F |
| 6-1 | SS | <20 | <20 | 0 | - | - | - | G |
| Test Solution | | - | - | - | 5.000 | 4.751 | 95 | G |
| 11-3 | SS | 26 | 26 | 0 | - | - | - | G |
| Test Solution | | - | - | - | 5.000 | 5.388 | 108 | G |
| 18-1 | SS | 22 | 33 | 40 | - | - | - | H |
| 2 ppb | STD | - | - | - | 2.000 | 1.833 | 92 | H |
| 4-4 | LE | - | - | - | 2.500 | 2.103 | 84 | I |
| 17-4 | LE | <.2 | <.2 | 0 | - | - | - | I |
| 5-2 | LE | <.2 | <.2 | 0 | - | - | - | I |
| 12-7 | LE | <.2 | <.2 | 0 | - | - | - | J |
| 12-5 | LE | .43 | .30 | 36 | - | - | - | J |
| 4 ppb | STD | - | - | - | 4.000 | 4.135 | 103 | J |
| Test Solution | | - | - | - | 5.000 | 4.999 | 100 | J |
| 18-1 | LE | <.2 | <.2 | 0 | - | - | - | K |
| Test Solution | | - | - | - | 5.000 | 5.206 | 104 | K |

GW - Ground water
LE - Leachate
SW - Surface water
SED - Sediment
SS - Soil
STD - Standard

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TABLE G.9
MONSANTO, COLUMBIA, TN
ARSENIC QA/QC
August 1985

| QA Sample Description | | Duplicates | | | Spikes | | | Sample Set |
|---|---|---|---|---|---|---|---|---|
| | | V1 | V2 | % Rel. Error | Added | Recovered | % Recovery | |
| 19-5 | GW | .013 | .015 | 14 | - | - | - | A |
| 9-6 | GW | - | - | - | 20 | 16.2 | 81 | B |
| 9-6 | GW | - | - | - | 10 | 9.1 | 91 | B |
| 9-6 | GW | <1 | <1 | 0 | 20 | 16.8 | 84 | B |
| 4-7 | GW | 23 | 24 | 4 | - | - | - | B |
| STA 6 | SW | 2 | 5 | 86 | - | - | - | C |
| STA 13 | SW | - | - | - | 20 | 19 | 95 | C |
| STA 6 | SED | 4.1 | 2.7 | 41 | 20 | 22 | 110 | D |
| 4-3 | SS | 4.4 | <2 | NA | 20 | 24 | 120 | E |
| 19-4 | SS | <1 | <1 | 0 | 1 | 1 | 100 | F |
| 17-4 | SS | <1 | <1 | 0 | 30 | 28 | 93 | F |
| 6-1 | SS | 2.3 | 1.8 | 24 | - | - | - | G |
| 4-4 | SS | - | - | - | 40 | 42 | 105 | G |
| 11-3 | SS | 45 | 42 | 7 | - | - | - | G |
| 18-1 | SS | 26 | 31 | 18 | - | - | - | H |
| 30 ppb | STD | - | - | - | 30 | 35 | 117 | F,G,H |
| 17-4 | LE | <1 | <1 | 0 | - | - | - | I |
| 12-7 | LE | <1 | <1 | 0 | - | - | - | J |
| 12-5 | LE | <1 | <1 | 0 | - | - | - | J |
| 30 ppb | STD | - | - | - | 30 | 35 | 117 | I,J,K |

GW - Ground water
LE - Leachate
SED - Sediment
SS - Soil
SW - Surface water
STD - Standard
NA - Not Applicable

8510J35

TABLE G.10
MONSANTO, COLUMBIA, TN
CYANIDE QA/QC
August 1985

| QA Sample Description | | Duplicates | | | Spikes | | | Sample Set |
|---|---|---|---|---|---|---|---|---|
| | | VI | V2 | % Rel. Error | Added | Recovered | % Recovery | |
| 12-1 | GW | .005 | .005 | 0 | - | - | - | A |
| 4-8 | GW | .005 | .005 | 0 | - | - | - | B |
| 9-6 | GW | - | - | - | 1.500 | 1.485 | 99 | B |
| STA-5 | SW | <.005 | <.005 | 0 | - | - | - | C |
| STA-11 | SW | - | - | - | 1.500 | 1.366 | 91 | C |
| STA-5 | SED | <.1 | <.1 | 0 | 1.500 | 1.665 | 111 | D |
| 12-3 | SS | - | - | - | 1.500 | 1.380 | 92 | E |
| 4-3 | SS | 55 | 46 | 18 | - | - | - | E |
| 19-7 | SS | 1.8 | 1.9 | 5 | - | - | - | F |
| 17-4 | SS | - | - | - | 1.500 | 1.620 | 108 | F |
| 3-4 | SS | 253 | 265 | 5 | - | - | - | G, H |
| 6-1 | SS | <.1 | <.1 | 0 | - | - | - | G, H |
| 4-4 | SS | - | - | - | 1.500 | 1.530 | 102 | G, H |
| 6-4 | SS | - | - | - | 1.500 | 1.720 | 115 | G, H |
| 19-7 | LE | .010 | .008 | 22 | - | - | - | I |
| 4-4 | LE | - | - | - | 1.500 | 2.020 | 135 | I |
| 12-3 | LE | - | - | - | 1.500 | 1.730 | 115 | I |
| 18-2 | LE | .008 | .008 | 0 | - | - | - | J |
| 3-4 | LE | .052 | .050 | 4 | - | - | - | J |
| 19-2 | LE | .008 | .008 | 0 | - | - | - | J |
| 12-8 | LE | .008 | .008 | 0 | - | - | - | K |

GW - Ground water
SED - Sediment
SS - Soil
SW - Surface water
LE - Leachate

8510J35

REFERENCE 7



cars from the point of initial manufacture, where raw materials are cheap, to distant plants for conversion to phosphoric acid, phosphates, and other compounds.

**USES AND ECONOMICS** With the commercialization of cheaper methods for producing phosphorus on a large scale, widening fields have been developed for it and its compounds. The consumption of phosphorus derivatives for use other than as fertilizers may be divided into four groups: (1) water treatment and detergents, (2) food and medicine, (3) phosphate esters, and (4) miscellaneous uses. Excluding fertilizers, the main outlet for phosphorus derivatives is *in water treatment and in soap and detergent* manufacture as various sodium phosphates. These salts, because of their ability to precipitate or sequester lime and magnesia, to emulsify or disperse solids in the detergent solution, and to augment the inherent detergent properties of soap and synthetic surface-active agents, are much used as *soap builders or detergent synergists.*

## MANUFACTURE OF PHOSPHORUS AND PURIFIED DERIVATIVES

**REACTIONS** Phosphorus is produced by the electric-furnace method (Fig. 16.7). The following reaction is considered to take place, the raw materials being phosphate rock, silica, and coke:

$$CaF_2 \cdot 3Ca_3(PO_4)_2 + 9SiO_2 + 15C \longrightarrow CaF_2 + 6P + 15CO$$

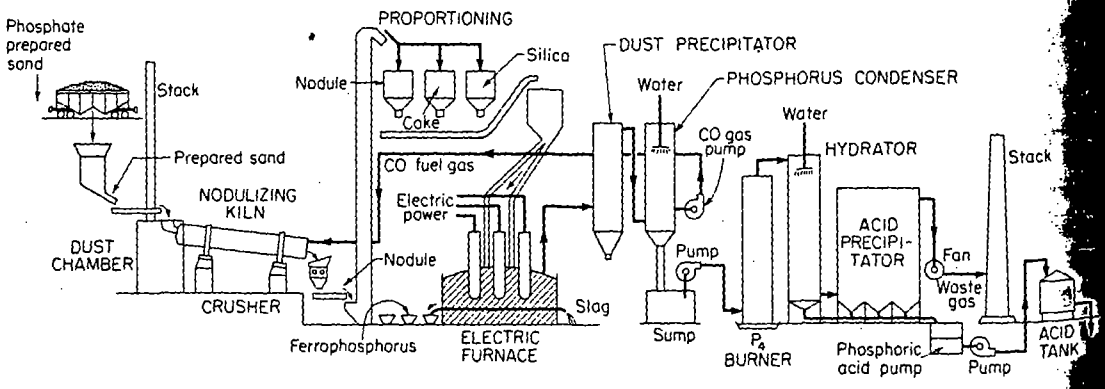
or, more simply expressed,

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \longrightarrow 6CaSiO_3 + P_4 + 10CO \qquad \Delta H = -730 \text{ kcal}$$

The silica is an essential raw material which serves as an acid and a flux. About 20% of the fluorine present in the phosphate rock is converted to $SiF_4$ and volatilized. In the presence of water vapor this reacts to give $SiO_2$ and $H_2SiF_6$:

$$3SiF_4 + 2H_2O \longrightarrow 2H_2SiF_6 + SiO_2$$

The fluorine is not recovered by manufacturers of phosphorus, but the CO is employed as a fuel in preparing the furnace charge (agglomeration). The slag tapped from the furnace is sold as ballast, or aggregate or fill. Ferrophosphorus is tapped as necessary, its quantity being dependent on the




| | | | |
|---|---|---|---|
| Phosphate rock (35.6% $P_2O_5$) | 3,970 lb | Iron (depends on ferrophosphorus requirements) | Per ton 85% $H_3PO_4$ |
| Silica rock | 1,270 lb | Electricity | 3,460 kwh |
| Coke | 748 lb | Direct labor | (est.) 0.5–1 man hr |

*Fig. 16.7* Phosphorus production flowchart. In most cases, the hot phosphorus is pumped into an insulated tank car and shipped to the oxidizing plant where it is made into phosphoric acid and various phosphates. Note: Brink Mist Eliminators have replaced the electrostatic acid mist precipitators in most of the phosphoric acid plants in the United States.

terials are cheap, to distant plants for
ounds.

n of cheaper methods for producing
veloped for it and its compounds. The
as fertilizers may be divided into four
edicine, (3) phosphate esters, and (4)
or phosphorus derivatives is *in water*
odium phosphates. These salts, because
to emulsify or disperse solids in the
operties of soap and synthetic surface-
*ynergists.*

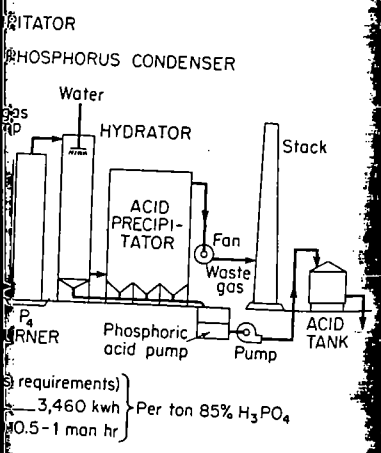
## D DERIVATIVES

e method (Fig. 16.7). The following
phosphate rock, silica, and coke:

$\Delta H = -730$ kcal

acid and a flux. About 20% of the
volatilized. In the presence of water

but the CO is employed as a fuel in
from the furnace is sold as ballast,
s quantity being dependent on the




is pumped into an insulated tank car and
phates. Note: Brink Mist Eliminators have
s in the United States.



amount of iron originally in the burden or added to it. The phosphorus is employed usually as an intermediate product, being shipped to consumption centers and there burned or oxidized to $P_2O_5$, which is dissolved in water to form acids or other compounds:

Phosphorus pentoxide: $4P + 5O_2 \longrightarrow 2P_2O_5$ $\Delta H = -720$ kcal

Orthophosphoric acid: $P_2O_5 + 3H_2O \longrightarrow 2H_3PO_4$ $\Delta H = -45$ kcal

The foregoing reactions for ordinary or orthophosphoric acid are commercialized in the following sequences of *physical operations* and *chemical conversions,* as exemplified by Figs. 16.4 and 16.5 for wet-process acid in comparison with Fig. 16.7 for phosphorus and furnace acid made therefrom.

*Wet-process phosphorus and acid*

Phosphate rock is finely ground and prepulped in the mixing tank with cooled recycled $H_3PO_4$ from the slurry cooler (Op and Ch)
Overflow from the mix tank is reacted with $H_2SO_4$ and recycle $H_3PO_4$ in an agitated digester system, forming gypsum crystals and $H_3PO_4$ (Ch)
Bulk of slurry is recycled through slurry cooler (Op)
Rest of slurry is conducted through the filter feed tank to the cells of the rotary Bird-Prayon tilting-pan filtration unit (Op)
In the progressive and tilting pans of this filter, the $H_3PO_4$ is separated from the gypsum, using three-stage countercurrent washing (Op)
Gypsum is automatically dumped (Op)
Off-gases are scrubbed to remove fluorine before venting (Op)
$H_3PO_4$ can be used directly (30–32% $P_2O_5$) or concentrated (Op)

*Electric-furnace phosphorus and acid*

Phosphate rock ground and sized (Op)
Rock and sand mixed with coke, sintered, and introduced into electric furnace (Op)
Mix heated and reduced at an elevated temperature (Ch)
Slag and ferrophosphorus run off separately (Op)
Phosphorus vapor and CO drawn off, phosphorus condensed (Op)
Phosphorus transported in tank cars to consuming centers (Op)
Phosphorus melted and sprayed into stainless-steel oxidation tower (Op)
Phosphorus oxidized to $P_2O_5$ (Ch)
$P_2O_5$ cooled and hydrated in stainless-steel hydrator or tower against water or dilute $H_3PO_4$ (Ch)
$H_3PO_4$ mist-precipitated in electrostatic precipitator or a Brink Mist Eliminator (Op)
$H_3PO_4$ filtered and purified (Op, Ch)

The electric-furnace[12] process was first employed commercially in 1920. This process permits the use of lower-grade rock than the wet-process phosphoric acid process, since the slag carries off impurities. Indeed, lower grades are frequently preferred because of the better $CaO/SiO_2$ balance for slag formation. The principal requirement is cheap electricity.

The phosphate rock must be charged in lump form or as +8-mesh (Fig. 16.1). Fine material tends to block the exit of the phosphorus vapors and to cause bridging and uneven descent of the furnace charge, resulting in puffs and the carrying over of excessive quantities of dust. Phosphate lumps may be prepared in the following ways: (1) pelletizing by tumbling or extrusion, (2) agglomeration by nodulizing at high temperatures, (3) sintering a mixture of phosphate fines and coke, and (4) briquetting, with the addition of a suitable binder. After agglomeration, coke breeze and siliceous flux (gravel) are added, and the materials are charged to the electric furnace. Iron slugs are added to the charge if more ferrophosphorus is desired. A flowchart with the quantities required is shown

[12]Curtis, The Manufacture of Phosphoric Acid by the Electric Furnace Method, *Trans. AIChE,* **31**, 278 (1935); Curtis *et al.,* Process Development at TVA Phosphoric Acid Plant, *Chem. Metall. Eng.,* **45**, 193 (1938); Mantell, Electrochemical Engineering, 4th ed., pp. 523–532, McGraw-Hill, 1960 (data and diagram); Highett and Striplin, Elemental Phosphorus in Fertilizer Manufacture, *Chem. Eng. Prog.,* **63**(5), 85 (1967); Bryant, Holloway and Silber, Phosphorus Plant Design, *Ind. Eng. Chem.,* **62**(4), 8 (1970).

# HAZARD EVALUATION/REMEDIAL ALTERNATIVES REPORT
# OLD PHOSPHORUS DISPOSAL AREA - SITE 3
# PHOSPHORUS SLURRY DISPOSAL - SITE 4
# NO. 1 POND DISPOSAL FACILITY - SITE 5
# OLD TANK FARM - SITE 12
# MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

**Prepared For**

**MONSANTO CHEMICAL COMPANY**

**Columbia, Tennessee**

**ENGINEERING-SCIENCE, INC.**
**57 Executive Park South**
**Suite 590**
**Atlanta, Georgia 30329**

**September 1990**

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| 5.4 | Detailed Analysis of Alternatives, Old Tank Farm - Site 12 | 5-10 |

# SECTION 1
# INTRODUCTION

Monsanto Chemical Company (Monsanto) retained Engineering-Science, Inc. (ES) to perform a Hazard Evaluation/Remedial Alternatives (HE/RA) study of Sites 3, 4, 5, and 12 at their facility in Columbia, Tennessee. These sites are on the Tennessee Superfund Promulgated List. The Promulgated List includes those sites within Tennessee that are eligible under the Hazardous Waste Remedial Action Fund for investigation, identification, containment and clean-up, including monitoring and maintenance.

The purpose of performing the HE/RA study is to present information to the Superfund Division of the Tennessee Department of Health and Environment (TDHE) so that TDHE may select a remedial alternative and subsequently issue a Record of Decision (ROD) for each site. During the HE/RA study, additional data collection activities were implemented to address the data gaps which were identified in the Site Investigation Report (ES 1985).

## 1.1 ORGANIZATION OF THE REPORT

The report is organized around the key elements of the HE/RA study as follows:

- Site Background (Section 1)
- Data Collection Activities (Section 2)
- Identification and Screening of Technologies (Section 3)
- Development and Screening of Alternatives (Section 4)
- Detailed Analysis of Alternatives (Section 5)
- Conclusions (Section 6)

Appendices contain information on Aquifer Pump Tests, Well Construction Methods, Well Logs, and Cost Estimates for Remedial Alternatives.

## 1.2 SITE BACKGROUND

Engineering-Science has summarized existing information on site background from the Site Investigation Report (ES 1985).

### 1.2.1 Site History

Monsanto began operating an elemental phosphorus plant at Columbia, Tennessee in 1936. The facility is located off Highway 50, west of Columbia, Tennessee. Phosphorus ore was processed at this facility to produce elemental phosphorus. Production activities at the plant have been terminated and the plant is currently being dismantled.

While the plant was in operation, waste fluids and materials were stored or disposed at several locations within the facility boundaries. Twenty-one such sites were identified in the Site Investigation Report (ES 1985). Of the 21 sites, four have been included on the Tennessee Superfund Promulgated List. These sites are Old Phosphorus Disposal Area (Site 3), Phosphorus Slurry Disposal (Site 4), No. 1 Pond Disposal Facility (Site 5), and Old Tank Farm (Site 12). Table 1.1 provides a summary description of Sites 3, 4, 5, and 12. As indicated, Sites 3, 4, and 5 are covered with clay caps and a hydrogeologic monitoring program is in place at each site. Figure 1.1 depicts the location of these sites.

Site 3 was a phosphorus barrel dump. Drums of phosphorus containing material were reportedly brought here for disposal from 1950 until 1978. The area was closed and capped in 1978. During the previous site investigation (ES 1985), magnetometry was used to confirm the boundaries of the buried trench. Groundwater beneath this site is monitored quarterly using monitoring well 3-East.

Site 4 is a closed phosphorus slurry dump. The site received phosphorus containing material, coke, dust, and slurry from the phosphorus still and centrifuge from the mid-1950's to 1978. The site was closed and covered with a clay cap (approximately three feet thick) in 1978. The site also includes an area where asbestos containing phosphorus was placed, an area where treater oil waste was placed, and an area where some large equipment containing phosphorus were buried. Details regarding geophysical surveys and exploratory borings, which were performed during site investigation, are presented in the Site Investigation Report (ES, 1985). Groundwater beneath the site is monitored using monitoring wells 4-5, 4-6, 4-7 and 4-8.

Site 5 is a closed sanitary and solid waste disposal area. This site, previously referred to as Tailings Pond No. 1, was used for sanitary and solid waste disposal from 1950's to 1978. The site was closed in 1978. In addition, the site was covered with a three feet thick clay cap in 1986. Groundwater beneath the site is monitored using monitoring wells 5-15 and 5-16.

Site 12 is located in the plant area to the west of the phosphorus storage and shipping area. Twelve gunite (concrete) storage tanks, which were built partially below grade, were used to store phosphorus and phossy water from 1948 to 1955. Materials stored in the tanks leaked to underlying rocks and soil. The tanks were

## TABLE 1.1[a]
## SITE SUMMARY
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Site No. | Site Name on State of Tennessee's Promulgated List | Site Name at Monsanto | Approximate Years of Operation | Status | Monitoring Program |
|---|---|---|---|---|---|
| 3 | Old Phosphorus Disposal Area | Barrel Dump | 1950-1978 | Inactive and covered | One shallow well |
| 4 | Phosphorus Slurry Disposal | Phosphorus Slurry Dump | 1955-1978 | Inactive and covered | Four shallow wells |
| 5 | No. 1 Pond Disposal Facility | Sanitary/Solid Waste Dump | 1950-1978 | Inactive and covered | Two shallow wells |
| 12 | Old Tank Farm | Phosphorus Tank Farm | 1948-1955 | Inactive | Nine shallow wells; three deep wells |

[a] - Modified Table 1.1, Site Investigation Report (ES 1985).

emptied, filled with slag and covered with soil. Elemental phosphorus was recovered downgradient and drummed. A retaining wall was constructed downgradient of the site to intercept phosphorus migration in groundwater. Seepage from the retaining wall is collected in sumps then treated in the onsite Wastewater Treatment Plant.

The original remediation plan was developed assuming all phosphorus production and handling operations would cease and the associated facilities and equipment would be dismantled. The plan called for capping the Site 12 area and extending the cap eastward toward Greenlick Creek to cover the phosphorus handling and phosphorus manufacturing areas.

Near the end of 1989, the longer range marketing outlook for drummed phosphorus had improved and the decision was made to continue utilizing the phosphorus handling area facilities for the drumming operation. This operation consists of transferring phosphorus from railroad tank cars into 55-gallon drums. (The phosphorus is manufactured at the Monsanto Plant in Soda Springs, Idaho and shipped to the Columbia, Tennessee Plant via railroad tank car.) This change necessitated a revision of the original capping plan.

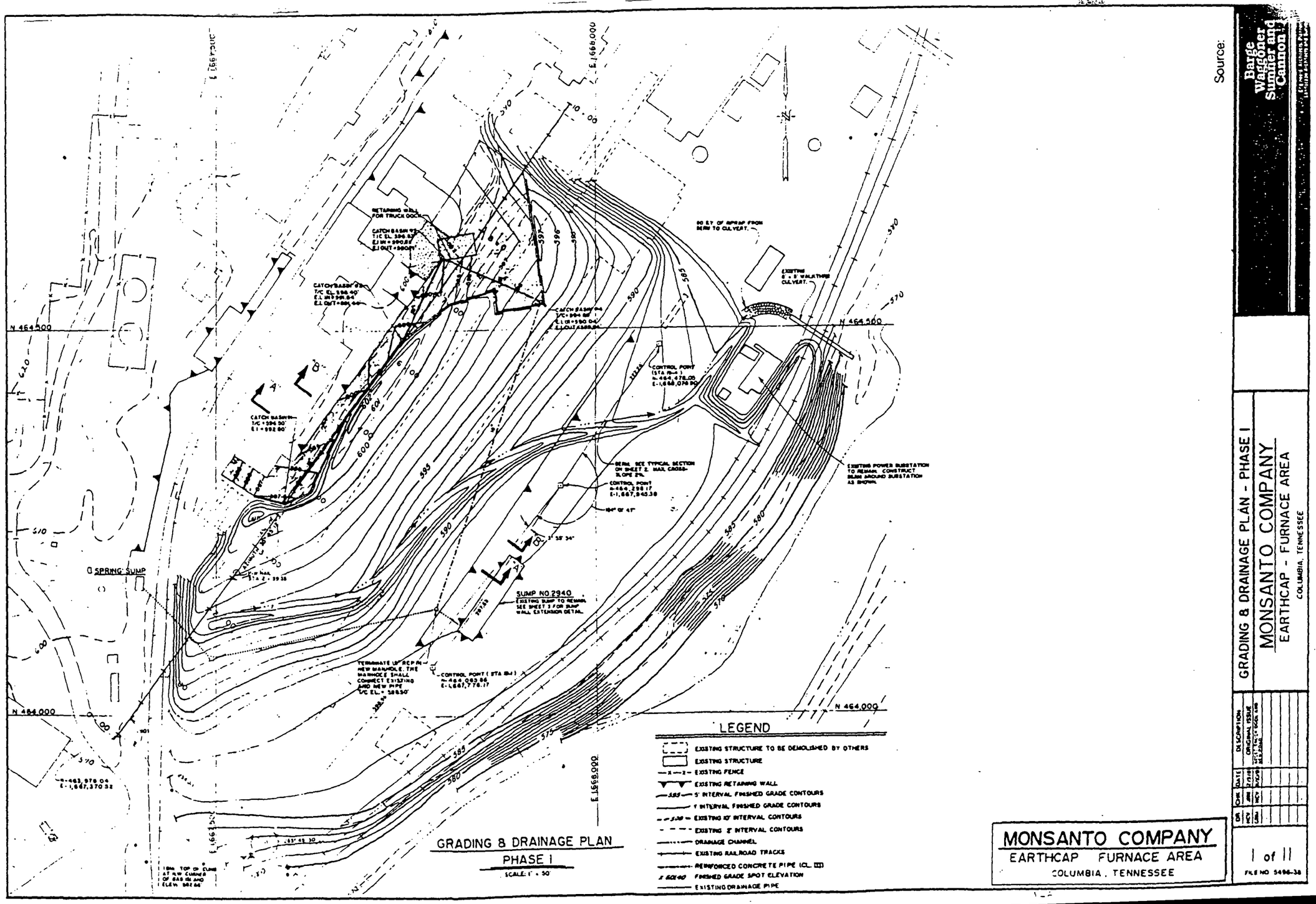
In the revised plan (Figures 1.2 and 1.3), the clay capping of both the underground tank farm at Site 12 and the furance manufacturing area remain essentially unchanged. A concrete trough is installed to the west and upgradient from Site 12 to collect and divert non-contaminated surface runoff from the site. The phosphorus handling area (drumming operation) will be covered with concrete and asphalt. Also drains will be installed to collect and divert surface runoff to sumps.

The drainage trough network in the former furnace area has been cleaned and filled with large washed limestone rock to funnel any water which infiltrates the furnace area cap to a sump for processing.

If, in the future, the economics for drummed phosphorus become unfavorable, the phosphorus handling area facilitites will be dismantled. A clay cap will be installed after bringing the area to grade (Figure 1.4).

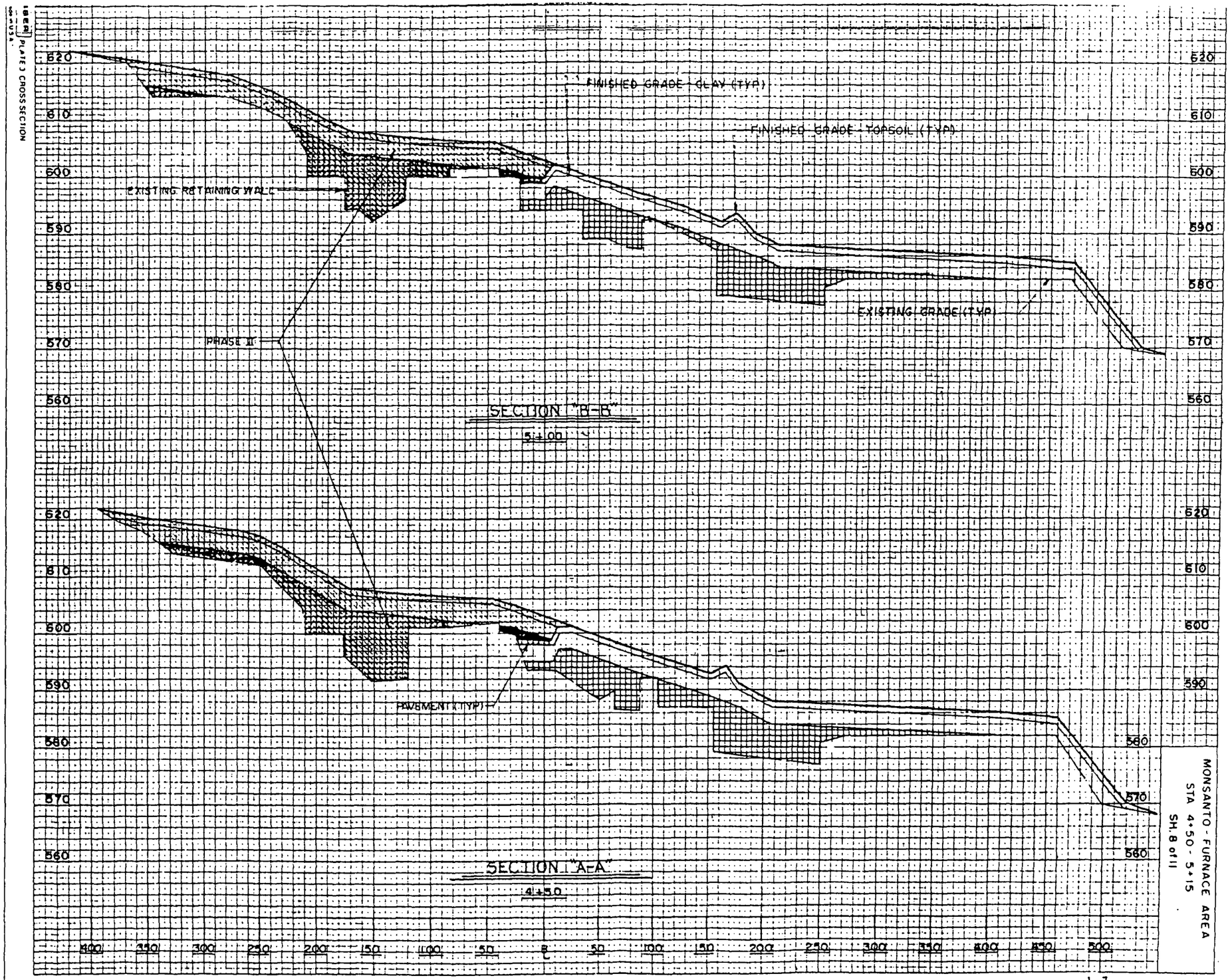
Groundwater beneath Site 12 is currently monitored using three wells. Because the shallow groundwater flows from the site towards Greenlick Creek (ES 1985), monitoring wells 17-5, 19-1, 19-3, 19-4, 19-5, and 19-7 are sampled quarterly to detect any movement of elemental phosphorus towards Greenlick Creek. Three deep wells (well depth greater than 100 feet), namely 12-9, 19-9, and 19-10, were installed during the HE/RA study to evaluate the potential for phosphorus to migrate deeper into the bedrock. Results obtained from monitoring are presented in Section 2.

Figure 1.2



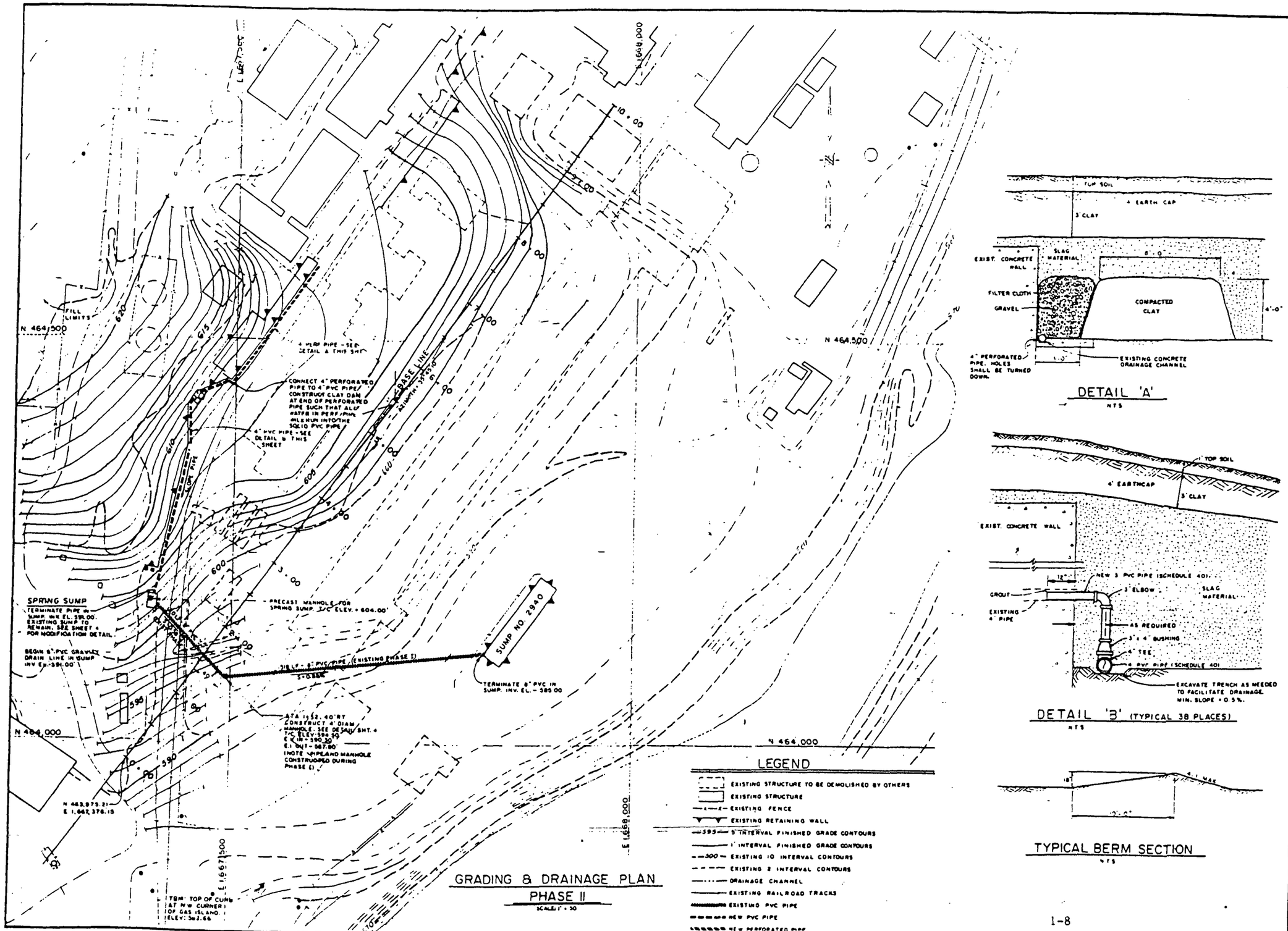

Source: Barge Waggoner Sumner and Cannon

Figure 1.3




Source:
Barge
Waggoner
Sumner and
Cannon

Figure 1.4


GRADING & DRAINAGE PLAN
PHASE II
SCALE: 1" = 30'
LEGEND
EXISTING STRUCTURE TO BE DEMOLISHED BY OTHERS
EXISTING STRUCTURE
EXISTING FENCE
EXISTING RETAINING WALL
5' INTERVAL FINISHED GRADE CONTOURS
1' INTERVAL FINISHED GRADE CONTOURS
EXISTING 10' INTERVAL CONTOURS
EXISTING 2' INTERVAL CONTOURS
DRAINAGE CHANNEL
EXISTING RAILROAD TRACKS
EXISTING PVC PIPE
NEW PVC PIPE
NEW PERFORATED PIPE
SPRING SUMP
SUMP NO. 2940
BASE LINE
N 464,500
N 464,000
E 1,667,500
E 1,668,000
DETAIL 'A'
DETAIL 'B' (TYPICAL 38 PLACES)
TYPICAL BERM SECTION
TOP SOIL
4' EARTH CAP
3' CLAY
SLAG MATERIAL
EXIST. CONCRETE WALL
FILTER CLOTH
GRAVEL
COMPACTED CLAY
EXISTING CONCRETE DRAINAGE CHANNEL
4" PERFORATED PIPE, HOLES SHALL BE TURNED DOWN
NEW 3" PVC PIPE (SCHEDULE 40)
3" ELBOW
GROUT
EXISTING 4" PIPE
AS REQUIRED
3" x 4" BUSHING
4" TEE
4" PVC PIPE (SCHEDULE 40)
EXCAVATE TRENCH AS NEEDED TO FACILITATE DRAINAGE. MIN. SLOPE = 0.5%.
Source:
Barge Waggoner Sumner and Cannon
GRADING & DRAINAGE PLAN - PHASE II
MONSANTO COMPANY
EARTHCAP - FURNACE AREA
COLUMBIA, TENNESSEE
DESCRIPTION
ORIGINAL ISSUE
2 of 11
FILE NO. 5496-38

### 1.2.2 Site Description

Geologically, Monsanto is located on the southern flank of the Nashville Dome. The Dome is a large, elliptical structure of Paleozoic age and is the major geologic structural feature in central Tennessee (Wilson, 1949). The subsurface at Monsanto consists of generally flat-lying bedrock overlain by unconsolidated material. The bedrock consists of Ordovian age limestone formations (Burwell, 1964). The overburden material consists of unconsolidated residual silts and clays derived from the limestone bedrock and slag material, a by-product of plant operations. Monsanto has used the slag material as road fill throughout the site.

The bedrock limestone formations present at Monsanto include, in increasing age, the Bigby-Cannon Formation, the Hermitage Formation, the Carters Formation, and the Lebanon Formation. Bedrock is exposed in the Greenlick Creek and Duck River Valleys. The Bigby-Cannon Formation immediately underlies the unconsolidated overburden along the ridge tops. The Hermitage Formation underlies the Bigby-Cannon Formation and makes up most of the intermediate slopes between the ridge tops and Greenlick Creek or Duck River. The Hermitage Formation is generally overlain by soils which vary from 3 to 20 feet in thickness.

The water table at the site generally occurs in the Hermitage Formation. Typically, water occurs in secondary openings in the limestone which includes fractures, joints, and solution channels and cavities. Groundwater is present in these secondary openings in all the limestone formations which underlie the facility. The degree to which the secondary openings are interconnected vary from formation to formation and locally within a single formation. Groundwater movement is generally from areas of high topographic areas to low topographic areas such as Greenlick Creek and Duck River.

# SECTION 2
# DATA COLLECTION ACTIVITIES

# SECTION 2
# DATA COLLECTION ACTIVITIES

## 2.1 MONITORING WELL INSTALLATION - SITE 12

To determine the vertical extent of phosphorus contamination at Site 12 and along Greenlick Creek, ES installed three new monitoring wells (12-9, 19-9, and 19-10) during the period April through June 1990 (Figure 2.1). The wells were designed to evaluate the bedrock aquifer and to monitor deep groundwater conditions. Shallow groundwater was isolated from the deeper groundwater by using multiple casing in each well.

A description of drilling, testing, and decontamination procedures for the deep wells is contained in Appendix A. ES performed geophysical logging of hole 12-9 to determine water entry zones and select depths to set packers. Figure 2.2 shows the logs and identifies the formations. The packer testing indicated Zone A (Figure 2.2) would yield about 0.6 gallons per minute (gpm) while Zone B (Figure 2.2) was dry after purging. Zone C (Figure 2.2) yielded very low (<0.05 gpm) quantities of groundwater and Zone D (Figure 2.2) yielded even less water (<0.02 gpm).

Engineering-Science obtained rock cores from each hole. These cores are available for examination at Monsanto offices, Columbia, TN. A description of the cores is contained in Appendix A, while the general lithology is shown (by example) for Well 12-9 in Figure 2.3. ES also conducted aquifer pump tests in the wells. The data and analytical methods are described in Appendix B. The results of the tests are summarized in the following subsection.

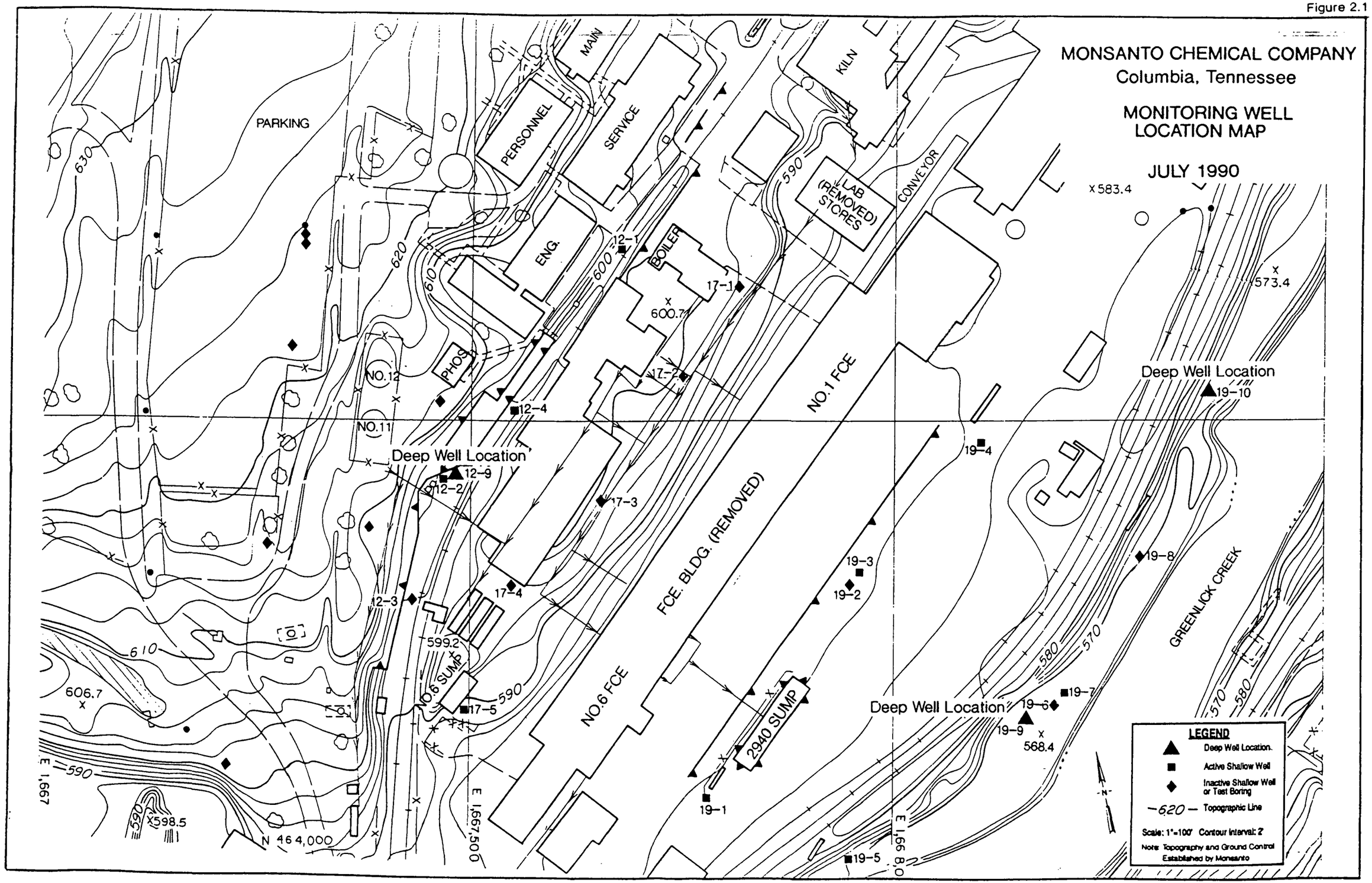
## 2.2 AQUIFER PUMP TESTS

Engineering-Science conducted pumping tests to evaluate aquifer properties including transmissivity, storage coefficient, hydraulic conductivity and overall aquifer response to pumpage. The aquifer response provided direct observations of drawdown patterns and an understanding of groundwater flow within the bedrock.

The aquifer testing program consisted of the following:

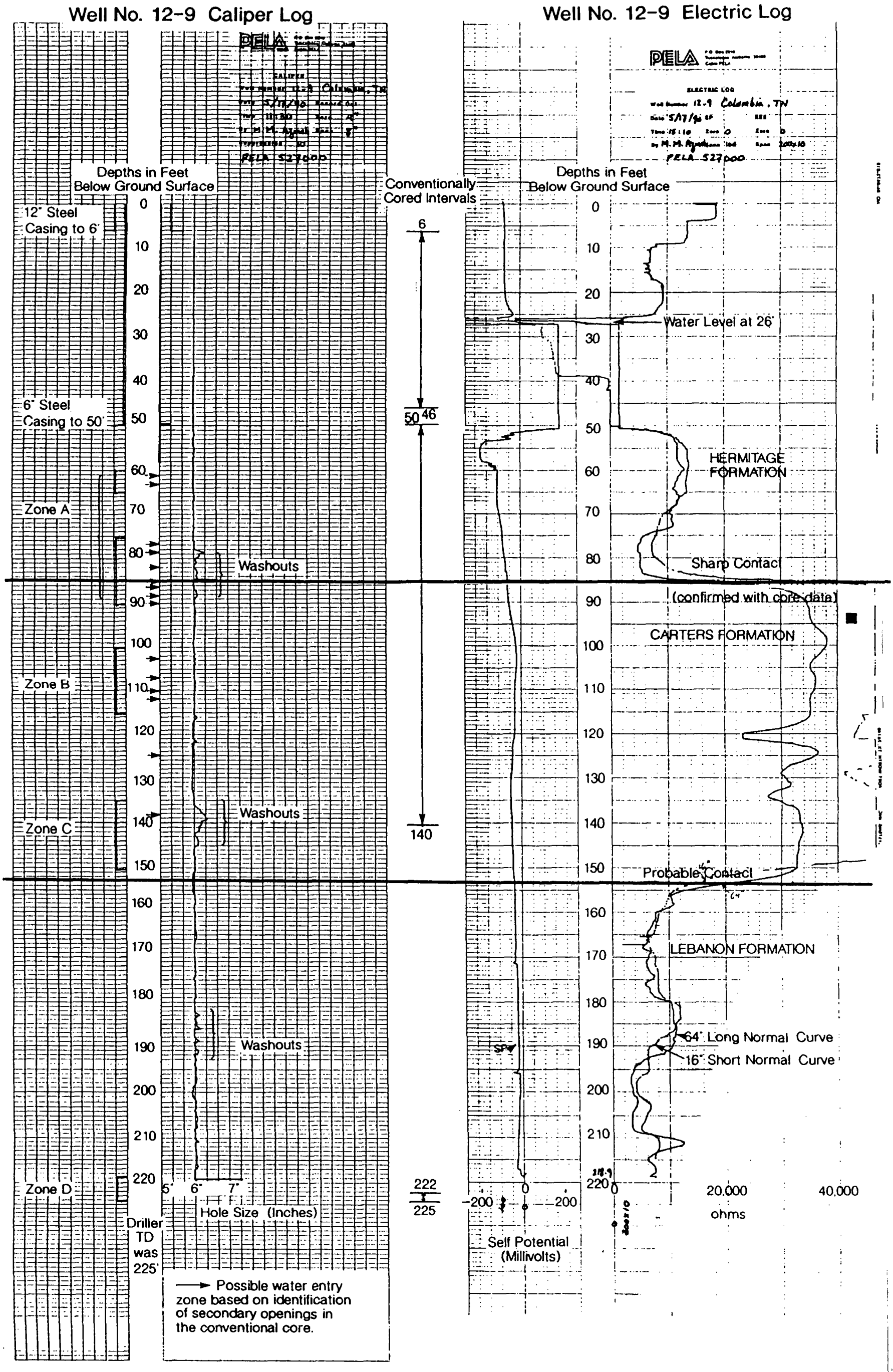
- A long-term (48 hours) aquifer test using recently installed deep bedrock well 19-9 to evaluate vertical hydraulic communication between the shallow and deep bedrock aquifers and to estimate the hydraulic properties of the deep bedrock aquifer.

Figure 2.1






ENGINEERING-SCIEN



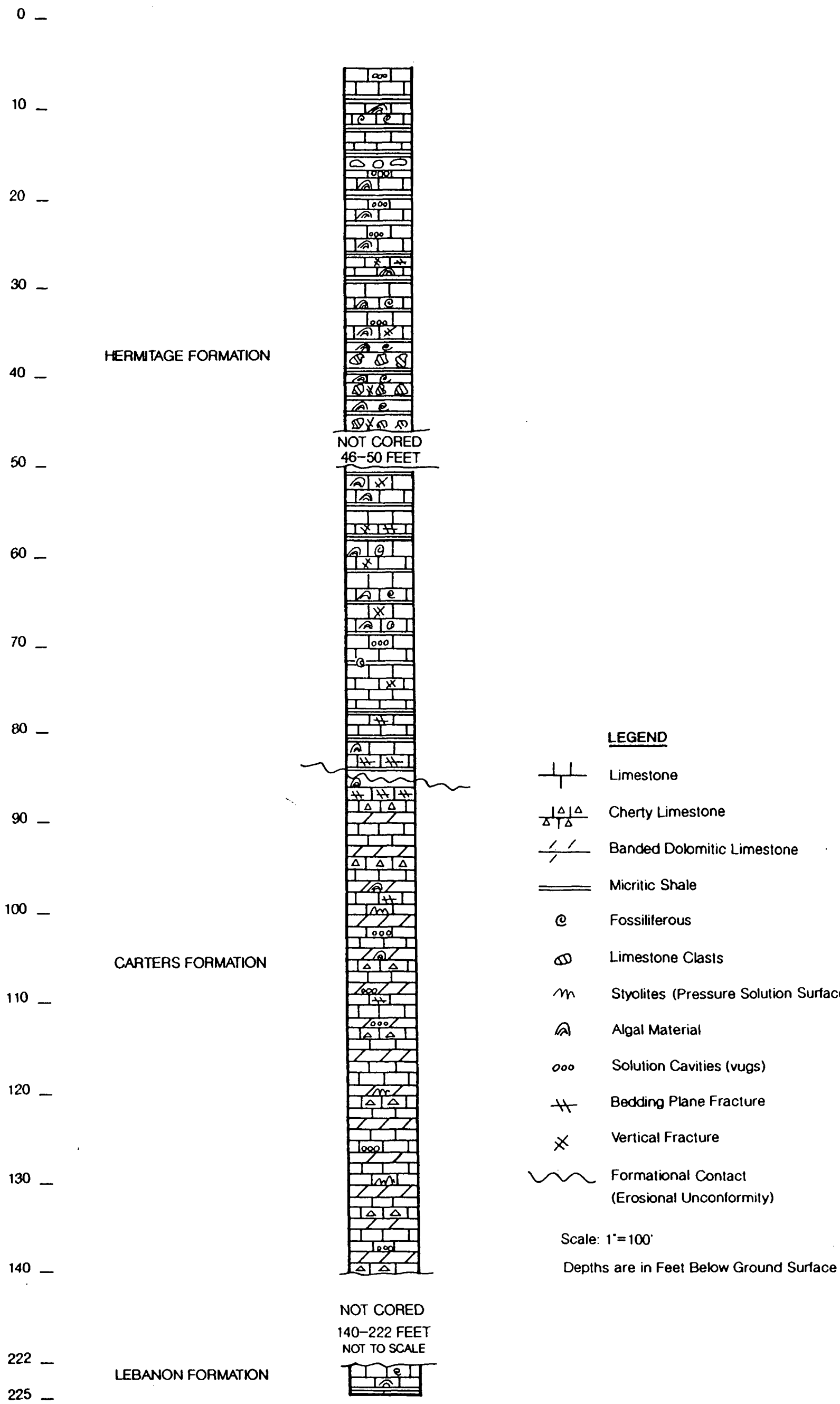

MONSANTO CHEMICAL COMPANY Columbia, Tennessee

DOWNHOLE GEOPHYSICAL LOGS – (Includes Packer Sampling Intervals and Formational Data)

Figure 2.2



ES ENGINEERING-SCIENCE




**MONSANTO CHEMICAL COMPANY Columbia, Tennessee**

**CONVENTIONAL CORE DESCRIPTION OF MONITORING WELL 12-9**

Figure 2.3



FR ENGINEERING·SCIENCE

- A short-term pumping test was conducted in bedrock well 19-6 to evaluate shallow aquifer properties.

During the 48-hour duration pump test water levels were monitored in wells 19-1 through 19-10, 12-2 and 12-9 using hand-held electronic water level indicators. Drawdown was observed in the pumped well 19-9 and deep observation wells 19-10 and 12-9 at a distance of 500 feet and 700 feet from the pumping well. There was no significant response in any of the shallow monitoring wells. Less than one inch of drawdown was observed in the shallow bedrock monitoring well cluster 19-6/19-7 at distances of only 30 feet from the pumping well. This pump test indicates a poor vertical hydraulic communication between the shallow and deep bedrock at Monsanto Sites 12 and 19.

The observed response in pumping well 19-9 is characteristic of a fracture-flow system, by which groundwater flows to wells through an interconnected network of fissures. Water level data were analyzed using a method that has been developed for this type of flow (see Appendix B). Based on this analysis, transmissivities for the deep fracture bedrock flow system ranged from 115 to 130 gallons per day per foot (gpd/ft) with storage values of $1.7 \times 10^{-4}$ to $2.1 \times 10^{-4}$. The vertical hydraulic conductivity ranged from $6.6 \times 10^{-4}$ to $1.8 \times 10^{-3}$ gallons per day per foot squared (gpd/ft$^2$). The low vertical hydraulic conductivity is a reasonable approximation considering the lack of aquifer response observed in the overlying shallow bedrock aquifers.

During the 6-hour pump test performed in well 19-6, water levels were monitored in wells 19-1 through 19-5, using tapes with electronic sensors and in 19-7 and 19-8 using In Situ Hermit™ pressure transducer and data logger systems. No appreciable drawdown was observed in any of the observation wells including shallow bedrock monitoring well 19-7 located at a distance of approximately 20 feet from the pumping well. Transmissivity values calculated for the shallow semi-confined unit ranged from 680 to 910 gpd/ft. A storage coefficient could not be calculated because no observation wells exhibited a measurable response during the test.

The results of the pumping test indicate the shallow bedrock and overburden is not well connected hydraulically to the deeper bedrock zones. This means the contaminants identified in shallow wells will migrate very slowly, if at all, into the deeper bedrock.

## 2.3 SAMPLING AND ANALYSIS OF GROUNDWATER AND SURFACE WATER AT MONSANTO

Monsanto submitted a Hydrogeologic Monitoring Plan for the facility to the State of Tennessee on November 25, 1986. In accordance with the plan, Monsanto has conducted quarterly monitoring of groundwater and surface water since 1987. Every quarter, groundwater samples are collected from 38 monitoring wells and

surface water samples are collected from seven locations. These samples are analyzed for the following parameters:

- pH
- Temperature
- Specific conductivity
- Lead
- Chromium
- Arsenic
- Cyanide
- Fluoride
- Phosphate ($PO_4$, soluble)
- Elemental Phosphorus ($P_4$)

In addition, the groundwater level in monitoring wells is recorded during each sampling event. Logs of the wells sampled each quarter are presented in Appendix C. ES has summarized the monitoring data from first quarter 1987 to second quarter 1990 in this report. The monitoring data is presented on a site-by-site basis in Subsections 2.3.1 through 2.3.4.

### 2.3.1 OLD PHOSPHORUS DISPOSAL AREA (SITE 3)

The Old Phosphorus Disposal Area is monitored by well 3-East. A groundwater sample is collected quarterly from well 3-East which is screened in bedrock.

Figure 2.4 indicates the elemental phosphorus concentration in groundwater samples collected from Well 3-East. As indicated, the elemental phosphorus concentration has been less than 0.01 ppb since the fourth quarter of 1987. Also, there has been no significant increase in the elemental phosphorus concentration since fourth quarter of 1987.

Table 2.1 presents the monitoring data on groundwater samples collected quarterly from well 3-East since 1987. As indicated, lead concentrations have always been less than the detection limit which was decreased from 0.05 ppm to 0.003 ppm in fourth quarter of 1988. Chromium and Arsenic concentrations also have been less than their respective detection limits. The chromium detection limit was decreased from 0.04 ppm to 0.01 ppm in fourth quarter of 1988. Similarly, the arsenic detection limit was lowered from 0.05 ppm to 0.01 ppm in fourth quarter of 1988.

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
WELL #3 EAST

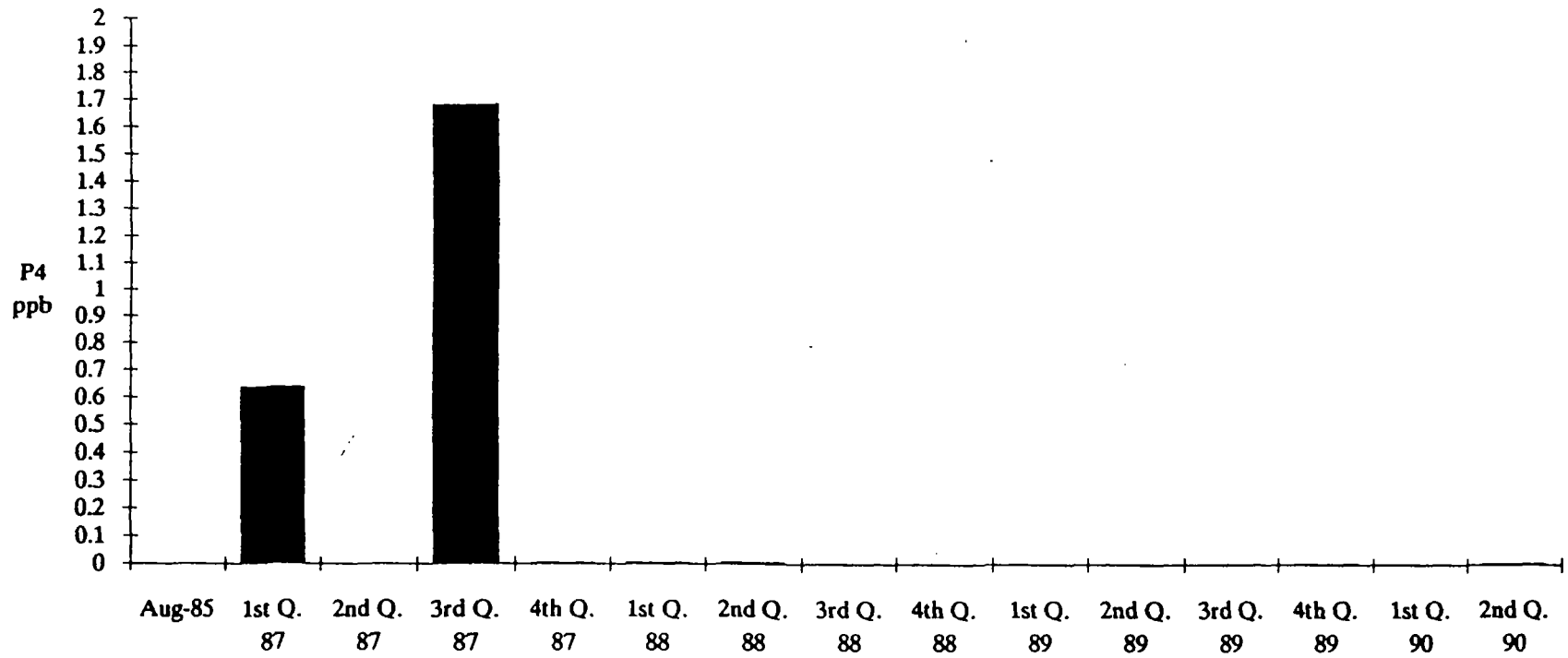



Figure 2.4

## TABLE 2.1
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 3-East | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 585.7 | 584.8 | 580.4 | 579.1 | 584.3 | 581.3 | 578.9 | 584.1 | 601.8 | 581.6 | 580.3 | 585.1 | 587.5 | 585.7 |
| Temperature, °C | -- | 15 | 18 | 17 | 15 | 14 | 16 | 17 | 15 | 13 | 17 | 17 | 15 | 17 | 16 |
| Conductivity, μmhos/cm | -- | 668 | 7,600 | 615 | 659 | 637 | 545 | 608 | 899 | 790 | 686 | 584 | 925 | 650 | 690 |
| pH | -- | 7.0 | 6.7 | 6.8 | 7.0 | 7.0 | 7.2 | 7.1 | 7.0 | 6.7 | 7.2 | 7.1 | 6.9 | 6.8 | 6.6 |
| Lead, ppm | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | 0.004 | <0.003 |
| Chromium, ppm | -- | -- | -- | -- | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | -- | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | -- | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | 6.0 | <5.0 |
| Fluoride, ppm | -- | 0.20 | 0.19 | 0.15 | 0.07 | 0.12 | 0.11 | 0.12 | 0.10 | 0.08 | 0.87 | 0.18 | 0.09 | 0.09 | <0.08 |
| $PO_4$, (Sol) as ppm $P_4$ | -- | 0.35 | 0.25 | 0.23 | 0.18 | 0.287 | 0.22 | 0.210 | 0.229 | 0.254 | 0.398 | 0.20 | 0.365 | 0.34 | 0.297 |
| $P_4$, ppb | -- | 0.64 | ND | 1.68 | 0.005 | 0.004 | 0.006 | 0.002 | 0.003 | 0.002 | 0.001 | 0.003 | 0.004 | 0.003 | 0.004 |

ND = None Detected

8912J122

Cyanide concentrations, as reported in Table 2.1, have always been less than 5 ppb. Fluoride concentrations have varied between 0.07 ppm and 0.87 ppm since 1987.

### 2.3.2 Phosphorus Slurry Disposal (Site 4)

The Phosphorus Slurry Disposal is also known as the Phosphorus Slurry Dump. Groundwater samples are collected quarterly from monitoring wells 4-5, 4-6, 4-7, and 4-8. Two monitoring wells, namely 4-5 and 4-6 are screened in the bedrock. Well 4-7 is screened at the contact of overburden and bedrock and well 4-8 is screened just above the bedrock. Wells 4-7 and 4-8 are often reported as "dry" during sampling events.

Figures 2.5, 2.6, 2.7, and 2.8 present the elemental phosphorus concentrations in groundwater samples collected from wells 4-5, 4-6, 4-7, and 4-8, respectively. As indicated, the phosphorus concentrations have been reported as less than 0.03 ppb since 1987 with the exception of monitoring well 4-7 in third quarter 1989 when the phosphorus concentration was reported as 0.12 ppb. Therefore, groundwater samples collected quarterly since 1987 do not exhibit an increasing trend in elemental phosphorus concentrations.

Table 2.2 presents the quarterly monitoring data from wells 4-5, 4-6, 4-7, and 4-8. The lead, chromium, and arsenic concentrations in groundwater samples have been consistently at or below detection limits. The arsenic concentrations in samples collected from well 4-6 in first and second quarters of 1989 increased to 0.054 ppm and 0.051 ppm, respectively. Since third quarter of 1989, however, the arsenic concentrations have decreased to near its detection limit (0.01 ppm).

Cyanide concentrations in samples collected from wells 4-5, 4-7, and 4-8 have been reported as less than 5.0 ppb. Groundwater samples from well 4-6, however, have indicated higher concentrations of cyanide than samples from wells 4-5, 4-7, and 4-8. The maximum cyanide concentration reported was 96.0 ppb (fourth quarter of 1988). Cyanide concentrations since then have decreased and were reported as less than 5 ppb in second quarter of 1990. Fluoride concentrations in groundwater sample have varied between 0.31 ppm and 1.49 ppm.

### 2.3.3 No. 1 Pond Disposal Facility (site 5)

The No. 1 Pond Disposal Facility is monitored by wells 5-15 and 5-16. These monitoring wells are screened in bedrock and are sampled quarterly.

Figure 2.9 presents the elemental phosphorus concentrations in groundwater samples collected from monitoring wells 5-15 and 5-16. As indicated, the elemental phosphorus concentrations have fluctuated between 0.002 ppb (MW 5-15 1st Quarter 1988, 2nd Quarter 1989, and 4th Quarter 1989; MW 5-16 1st Quarter 1988) and 0.205 ppb (MW 5-15, 3rd Quarter 1989). The elemental phosphorus

(0.4ppb (MW 5-16, 4th Q. 1989)

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 4-5

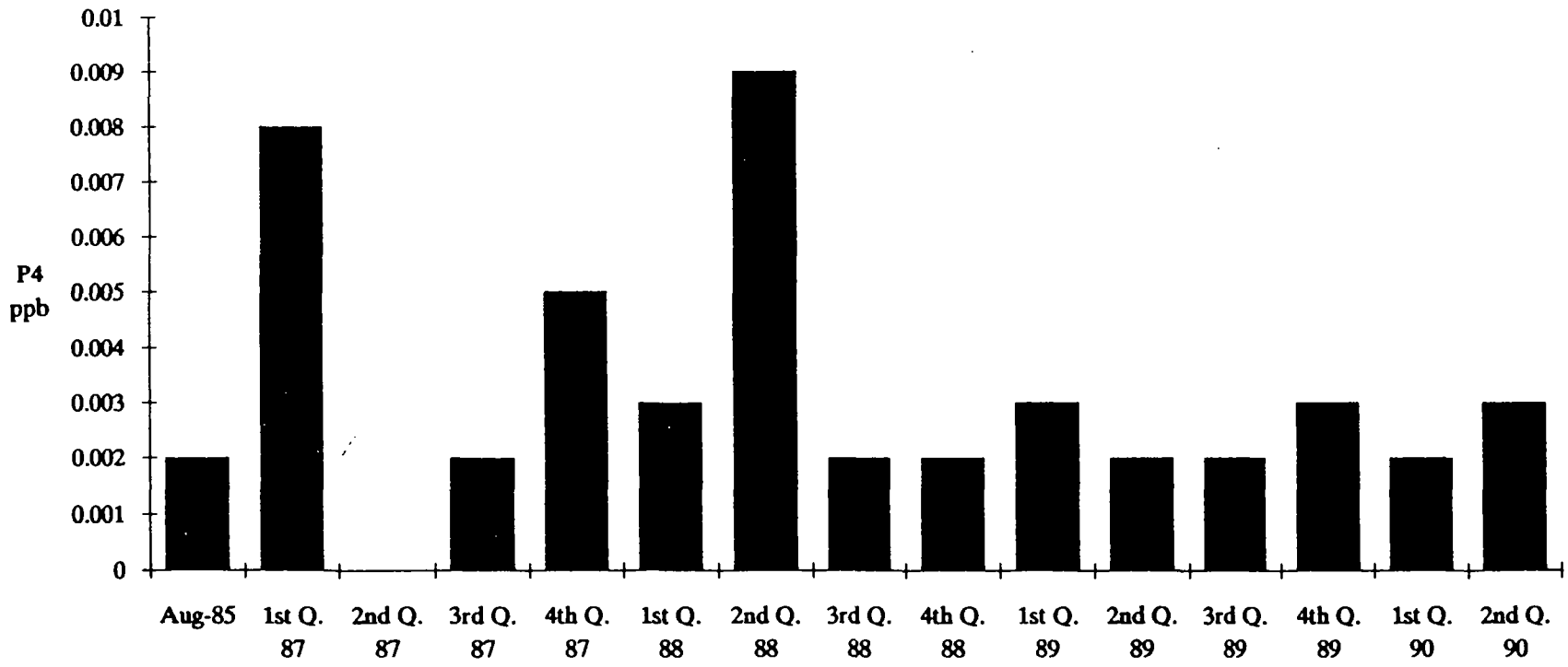



Figure 2.5

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 4-6

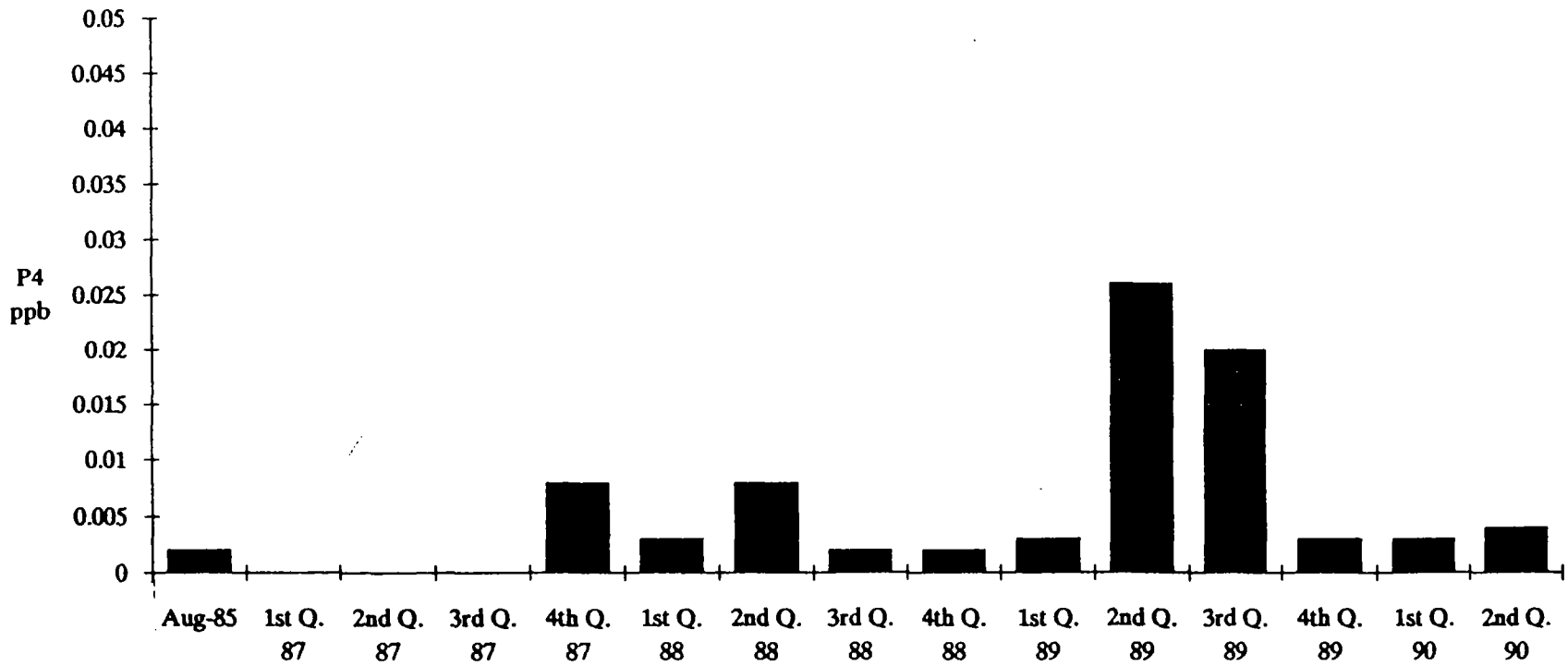
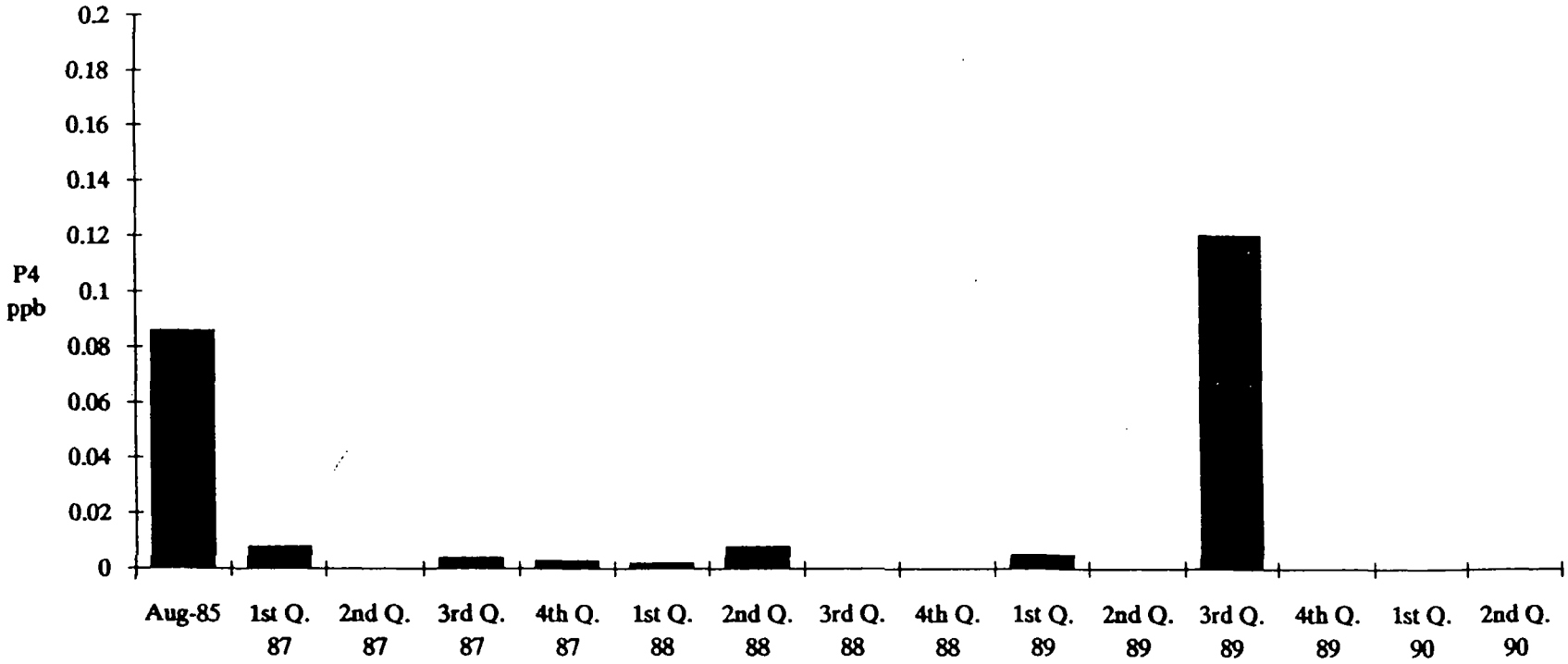



Figure 2.6

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 4-7



MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 4-8

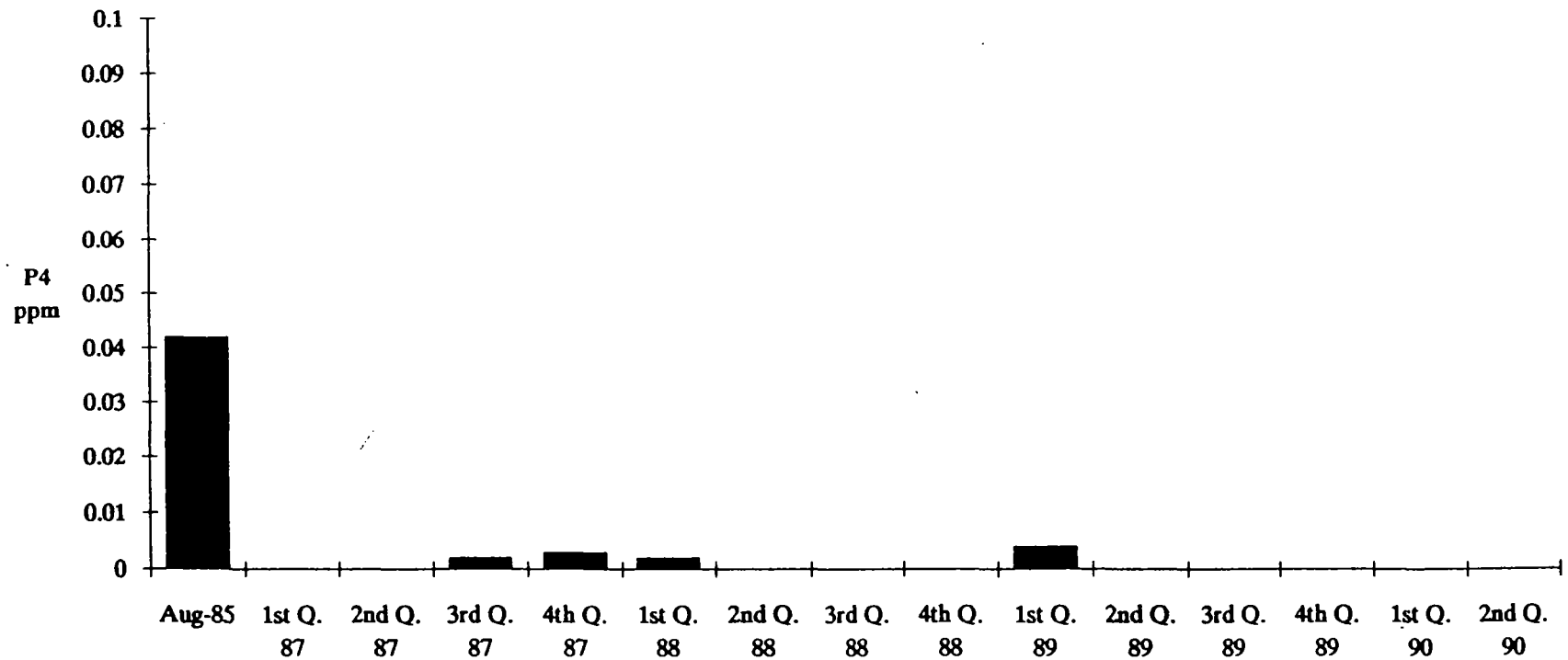



Figure 2.8



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## TABLE 2.2
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 4-5 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 648.4 | 649.5 | 647.6 | 647.6 | 647.7 | 647.6 | 647.6 | 647.6 | 653.2 | 647.9 | 647.8 | 646.6 | 647.8 | 647.8 |
| Temperature, °C | 18 | 16 | 19 | 17 | 16 | 16 | 19 | 17 | 15 | 11 | 16 | 17 | 16 | 18 | 16 |
| Conductivity, μmhos/cm | 1,000 | 905 | 529 | 895 | 1,106 | 1,330 | 872 | 844 | 1,278 | 2,540 | 1,013 | 965 | 1,112 | 1,270 | 1,000 |
| pH | 6.9 | 6.8 | 7.2 | 7.2 | 7.0 | 6.8 | 7.3 | 6.5 | 6.9 | 7.5 | 7.0 | 6.9 | 7.1 | 6.8 | 6.7 |
| Lead, ppm | 0.026 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | 0.009 | <0.003 |
| Chromium, ppm | <0.01 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | 0.011 |
| Arsenic, ppm | 0.001 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | <5.0 | -- | -- | -- | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Fluoride, ppm | 0.9 | 1.22 | 1.14 | 1.30 | 1.19 | 1.06 | 1.23 | 1.13 | 0.98 | 1.00 | 0.87 | 1.30 | 1.19 | 1.49 | 1.13 |
| $PO_4$, (Sol) as ppm $P_4$ | 1.0 | 0.03 | <0.025 | <0.025 | <0.025 | <0.025 | 0.026 | <0.025 | <0.025 | 0.069 | 0.053 | <0.025 | <0.025 | <0.025 | 0.003 |
| $P_4$, ppb | 0.002 | 0.008 | ND | 0.002 | 0.005 | 0.003 | 0.009 | 0.002 | 0.002 | 0.003 | 0.002 | 0.002 | 0.003 | 0.002 | 0.003 |



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## TABLE 2.2--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 4-6 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 634.6 | 635.6 | 634.0 | 634.3 | 634.2 | 634.2 | 634.0 | 634.3 | 635.1 | 634.4 | 635.6 | 634.5 | 634.4 | 634.3 |
| Temperature, °C | 17 | 20 | 33 | 16 | 16 | 16 | 18 | 18 | 16 | 13 | 18 | 19 | 16 | 18 | 17 |
| Conductivity, µmhos/cm | 1,575 | 2,960 | 3,930 | 2,350 | 2,590 | 2,220 | 2,110 | 2,250 | 3,290 | 2,530 | 1,965 | 2,170 | 2,360 | 1,820 | 1,800 |
| pH | 7.4 | 6.9 | 7.0 | 7.0 | 7.1 | 7.1 | 7.3 | 6.9 | 7.1 | 7.3 | 6.9 | 6.9 | 7.2 | 6.4 | 6.4 |
| Lead, ppm | 0.042 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | 0.004 | <0.003 | 0.004 | 0.004 | <0.003 | 0.0057 | <0.003 |
| Chromium, ppm | <0.01 | -- | -- | -- | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.015 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | 0.034 | 0.054 | 0.051 | <0.01 | <0.01 | 0.01 | 0.03 |
| Cyanide, ppb | 5.0 | -- | -- | -- | 62.0 | 6.0 | <5.0 | 90.2 | 96.0 | 6.5 | 6.0 | 6.0 | <5.0 | 8.0 | <5.0 |
| Fluoride, ppm | 0.6 | -- | -- | -- | 0.6 | 0.68 | 0.98 | 0.72 | 0.69 | 0.60 | 0.66 | 0.86 | 0.68 | 0.51 | 0.49 |
| $PO_4$, (Sol) as ppm $P_4$ | 1.4 | -- | -- | -- | 6.0 | 24.25 | 12.9 | 6.14 | 11.95 | 41.9 | 23.4 | 28.2 | 55.8 | 63.4 | 48.15 |
| $P_4$, ppb | 0.002 | -- | -- | -- | 0.008 | 0.003 | 0.008 | 0.002 | 0.002 | 0.003 | 0.026 | 0.02 | 0.003 | 0.003 | 0.004 |

## TABLE 2.2--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 4-7 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 633.0 | 632.8 | 632.6 | 632.7 | 632.9 | 632.6 | * | * | 636.7 | * | 632.5 | * | * | * |
| Temperature, °C | 15 | 15 | 22 | 17 | 15 | 15 | 18 | * | * | 13 | * | 17 | * | * | * |
| Conductivity, μmhos/cm | 1,500 | 405 | 4,640 | 762 | 814 | 540 | 524 | * | * | 412 | * | 430 | * | * | * |
| pH | 6.8 | 5.9 | 6.0 | 6.8 | 6.3 | 5.9 | 6.9 | * | * | 6.1 | * | 6.0 | * | * | * |
| Lead, ppm | 0.72 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | * | * | <0.003 | * | <0.003 | * | * | * |
| Chromium, ppm | 0.2 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | * | * | <0.01 | * | <0.01 | * | * | * |
| Arsenic, ppm | 0.023 | -- | -- | -- | <0.05 | <0.05 | <0.05 | * | * | <0.01 | * | <0.01 | * | * | * |
| Cyanide, ppb | 6.0 | -- | -- | -- | <5.0 | <5.0 | <5.0 | * | * | <5.0 | * | <5.0 | * | * | * |
| Fluoride, ppm | 1.0 | 0.53 | 0.58 | 0.49 | 0.52 | 0.51 | 0.74 | * | * | 0.31 | * | 0.64 | * | * | * |
| $PO_4$, (Sol) as ppm $P_4$ | 15.3 | 45 | 55.36 | 16.5 | 50.0 | 33.5 | 16.7 | * | * | 18.7 | * | 30.53 | * | * | * |
| $P_4$, ppb | 0.086 | 0.008 | ND | 0.004 | 0.003 | 0.002 | 0.008 | * | * | 0.005 | * | 0.12 | * | * | * |

* Dry during sampling



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## TABLE 2.2--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 4-8 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 575.2 | * | 585.6 | 584.7 | 585.6 | * | * | * | 598.6 | * | * | * | * | * |
| Temperature, °C | 23 | 15 | * | 17 | 14 | 15 | * | * | * | 12 | * | * | * | * | * |
| Conductivity, µmhos/cm | 800 | 476 | * | 519 | 670 | 463 | * | * | * | 488 | * | * | * | * | * |
| pH | 6.5 | 6.3 | * | 6.0 | 6.9 | 6.2 | * | * | * | 6.3 | * | * | * | * | * |
| Lead, ppm | 0.125 | <0.05 | * | <0.05 | <0.05 | <0.05 | * | * | * | <0.003 | * | * | * | * | * |
| Chromium, ppm | <0.01 | <0.04 | * | <0.04 | <0.04 | <0.04 | * | * | * | <0.01 | * | * | * | * | * |
| Arsenic, ppm | 0.047 | -- | * | -- | <0.05 | <0.05 | * | * | * | <0.01 | * | * | * | * | * |
| Cyanide, ppb | <5.0 | -- | * | -- | <5.0 | <5.0 | * | * | * | <5.0 | * | * | * | * | * |
| Fluoride, ppm | 0.9 | 0.4 | * | 0.34 | 0.43 | 0.38 | * | * | * | 0.52 | * | * | * | * | * |
| $PO_4$, (Sol) as ppm $P_4$ | 119.9 | 1.05 | * | 2.4 | 0.46 | 1.1 | * | * | * | 0.804 | * | * | * | * | * |
| $P_4$, ppb | 0.042 | -- | * | 0.002 | 0.003 | 0.002 | * | * | * | 0.004 | * | * | * | * | * |

ND = None Detected
* Well was dry during sampling event.

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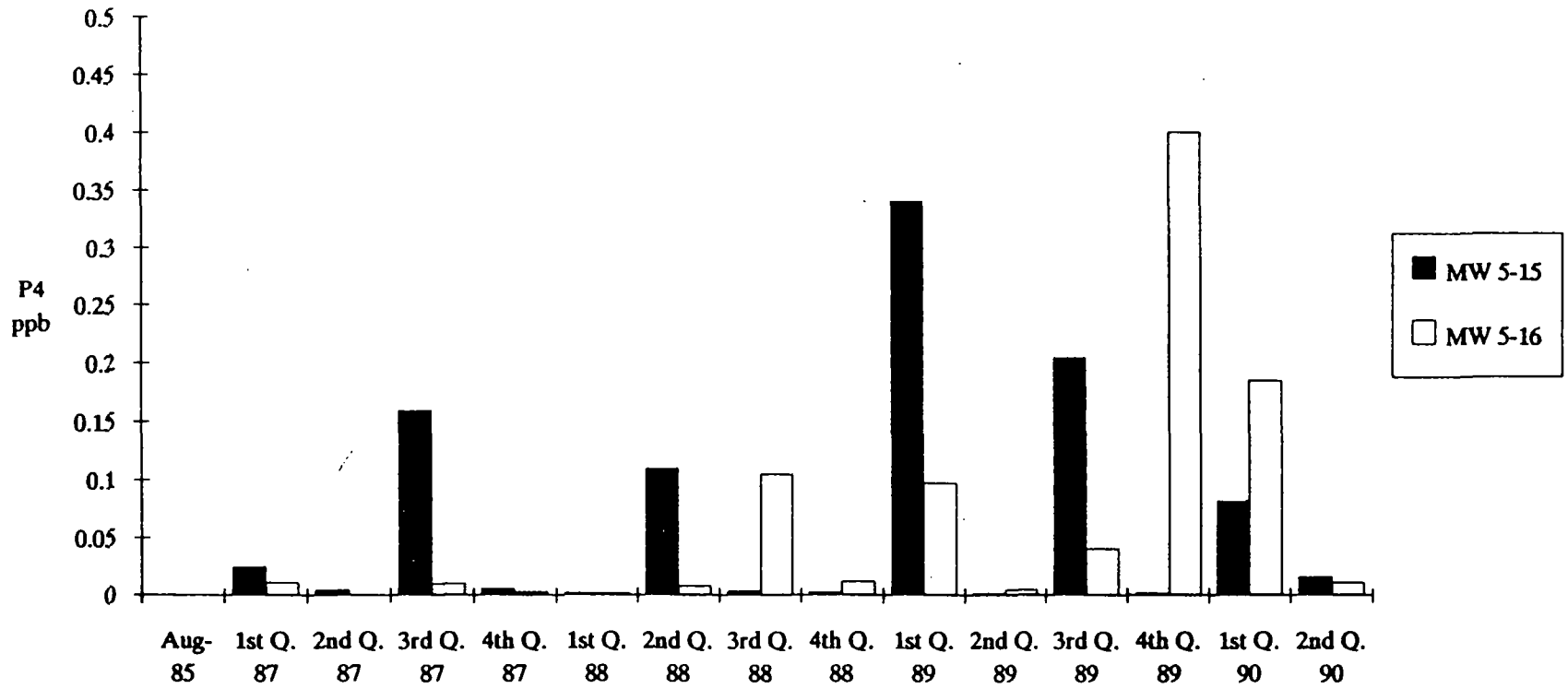


Figure 2.9



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in samples collected from wells 5-15 and 5-16 during the second quarter of 1990 were 0.016 ppb and 0.011 ppb, respectively.

Table 2.3 presents the quarterly monitoring data obtained from wells 5-15 and 5-16. The lead, chromium, arsenic, and cyanide concentrations reported to date have been less than their respective detection limits (lead = 0.003 ppm, chromium = 0.01 ppm, arsenic = 0.01 ppm, and cyanide = 5.0 ppb). Fluoride concentration in samples collected from well 5-15 has varied between 0.23 ppm and 0.65 ppm, whereas the fluoride concentration in samples collected from well 5-16 has fluctuated between 1.71 ppm and 2.94 ppm.

### 2.3.4 OLD TANK FARM (SITE 12)

The groundwater at Old Tank Farm is monitored using wells 12-1, 12-2, and 12-4. Groundwater is also sampled quarterly from downgradient wells 17-5, 19-1, 19-3, 19-4, 19-5, and 19-7 which are located between Site 12 and Greenlick Creek.

Figure 2.10 presents the elemental phosphorus concentration in groundwater samples collected from wells 12-1 and 12-4. The elemental phosphorus concentration in samples collected from well 12-1 fluctuated between 0.003 ppb (1st Quarter 1989) and 184 ppb (1st Quarter 1988). The elemental phosphorus concentration in groundwater samples collected from Well 12-1, in the second quarter of 1990 was 0.66 ppb. The elemental phosphorus concentration in samples collected from well 12-4 have fluctuated between 0.005 (3rd Quarter 1988) and 265 ppb (2nd Quarter 1990). Moreover, the elemental phosphorus concentrations have exhibited a steady increase since the fourth quarter of 1988.

Figure 2.11 presents the elemental phosphorus concentration in groundwater samples collected from well 12-2. Elemental phosphorus concentrations have varied between 1.48 ppb (3rd Quarter 1987) and 1,440 ppb (2nd Quarter 1990). The samples collected from this well on August 1, 1985 had an elemental phosphorus concentration of 1,430 ppb. There is neither an increasing nor a decreasing trend in elemental phosphorus concentration in this well since 1985.

Table 2.4 presents quarterly monitoring data for groundwater samples collected from wells 12-1, 12-2, and 12-4. As indicated, the lead concentrations were always below the detection limit which was decreased to 0.003 ppm in the fourth quarter of 1988. Prior to the fourth quarter of 1988, the detection limit for lead was reported as 0.05 ppm.

Except for the third quarter of 1988, the chromium concentrations in samples collected from wells 12-1 and 12-2 have always been reported as less than detection limit. The chromium concentrations in samples collected from well 12-4 has always been reported as less than detection limit. The detection limit for chromium was decreased from 0.04 ppm to 0.01 ppm in the fourth quarter of 1988.

## TABLE 2.3
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 5-15 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 537.3 | 536.5 | 536.0 | 536.5 | 537.1 | 535.9 | 536.9 | 537.8 | 544.1 | 537.7 | 537.0 | 537.8 | 538.1 | 536.7 |
| Temperature, °C | -- | 14 | 19 | 19 | 16 | 16 | 18 | 18 | 15 | 17 | 17 | 17 | 15 | 18 | 17 |
| Conductivity, μmhos/cm | -- | 872 | 693 | 733 | 963 | 928 | 730 | 775 | 1,291 | 1,100 | 757 | 730 | 952 | 742 | 900 |
| pH | -- | 6.8 | 7.0 | 6.9 | 6.8 | 6.7 | 7.1 | 6.5 | 6.8 | 7.0 | 6.9 | 6.8 | 6.8 | 6.5 | 6.5 |
| Lead, ppm | -- | <0.05 | <0.05 | 0.13 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.007 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | -- | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | -- | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | -- | -- | -- | -- | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Fluoride, ppm | -- | 0.29 | 0.28 | 0.23 | 0.23 | 0.26 | 0.28 | 0.30 | 0.32 | 0.65 | 0.37 | 0.28 | 0.34 | 0.34 | 0.25 |
| $PO_4$, (Sol) as ppm $P_4$ | -- | 0.10 | 0.23 | 0.35 | 0.19 | 0.234 | 0.269 | 0.26 | 0.35 | 0.189 | 0.377 | 0.31 | 0.366 | 0.32 | 0.256 |
| $P_4$, ppb | -- | 0.025 | 0.005 | 0.16 | 0.006 | 0.002 | 0.11 | 0.004 | 0.003 | 0.34 | 0.002 | 0.205 | 0.002 | 0.082 | 0.016 |



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## TABLE 2.3--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 5-16 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 529.9 | 524.8 | 525.6 | 524.9 | 527.7 | 524.9 | 524.9 | 526.6 | 539.0 | 531.0 | 528.0 | 527.9 | 530.9 | 526.6 |
| Temperature, °C | -- | 13 | 21 | 19 | 16 | 16 | 18 | 19 | 16 | 16 | 17 | 18 | 16 | 19 | 18 |
| Conductivity, µmhos/cm | -- | 635 | 543 | 520 | 818 | 637 | 520 | 606 | 752 | 1,100 | 735 | 889 | 1,178 | 761 | 660 |
| pH | -- | 5.5 | 7.4 | 7.6 | 7.2 | 7.3 | 7.6 | 7.7 | 7.8 | 7.5 | 6.9 | 7.3 | 7.3 | 7.0 | 6.9 |
| Lead, ppm | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | 0.004 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | -- | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | -- | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | -- | -- | -- | -- | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Fluoride, ppm | -- | 2.11 | 2.36 | 2.94 | 2.3 | 2.92 | 2.58 | 2.85 | 2.64 | 1.25 | 2.39 | 1.74 | 1.71 | 2.16 | 2.01 |
| $PO_4$, (Sol) as ppm $P_4$ | -- | 0.07 | 0.03 | 0.06 | 0.07 | 0.048 | 0.048 | 0.06 | 0.043 | 0.193 | 0.199 | 0.32 | 0.384 | 0.204 | 0.227 |
| $P_4$, ppb | -- | 0.011 | ND | 0.01 | 0.003 | 0.002 | 0.008 | 0.105 | 0.012 | 0.097 | 0.005 | 0.04 | 0.40 | 0.185 | 0.011 |

ND = None Detected

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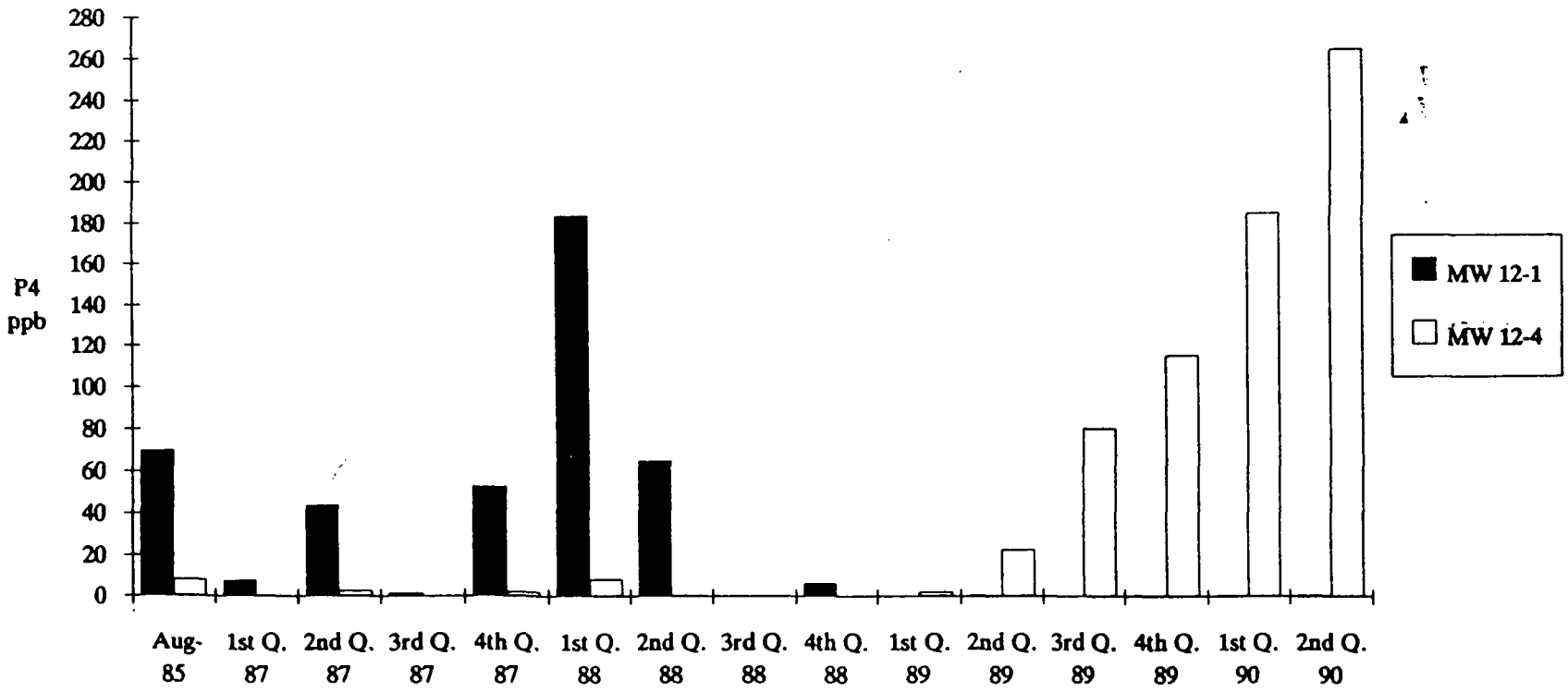


Figure 2.10



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MW 12-2

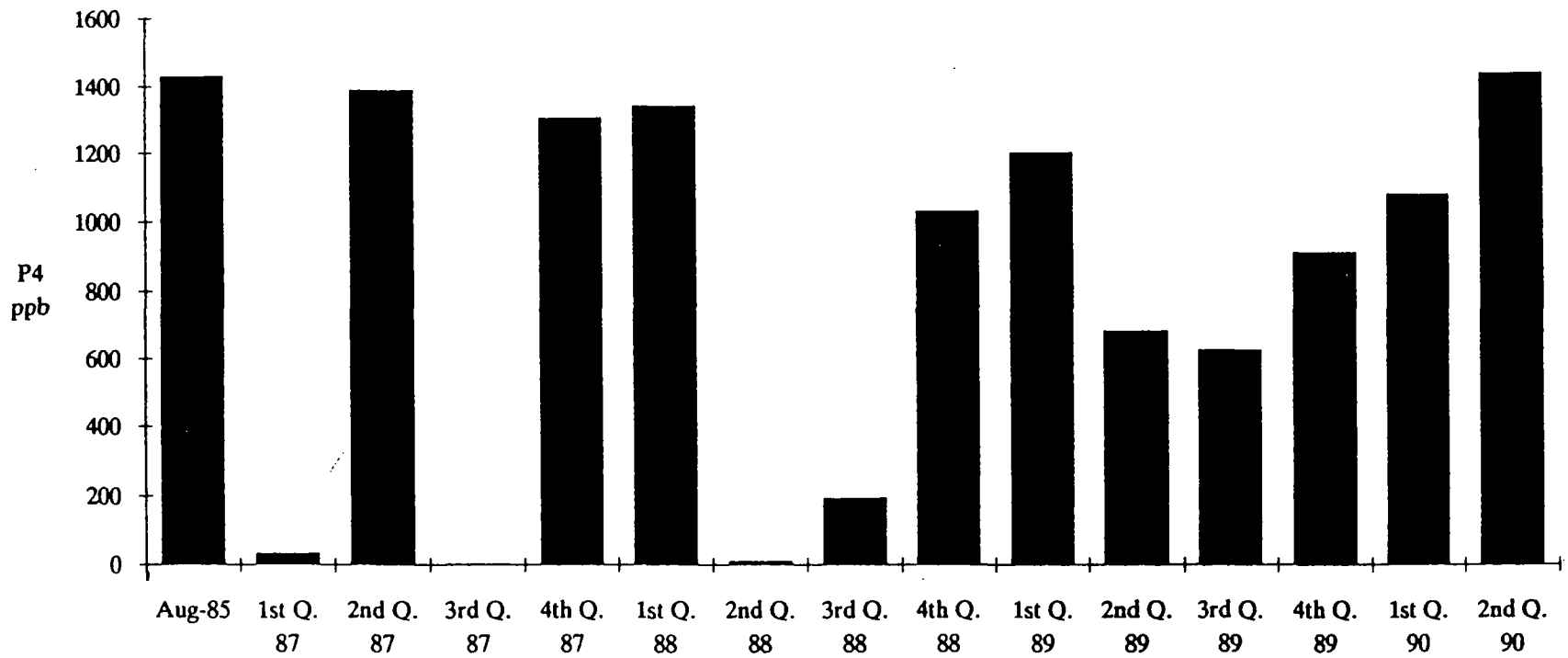


Figure 2.11



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# TABLE 2.4
# GROUNDWATER QUALITY DATA
# MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| **WELL NO. 12-1** | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | – | 585.9 | 586.1 | 585.0 | 586.2 | 585.1 | 580.3 | 577.5 | 590.1 | 581.2 | 591.1 | 590.8 | 591.0 | 590.1 | 590.3 |
| Temperature, °C | 20 | 20 | 22 | 24 | 20 | 19 | 19 | 21 | 12 | 13 | 20 | 24 | 15 | 18 | 20 |
| Conductivity, µmhos/cm | 989 | 1,104 | 580 | 939 | 1,096 | 1,015 | 647 | 1,640 | 514 | 726 | 3,140 | 630 | 605 | 1,257 | 2,800 |
| pH | 7.2 | 7.0 | 6.0 | 7.2 | 7.4 | 7.2 | 7.0 | 9.3 | 7.6 | 7.2 | 7.0 | 7.1 | 7.4 | 7.1 | 6.8 |
| Lead, ppm | <0.005 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | <0.03 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | 2.34 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.007 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | 5 | -- | -- | -- | 6.0 | 8.0 | 12.0 | <5.0 | <5.0 | <5.0 | <5.0 | 11.0 | 10.0 | 8.0 | 7.0 |
| Fluoride, ppm | 2.4 | 0.27 | 0.58 | 0.98 | 0.49 | 0.44 | 0.08 | 3.23 | 0.19 | 0.26 | 0.19 | 0.35 | 0.27 | 3.02 | 1.88 |
| $PO_4$, (Sol) as ppm $P_4$ | 2.8 | 3.9 | 2.5 | 2.94 | 0.95 | 4.2 | 16.4 | 0.04 | 0.075 | <0.025 | 0.08 | 0.06 | 0.034 | 1.6 | 0.66 |
| $P_4$, ppb | 70 | 8.0 | 44.0 | 1.48 | 53.0 | 184.0 | 65.0 | 0.008 | 6.40 | 0.003 | 0.28 | 0.004 | 0.51 | 0.365 | 0.66 |



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## TABLE 2.4--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 12-2 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 593.8 | 594.2 | 593.5 | 593.6 | 593.6 | 593.5 | 592.8 | 593.5 | 594.0 | 593.9 | 593.9 | 593.8 | 594.0 | 593.8 |
| Temperature, °C | 20 | 18 | 21 | 22 | 16 | 15 | 21 | 19 | 17 | 11 | 19 | 20 | 18 | 18 | 18 |
| Conductivity, µmhos/cm | 767 | 1,294 | 551 | 643 | 874 | 646 | 493 | 1,900 | 863 | 636 | 485 | 915 | 822 | 634 | 400 |
| pH | 7.0 | 6.8 | 6.3 | 6.8 | 7.0 | 6.7 | 6.7 | 7.1 | 6.9 | 7.0 | 6.8 | 6.6 | 7.0 | 6.6 | 6.2 |
| Lead, ppm | 0.13 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | 0.21 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | 1.69 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.004 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | <5 | -- | -- | -- | 11.0 | 8.0 | 10.0 | 6.0 | 6.6 | 5.0 | 7.0 | 7.0 | <5.0 | 10.0 | 9.0 |
| Fluoride, ppm | 1.3 | 0.96 | 1.90 | 2.15 | 2.0 | 2.11 | 1.94 | 0.14 | 2.24 | 2.4 | 2.33 | 2.11 | 2.09 | 2.18 | 2.39 |
| $PO_4$, (Sol) as ppm $P_4$ | 4.6 | 34.0 | 54.5 | 51.8 | 55.0 | 49.9 | 63.6 | 7.28 | 45.98 | 50.7 | 39.1 | 34.09 | 45.7 | 44.9 | 46.9 |
| $P_4$, ppb | 1,430 | 33.5 | 1,390 | 1.48 | 1,305 | 1,340 | 10.3 | 194 | 1,030 | 1,200 | 680 | 625 | 910.0 | 1,080.0 | 1,440.0 |

## TABLE 2.4--Continued
## GROUNDWATER QUALITY DATA
## *MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE*

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 12-4 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 592.2 | 592.1 | 592.8 | 593.5 | 593.6 | 593.2 | 592.0 | 576.2 | 578.8 | 575.7 | 582.7 | 584.0 | 585.6 | 583.6 |
| Temperature, °C | 24 | 17 | 23 | 27 | 15 | 12 | 17 | 25 | 17 | 21 | 21 | 21 | 21 | 22 | 20 |
| Conductivity, µmhos/cm | 1,312 | 927 | 745 | 912 | 670 | 438 | 351 | 340 | 3,450 | 1,600 | 924 | 980 | 1,334 | 885 | 900 |
| pH | 7.1 | 6.1 | 6.5 | 6.7 | 7.3 | 7.5 | 7.2 | 7.2 | 12.5 | 11.5 | 9.6 | 8.9 | 7.9 | 8.1 | 6.4 |
| Lead, ppm | <0.005 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | 0.32 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.003 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | 15 | -- | -- | -- | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | 5.0 | <5.0 | <5.0 | <5.0 |
| Fluoride, ppm | 2 | 1.68 | 2.87 | 2.62 | 0.44 | 0.33 | 0.34 | 0.27 | 0.4 | 0.4 | 1.62 | 0.7 | 0.23 | 0.41 | 0.11 |
| $PO_4$, (Sol) as ppm $P_4$ | 6.2 | 0.03 | 54.6 | 57.2 | 0.14 | 0.051 | 0.096 | 0.07 | <0.025 | 0.03 | 0.26 | 0.52 | 1.22 | 1.6 | 7.73 |
| $P_4$, ppb | 8.18 | 0.18 | 2.8 | 0.015 | 2.2 | 8.10 | 0.064 | 0.005 | 0.02 | 2.15 | 22.4 | 80.0 | 115.0 | 185.0 | 265.0 |

The arsenic concentrations in samples from all three wells have been below detection limit since 1987. The detection limit for arsenic was decreased from 0.05 ppm to 0.01 ppm in the fourth quarter of 1988.

Cyanide concentration in samples collected from wells 12-1, 12-2, and 12-4 have varied from less than 5 ppb (detection limit) to 15 ppb. Fluoride concentrations in samples from wells 12-1, 12-2, and 12-4 have fluctuated between 0.14 ppm to 3.23 ppm.

Figure 2.12 presents the elemental phosphorus concentrations in samples collected from well 17-5. As indicated, phosphorus concentrations fluctuated between 0.025 ppb (3rd Quarter, 1987) to 110 ppb (4th Quarter, 1989). Based on the available data, there is no trend in phosphorus concentration in groundwater samples collected from well 17-5.

Table 2.5 presents quarterly monitoring data on samples collected from well 17-5. Lead concentrations have been less than 0.003 ppm (detection limit) since the first quarter of 1989. Chromium concentration have been less than 0.01 ppm since the fourth quarter of 1988. Arsenic concentrations have been less than or equal to 0.01 ppm since first quarter of 1989. Cyanide concentrations have varied between 13 ppb (8/1/85) and 192 ppb (2nd Quarter 1990). Fluoride concentrations have varied between 22.5 ppm (1st Quarter 1987) and 44 ppm (8/1/85).

Figures 2.13 and 2.14 presents the elemental phosphorus concentrations in groundwater samples collected from wells 19-1, 19-3, and 19-4. As indicated in Figure 2.13, phosphorus concentration in samples collected from wells 19-1 and 19-4 have fluctuated between 0.001 ppb and 24.8 ppb. Samples collected from both wells do not exhibit an increasing trend in elemental phosphorus concentrations. The elemental phosphorus concentrations in samples collected from well 19-3 were in a range from 0.001 ppb to 1.5 ppb. Furthermore, the phosphorus concentrations do not exhibit any trend since 1987.

Table 2.6 presents quarterly monitoring data on samples collected from wells 19-1, 19-3, and 19-4. Lead and chromium concentrations have usually been equal to or less than their respective detection limit. Except for fourth quarter of 1988 and first quarter of 1989, arsenic concentrations have been less than the detection limit. The maximum arsenic concentration reported in samples collected from wells 19-3 and 19-4 is 0.016 ppm.

Cyanide concentrations in samples from wells 19-1, 19-3, and 19-4 have varied between less than 5 ppb (detection limit) and 88 ppb. The fluoride concentrations have varied 1.57 ppm and 17.9 ppm.

Figures 2.15 and 2.16 present the elemental phosphorus concentrations in samples collected from wells 19-5 and 19-7. These wells are located near Greenlick Creek. Phosphorus concentration in samples collected from well 19-5 has varied between 0.002 ppb, and 7.8 ppb, whereas phosphorus concentration in samples

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 17-5

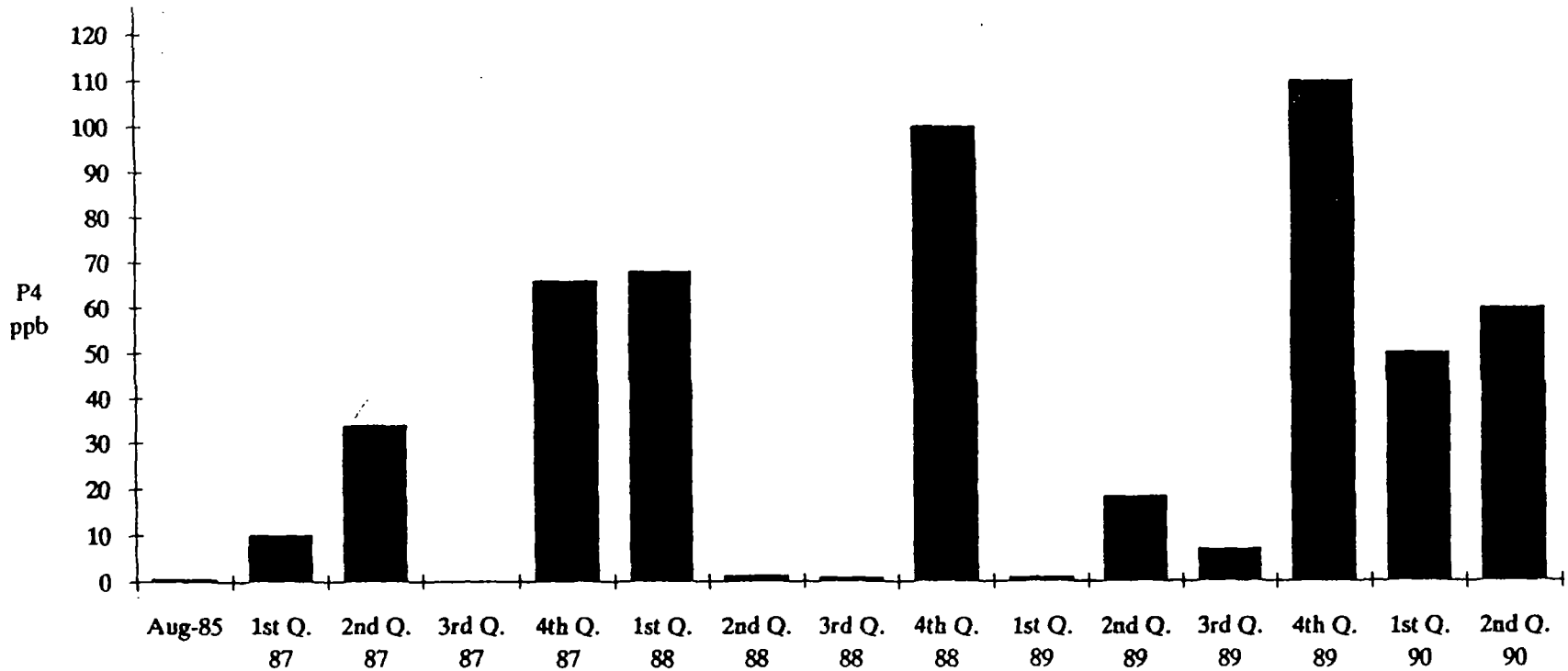


Figure 2.12

## TABLE 2.5
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 17-5 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 583.9 | 583.2 | 583.0 | 584.7 | 584.9 | 583.1 | 584.8 | 584.9 | 586.7 | 584.8 | 585.1 | 585.8 | 585.3 | 585.3 |
| Temperature, °C | 20 | 17 | 21 | 24 | 16 | 15 | 20 | 25 | 18 | 15 | 21 | 24 | 18 | 20 | 21 |
| Conductivity, µmhos/cm | 1,312 | 693 | 546 | 622 | 1,040 | 719 | 529 | 676 | 1,072 | 930 | 637 | 655 | 608 | 482 | 420 |
| pH | 7.4 | 5.6 | 6.0 | 6.3 | 6.1 | 5.8 | 6.5 | 6.1 | 6.2 | 6.0 | 6.0 | 6.0 | 6.2 | 6.0 | 5.8 |
| Lead, ppm | 0.006 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.005 | <0.003 | <0.003 | <0.003 | 0.003 | <0.003 | <0.003 |
| Chromium, ppm | 0.123 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.008 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | 0.013 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | 13 | -- | -- | -- | 30.0 | 21.0 | 41.0 | 50.0 | 40.0 | 41.3 | 23.2 | 34.0 | 24.2 | 174.0 | 192.0 |
| Fluoride, ppm | 44 | 22.5 | 23 | 26.5 | 29.8 | 28.0 | 24.2 | 30.6 | 23.3 | 35.4 | 30.1 | 26.08 | 28.33 | 33.8 | 27.0 |
| $PO_4$, (Sol) as ppm $P_4$ | 4.6 | 42.0 | 30.3 | 20.5 | 22.0 | 17.4 | 0.515 | 16.01 | 20.34 | 0.24 | 12.3 | 11.37 | 21.3 | 18.0 | 16.41 |
| $P_4$, ppb | 0.7 | 10.0 | 34.0 | 0.025 | 66.0 | 68.0 | 1.32 | 0.96 | 100.0 | 0.90 | 18.4 | 6.9 | 110.0 | 50.0 | 60.0 |

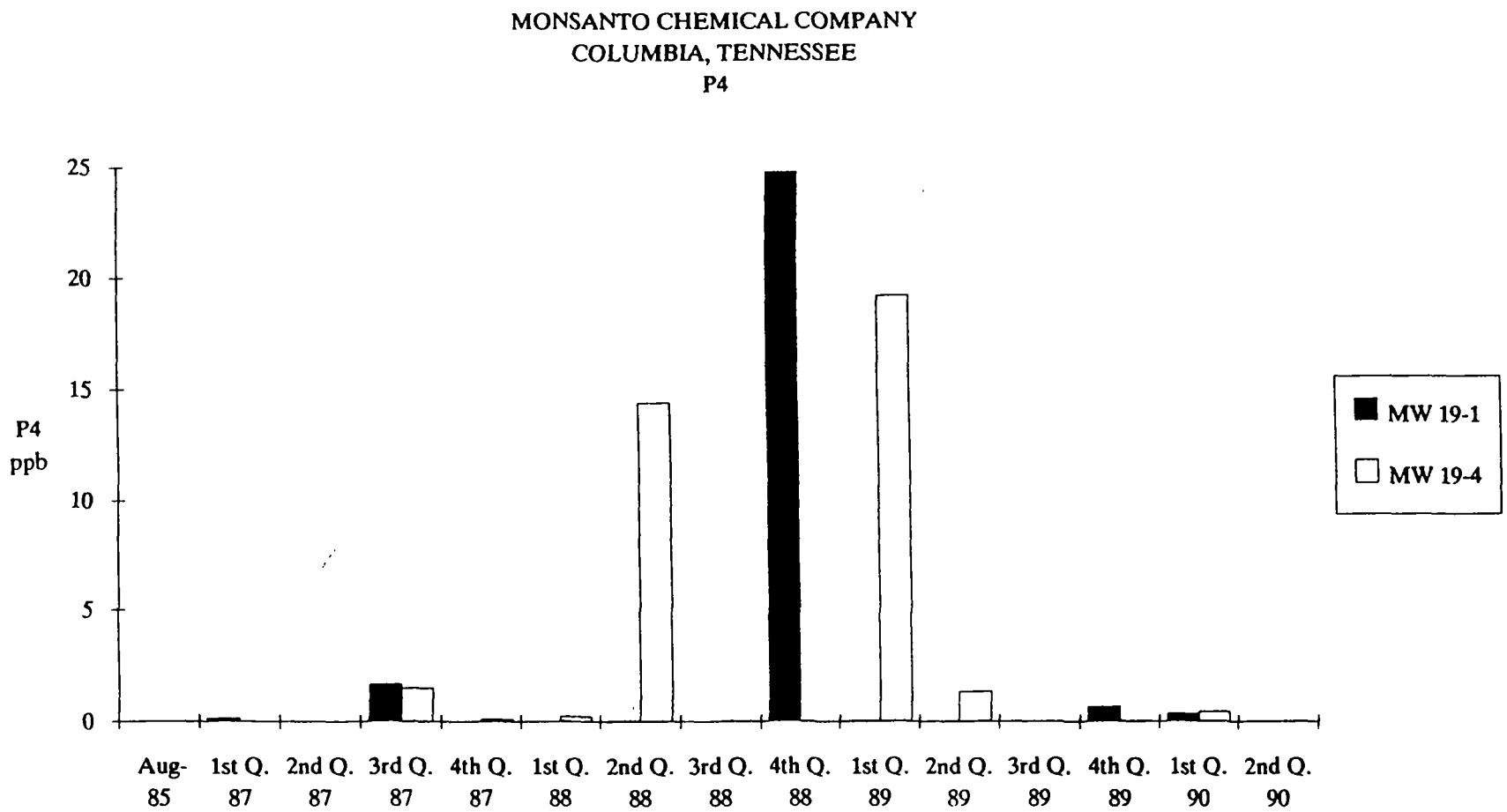
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
P4
ppb
25
20
15
10
5
0
Aug-85
1st Q. 87
2nd Q. 87
3rd Q. 87
4th Q. 87
1st Q. 88
2nd Q. 88
3rd Q. 88
4th Q. 88
1st Q. 89
2nd Q. 89
3rd Q. 89
4th Q. 89
1st Q. 90
2nd Q. 90
MW 19-1
MW 19-4

Figure 2.13

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 19-3

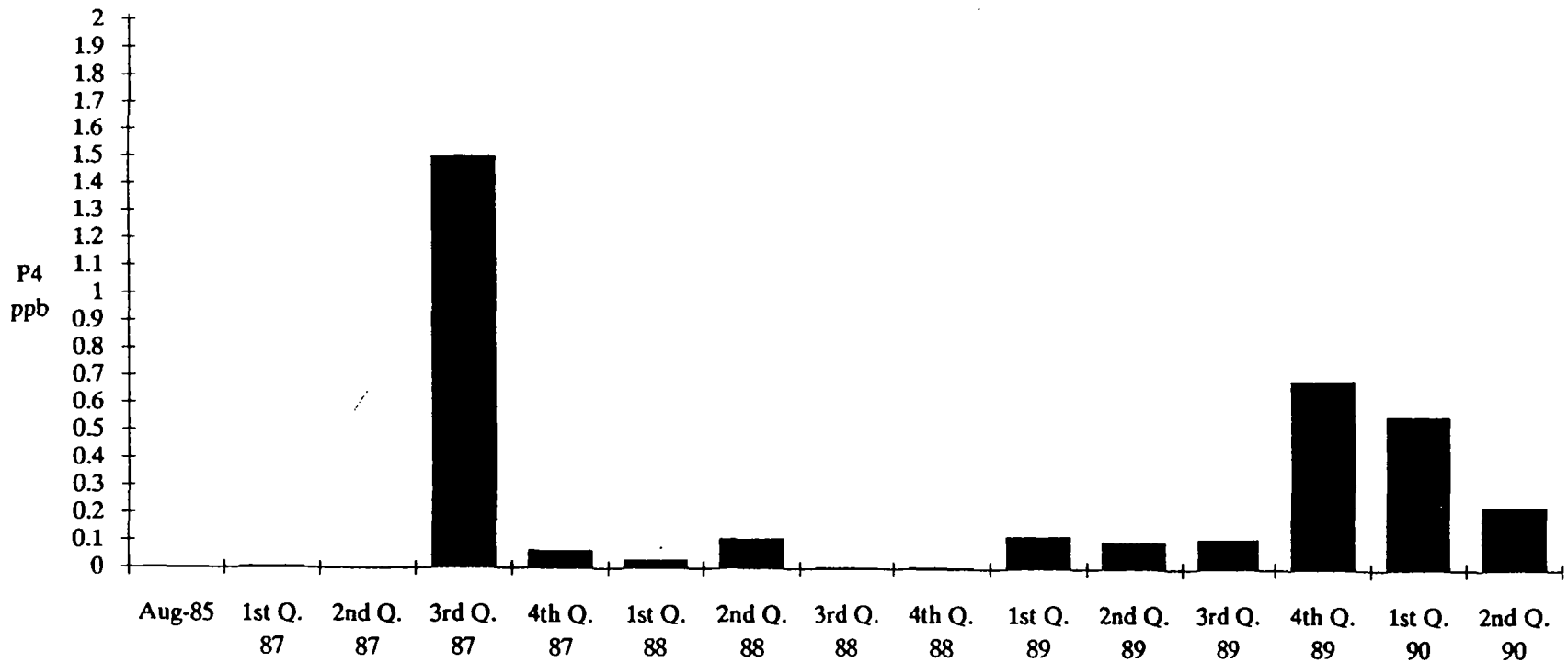


Figure 2.14

# TABLE 2.6
# GROUNDWATER QUALITY DATA
# MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 19-1 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 570.0 | 570.6 | 570.0 | 570.9 | 570.9 | 570.0 | 570.9 | 571.2 | 572.2 | 571.6 | 571.5 | 570.8 | 571.5 | 568.9 |
| Temperature, °C | 19 | 20 | 20 | 25 | 20 | 18 | 19 | 21 | 16 | 18 | 19 | 19 | 18 | 19 | 19 |
| Conductivity, μmhos/cm | 616 | 473 | 4,230 | 464 | 758 | 556 | 427 | 420 | 590 | 648 | 342 | 494 | 537 | 337 | 340 |
| pH | 7.6 | 7.5 | 7.6 | 8.0 | 7.7 | 7.6 | 8.0 | 9.3 | 7.9 | 8.4 | 7.1 | 7.4 | 7.5 | 7.3 | 6.7 |
| Lead, ppm | 0.016 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | <0.03 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 |
| Arsenic, ppm | 0.002 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | <5 | -- | -- | -- | 10.0 | 6.0 | 14.0 | 10.0 | 7.6 | <5.0 | <5.0 | 34.0 | 9.0 | 6.0 | <5.0 |
| Fluoride, ppm | 10 | 11.1 | 10.28 | 13.1 | 13.4 | 11.55 | 12.8 | 11.9 | 12.8 | 13.3 | 13.6 | 11.20 | 10.93 | 13.5 | 11.07 |
| $PO_4$, (Sol) as ppm $P_4$ | 1.3 | 0.03 | 0.05 | 0.07 | 0.05 | <0.025 | 0.041 | <0.025 | 0.24 | <0.025 | 0.052 | <0.025 | 0.024 | 0.052 | 0.033 |
| $P_4$, ppb | 0.001 | 0.18 | ND | 1.68 | 0.004 | 0.003 | 0.07 | 0.004 | 24.8 | 0.016 | 0.038 | 0.002 | 0.69 | 0.37 | 0.006 |

## TABLE 2.6--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 19-3 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L. | -- | 572.4 | 571.4 | 571.1 | 571.5 | 571.7 | 571.3 | 572.2 | 572.3 | 573.6 | 572.8 | 572.7 | 572.7 | 572.8 | 571.9 |
| Temperature, °C | 21 | 17 | 20 | 25 | 18 | 15 | 17 | 23 | 16 | 11 | 17 | 22 | 20 | 18 | 16 |
| Conductivity, µmhos/cm | 1,514 | 1,153 | 11 | 1,214 | 1,050 | 1,006 | 735 | 1,100 | 2,070 | 1,238 | 807 | 689 | 635 | 454 | 480 |
| pH | 8.5 | 7.5 | 8.5 | 8.9 | 8.9 | 8.0 | 8.5 | 11.7 | 7.4 | 8.0 | 7.9 | 8.1 | 7.7 | 7.6 | 8.2 |
| Lead, ppm | 0.68 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | 0.32 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.01 | <0.01 |
| Arsenic, ppm | 0.07 | -- | -- | -- | <0.05 | 0.099 | <0.05 | <0.05 | 0.016 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 |
| Cyanide, ppb | <5 | -- | -- | -- | 30.0 | 34.0 | 84.0 | 35.0 | 88.0 | 8.6 | 19.2 | 10.0 | 25.0 | 21.0 | 27.0 |
| Fluoride, ppm | 14 | 11.91 | 13.92 | 17.9 | 14.3 | 11.3 | 14.4 | 15.0 | 7.7 | 8.8 | 12.0 | 13.25 | 13.02 | 1.73 | 12.69 |
| $PO_4$, (Sol) as ppm $P_4$ | 2.5 | 0.84 | 0.08 | 0.05 | 0.06 | 0.06 | 0.051 | 0.1 | 0.19 | 0.44 | 0.15 | 0.11 | 0.034 | 0.121 | 0.036 |
| $P_4$, ppb | 0.001 | 0.008 | ND | 1.50 | 0.068 | 0.032 | 0.11 | 0.004 | 0.008 | 0.12 | 0.10 | 0.11 | 0.69 | 0.56 | 0.23 |



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## TABLE 2.6--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 19-4 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 573.3 | 566.8 | 566.1 | 566.7 | 569.6 | 566.1 | 566.6 | 568.4 | 572.1 | 569.7 | 568.2 | 567.3 | 567.5 | 566.6 |
| Temperature, °C | 20 | 20 | 24 | 23 | 19 | 15 | 22 | 21 | 18 | 16 | 20 | 20 | 20 | 20.0 | 20.0 |
| Conductivity, µmhos/cm | 2,573 | 2,010 | 1,186 | 1,219 | 2,160 | 1,378 | 920 | 1,129 | 1,847 | 1,410 | 867 | 921 | 1,475 | 1,314 | 990 |
| pH | 7.8 | 7.1 | 9.5 | 7.2 | 7.5 | 7.0 | 7.0 | 7.0 | 7.4 | 7.3 | 6.9 | 7.0 | 7.1 | 6.9 | 6.6 |
| Lead, ppm | 0.74 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | 0.24 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.07 | -- | -- | -- | <0.05 | 0.097 | <0.05 | <0.05 | 0.016 | 0.011 | 0.014 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | <5 | -- | -- | -- | 49.0 | 34.0 | 52.0 | 33.0 | 65.0 | 28.8 | 33.2 | 28.0 | 68.0 | <5.0 | 46.0 |
| Fluoride, ppm | 4.4 | 2.17 | 2.86 | 5.39 | 2.40 | 10.93 | 2.3 | 3.70 | 3.75 | 1.57 | 3.31 | 5.4 | 4.35 | 5.0 | 4.73 |
| $PO_4$, (Sol) as ppm $P_4$ | 1.5 | 2.2 | 2.0 | 0.14 | 0.66 | 0.442 | 0.8 | 0.28 | 3.05 | 23.7 | 8.51 | 0.3 | 0.074 | 0.06 | 0.052 |
| $P_4$, ppb | 0.002 | 0.005 | ND | 1.5 | 0.11 | 0.24 | 14.4 | 0.01 | 0.003 | 19.2 | 1.35 | 0.004 | 0.043 | 0.44 | 0.006 |

ND = None Detected

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 19-5

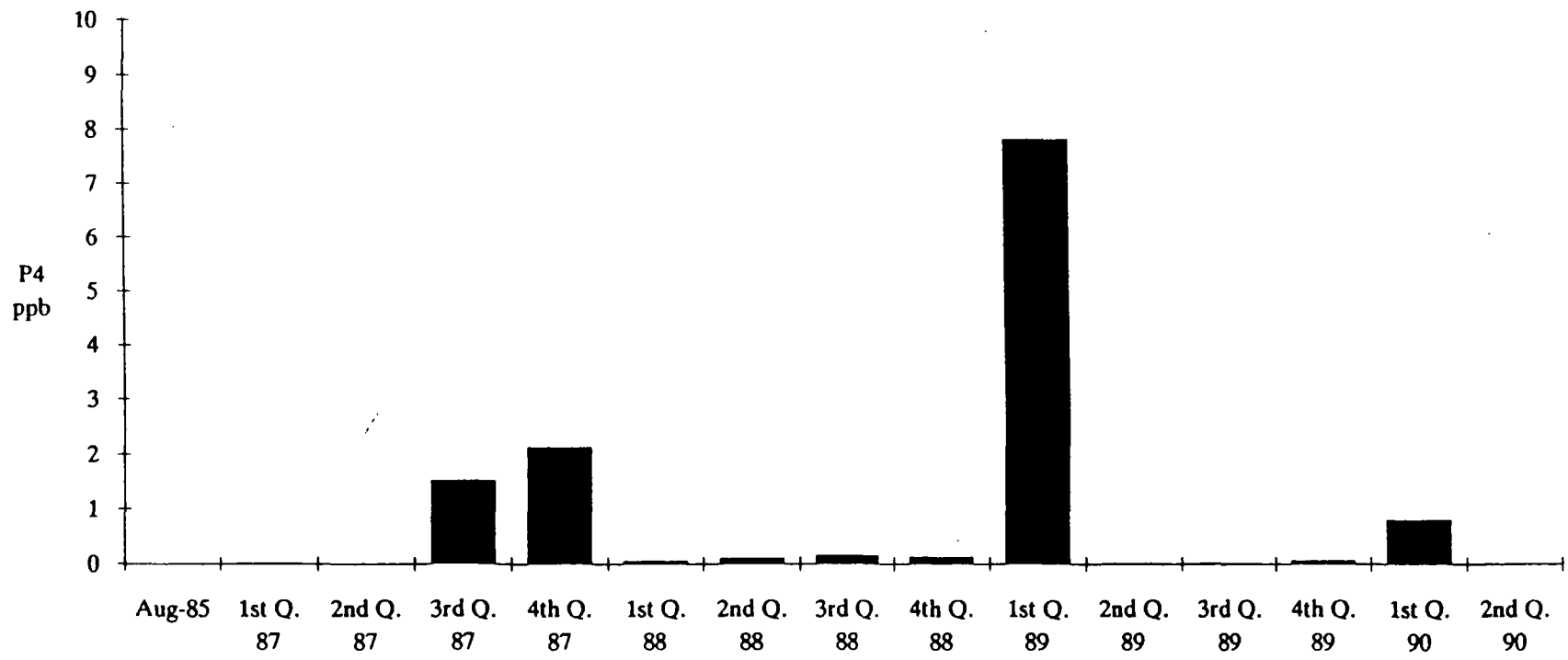



Figure 2.15

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
MW 19-7

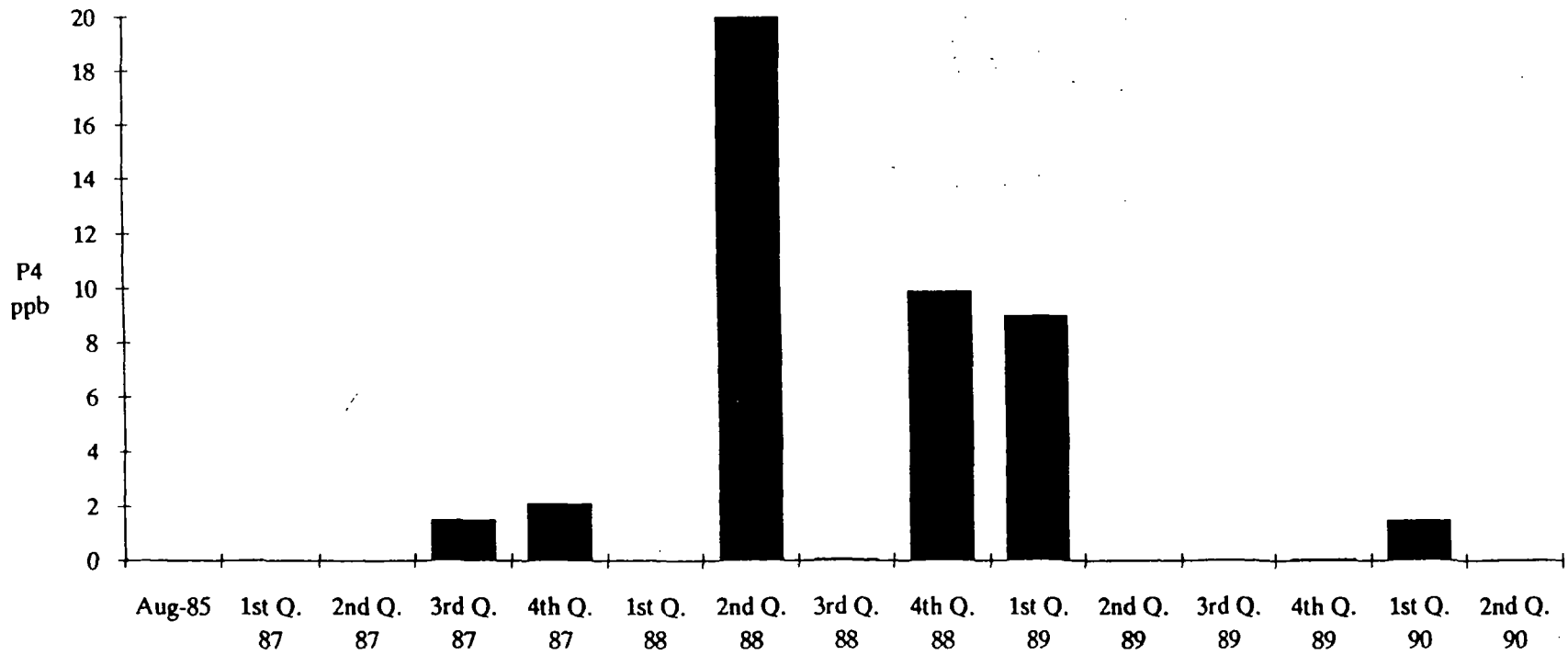



Figure 2.16

collected from well 19-7 has varied between 0.003 ppb and 2.13 ppb. The samples collected from both wells since 1987 do not exhibit increasing trends in elemental phosphorus concentration.

Table 2.7 presents quarterly monitoring data on samples collected from wells 19-5 and 19-7. Lead concentrations in samples from both wells are reported as less than 0.05 ppm prior to the third quarter of 1988 and as less than 0.003 ppm since the fourth quarter of 1988. Chromium concentrations in samples collected from both wells have been equal to or less than the detection limit with the only exception in the third quarter of 1988 when the chromium concentration in the sample from well 19-5 was reported as 0.4 ppm. The arsenic concentrations in samples from both wells have been less than the detection limit.

The cyanide concentration in samples from both wells has varied between less than 5 ppb (detection limit) and 30 ppb. The fluoride concentration in samples from both wells has varied between 4.25 ppm and 13.10 ppm.

Figure 2.17 presents the elemental phosphorus concentration in samples collected from Greenlick Creek. As indicated, the phosphorus concentrations have fluctuated between 0.002 ppb and 0.086 ppb. In fact, the phosphorus concentration in surface water samples has been less than 0.03 ppb since 1987. The quarterly monitoring data reported since 1987 does not indicate an increasing trend in phosphorus concentration in samples collected from Greenlick Creek.

Table 2.8 presents the quarterly monitoring data on surface water samples collected from Greenlick Creek. Lead concentrations varied from less than 0.003 ppm to 0.026 ppm. Since the fourth quarter of 1988, the lead concentration in surface water samples has been less than 0.003 ppm except on two occasions when it was 0.006 ppm and 0.005 ppm. Chromium concentration has been less than 0.01 ppm since fourth quarter of 1988 except in the first quarter of 1990 when it was 0.02 ppm. Arsenic concentration has been less than 0.01 ppm since the fourth quarter of 1988.

The cyanide concentration in surface water samples collected from Greenlick Creek has always been less than 5.0 ppb (detection limit). Fluoride concentrations have varied between 0.49 ppm and 2.07 ppm.

### 2.3.5. Sampling and Analysis of Groundwater from Deep Wells

Engineering-Science sampled the three deep wells, namely 12-9, 19-9, and 19-10 during the HE/RA Study. Groundwater samples were collected from these wells during packer sampling of well 12-9, aquifer tests, and quarterly monitoring (Second Quarter 1990).

The analytical results of samples from well 12-9 are presented in Table 2.9. As previously discussed, the elemental phosphorus concentration in groundwater

## TABLE 2.7
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 19-5 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 566.1 | 565.4 | 565.0 | 565.4 | 566.9 | 564.9 | 564.9 | 566.0 | 568.0 | 566.1 | 566.0 | 566.8 | 567.2 | 566.2 |
| Temperature, °C | 19 | 18 | 22 | 21 | 16 | 16 | 19 | 19 | 14 | 17 | 17 | 19 | 18 | 18 | 18 |
| Conductivity, μmhos/cm | 713 | 640 | 432 | 472 | 702 | 855 | 488 | 570 | 1,002 | 1,032 | 542 | 490 | 735 | 586 | 470 |
| pH | 7.7 | 6.5 | 7.0 | 8.0 | 7.4 | 7.3 | 7.4 | 11.3 | 6.8 | 7.5 | 7.0 | 7.4 | 7.2 | 7.4 | 7.2 |
| Lead, ppm | 0.3 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | 0.19 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | 0.4 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | 0.014 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | <5 | -- | -- | -- | 7.0 | <5.0 | 7.0 | 8.0 | 5.3 | 5.0 | <5.0 | <5.0 | 7.0 | 6.0 | 7.0 |
| Fluoride, ppm | 7.2 | 6.47 | 7.42 | 9.16 | 8.35 | 7.10 | 7.95 | 7.45 | 8.0 | 6.51 | 8.71 | 8.35 | 13.10 | 7.78 | 8.19 |
| $PO_4$, (Sol) as ppm $P_4$ | 0.7 | 0.24 | 0.035 | 0.09 | 0.09 | 0.493 | 0.101 | 0.04 | 0.2 | 0.16 | 0.11 | 0.03 | 0.069 | 0.082 | 0.074 |
| $P_4$, ppb | 0.002 | 0.007 | ND | 1.52 | 2.13 | 0.053 | 0.11 | 0.16 | 0.13 | 7.8 | 0.003 | 0.004 | 0.071 | 0.815 | 0.005 |

## TABLE 2.7--Continued
## GROUNDWATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Parameters | 8/1/85 | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| WELL NO. 19-7 | | | | | | | | | | | | | | | |
| Water Level, Ft. Above M.S.L | -- | 566.4 | 565.5 | 565.2 | 565.6 | 566.9 | 565.2 | 564.9 | 566.1 | 567.7 | 566.3 | 566.3 | 566.9 | 567.3 | 566.3 |
| Temperature, °C | 20 | 18 | 21 | 26 | 16 | 16 | 20 | 19 | 17 | 17 | 17 | 19 | 19 | 19 | 18 |
| Conductivity, μmhos/cm | 868 | 1,017 | 815 | 882 | 904 | 1,398 | 695 | 820 | 1,250 | 1,430 | 847 | 740 | 1,066 | 663 | 680 |
| pH | 7.9 | 6.8 | 7.4 | 7.4 | 7.6 | 7.2 | 7.1 | 7.3 | 6.9 | 7.4 | 7.0 | 7.1 | 6.5 | 7.1 | 6.8 |
| Lead, ppm | <0.005 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | <0.03 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 |
| Arsenic, ppm | 0.005 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | 9 | -- | -- | -- | 15.7 | 11.0 | 9.0 | 11.0 | 30.0 | 7.6 | 8.0 | 11.7 | 12.0 | 10.0 | 12.0 |
| Fluoride, ppm | 6.2 | 4.87 | 5.24 | 5.44 | 6.64 | 4.25 | 6.05 | 5.45 | 6.30 | 5.33 | 5.85 | 6.23 | 6.06 | 7.78 | 6.56 |
| $PO_4$, (Sol) as ppm $P_4$ | 1.3 | 0.28 | 0.62 | 0.76 | 0.78 | 0.186 | 1.15 | 0.75 | 0.86 | 0.69 | 0.65 | 0.63 | 0.686 | 0.732 | 0.687 |
| $P_4$, ppb | 0.006 | 0.028 | ND | 1.52 | 2.13 | 0.002 | 20.0 | 0.064 | 9.9 | 9.0 | 0.003 | 0.024 | 0.078 | 1.50 | 0.006 |

ND = None Detected

8912J122

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE
P4
GREENLICK CREEK

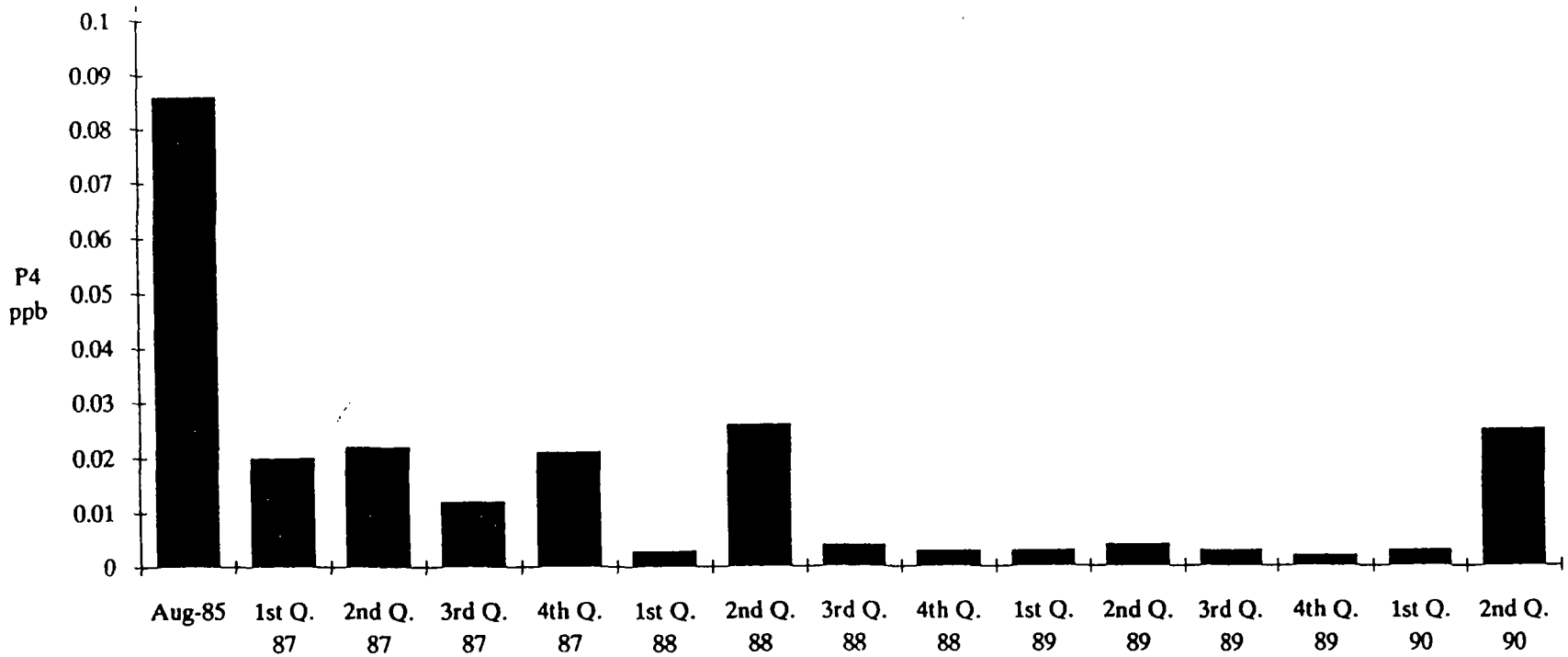



Figure 2.17



ES ENGINEERING-SCIENCE

## TABLE 2.8
## SURFACE WATER QUALITY DATA
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE
## GREENLICK CREEK AT CONFLUENCE WITH DUCK RIVER

| | | 1987 | | | | 1988 | | | | 1989 | | | | 1990 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Parameters | 7/18/85 | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr | 3rd Qtr | 4th Qtr | 1st Qtr | 2nd Qtr |
| Temperature, °C | 29 | -- | 23 | 22 | 10 | 13 | 28 | 24 | 10 | 14 | 22 | 25 | 11 | 17 | 20 |
| Conductivity, μmhos/cm | 285 | -- | 437 | 390 | 599 | 434 | 490 | 450 | 527 | 360 | 324 | 498 | 510 | 341 | 360 |
| pH | 6.7 | 8.1 | 7.8 | 7.8 | 8.1 | 7.6 | 8.1 | 7.7 | 7.8 | 8.1 | 7.6 | 7.6 | 6.5 | 7.6 | 7.2 |
| Lead, ppm | 0.026 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.003 | 0.003 | <0.003 | 0.006 | <0.003 | 0.005 | <0.003 |
| Chromium, ppm | <0.01 | -- | -- | -- | <0.04 | <0.04 | <0.04 | <0.04 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.020 | <0.010 |
| Arsenic, ppm | 0.003 | -- | -- | -- | <0.05 | <0.05 | <0.05 | <0.05 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.010 |
| Cyanide, ppb | 5 | -- | -- | -- | <5 | <5 | <5 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 | <5.0 |
| Fluoride, ppm | -- | 0.65 | 1.36 | 2.05 | 1.33 | 0.49 | 1.21 | 2.07 | 0.95 | 0.55 | 0.86 | 1.58 | 0.53 | 0.51 | 0.70 |
| $PO_4$, (Sol) as ppm $P_4$ | 0.7 | 0.8 | 0.95 | 0.74 | 0.22 | 0.293 | 0.12 | 14.37 | 0.225 | 2.39 | 0.3 | 0.28 | 0.104 | 0.29 | 0.29 |
| $P_4$, ppb | 0.086 | 0.02 | 0.022 | 0.012 | 0.021 | 0.003 | 0.026 | 0.004 | 0.003 | 0.003 | 0.004 | 0.003 | 0.002 | 0.003 | 0.025 |

**TABLE 2.9**
**GROUNDWATER QUALITY DATA**
**PACKER SAMPLING OF MONITORING WELL 12-9**
**MONSANTO INDUSTRIAL CHEMICAL COMPANY**
**COLUMBIA, TENNESSEE**

| Zone | Formation | Depth Below Ground Surface (ft) | Sample Description | Elemental Phosphorus (ppb) |
|---|---|---|---|---|
| A | Contact between Hermitage and Carters | 60-90 | Initial Pump Rinsate | <0.008* |
| B | Carters | 100-115 | Unable to sample as zone was dry | -- |
| C | Carters | 135-150 | Pump Rinsate<br>Sample | <0.008<br><0.008 |
| D | Lebanon | 220-225 | Pump Rinsate<br>Sample | <0.008<br><0.008 |

* Detection limit for phosphorus.

samples collected quarterly from nearby well 12-2 has always been approximately 1,000 ppb. As indicated in Table 2.9, well 12-9 was divided into four zones and samples were obtained from three zones (as one of the zones was dry). The phosphorus concentration in the packer samples was less than 0.008 ppb (detection limit) which indicated that deep groundwater at Site 12 did not contain elemental phosphorus in measurable quantities.

Table 2.10 presents the groundwater quality data obtained during routine quarterly sampling of all monitoring wells at Monsanto (2nd Quarter 1990). The samples collected from wells 12-9, 19-9, and 19-10 indicated elemental phosphorus concentrations above the detection limit. To confirm these results, additional samples were collected by ES from these wells during June 13-14, 1990. Nine groundwater samples were collected from well 19-9 during the 48-hour aquifer pump test. Seven and four groundwater samples were collected from well 12-9 and well 19-10, respectively. anomaly?

As indicated in Table 2.11, none of the 20 samples had an elemental phosphorus concentration greater than 0.008 ppb (detection limit). These results are in agreement with results obtained from analyses of samples which were collected immediately after the installation of these wells. ES therefore concludes that phosphorus concentration in samples collected from these wells was below the detection limit. The procedure used to establish a detection limit for elemental phosphorus is described in Appendix E.

The lead, chromium, arsenic, and cyanide concentrations in groundwater samples collected from wells 12-9, 19-9, and 19-10 were all below their respective detection limits.

The deep wells (well 12-9, 19-9, and 19-10) will be included in the quarterly monitoring program at Monsanto.

## 2.4 CONTAMINANT EXTENT AND MIGRATION

The extent of contamination is based on previous information provided in the Site Investigation Report (ES 1985), the quarterly monitoring data and hydrogeological conditions determined as a result of the HE/RA study.

### 2.4.1 Old Phosphorus Disposal Area (Site 3)

Well 3-East (Figure 2.18) is located downgradient of Site 3, between the site and the Duck River. The phosphorus concentration in groundwater samples have been consistently less than 0.01 ppb since the fourth quarter of 1987 (Subsection 2.3.1) which indicates that significant migration of phosphorus contamination is not occurring in the bedrock.

## TABLE 2.10
## GROUNDWATER QUALITY DATA
## DEEP MONITORING WELLS 12-9, 19-9, AND 19-10
## MONSANTO INDUSTRIAL CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

2ND Quarter 1990

| Parameters | Monitoring Well | | |
|---|---|---|---|
| | 12-9 | 19-9 | 19-10 |
| Water level, ft above MSL | 567.6* | 567.7* | 567.4* |
| Temperature, °C | 20 | 20 | 19 |
| Conductivity, μmhos/cm | 1,200 | 980 | 1,200 |
| pH | 6.5 | 7.1 | 6.8 |
| Lead, ppm | <0.003 | <0.003 | <0.003 |
| Chromium, ppm | <0.01 | <0.01 | <0.01 |
| Arsenic, ppm | <0.01 | <0.01 | <0.01 |
| Cyanide, ppb | <5.0 | <5.0 | <5.0 |
| Fluoride, ppm | 0.91/0.91** | 1.05/1.04** | 0.79/0.79** |
| $PO_4$, (Sol) as ppm $P_4$ | <0.025 | <0.025 | 0.019/0.014** |
| $P_4$, ppb | <0.008***/0.025** | 0.023/0.015** | 0.051/0.058** |

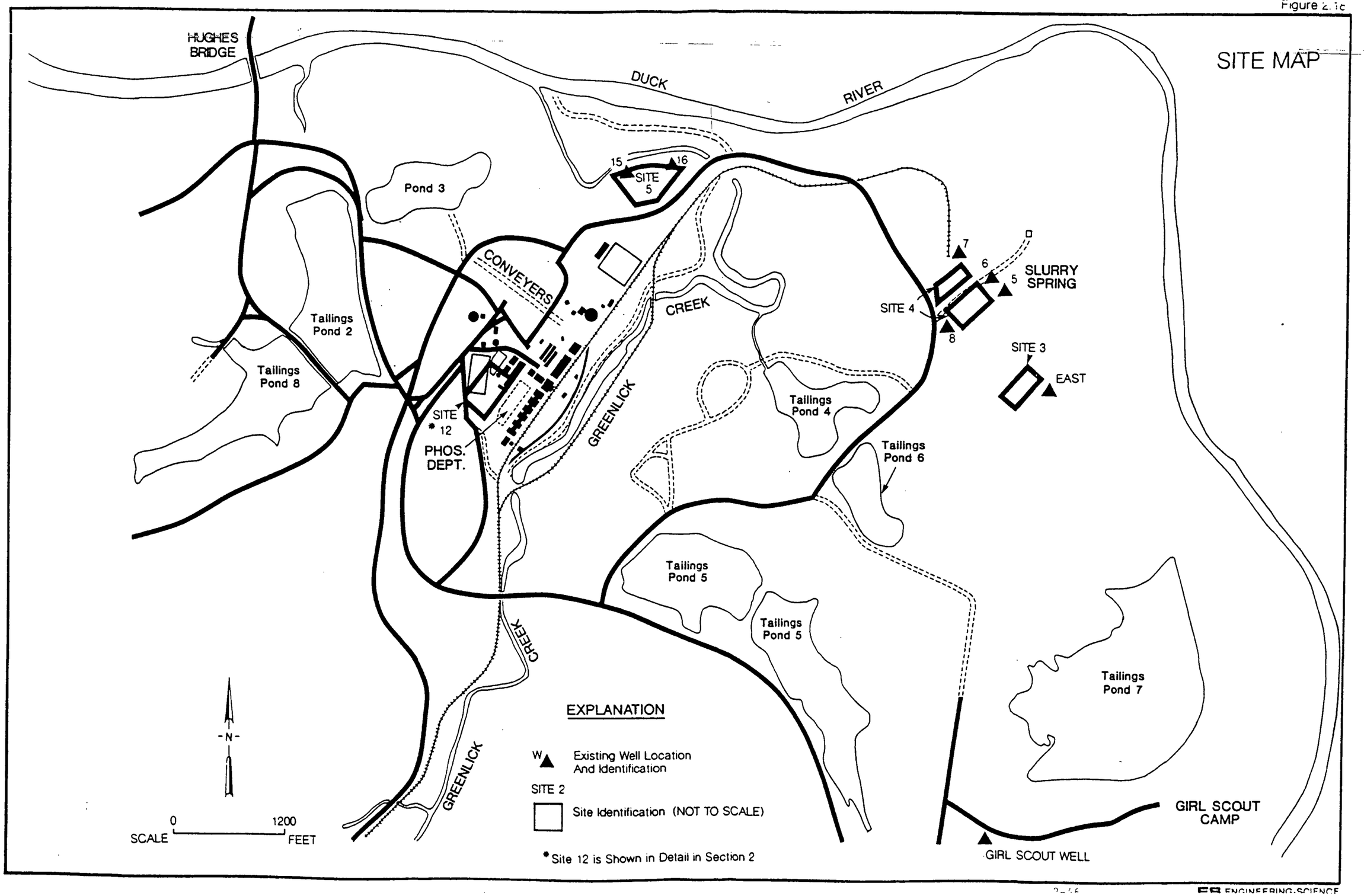
* Measured on 7 June 1990
** Duplicate sample.
*** $P_4$ detection limit = 0.008 ppb

## TABLE 2.11
## ELEMENTAL PHOSPHORUS CONCENTRATIONS IN CONFIRMATORY GROUNDWATER SAMPLES COLLECTED FROM MONITORING WELLS 12-9, 19-9, AND 19-10 MONSANTO INDUSTRIAL CHEMICAL COMPANY COLUMBIA, TENNESSEE

| Monitoring Well | Date | Number of Groundwater Samples | Concentration of Elemental Phosphorus (ppb) |
|---|---|---|---|
| 12-9 | 6-14-90/6-15-90 | 7 | BDL* |
| 19-9 | 6-14-90 | 9 | BDL |
| 19-10 | 6-13-90/6-14-90 | 4 | BDL |

* BDL = Below Detection Limit; phosphorus concentration in none of the 20 groundwater samples exceeded 0.008 ppb.

Figure 2.1c



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### 2.4.2 Phosphorus Slurry Disposal (Site 4)

Wells 4-5, 4-6, 4-7, and 4-8 (Figure 2.18) monitor downgradient of Site 4. Wells 4-5 and 4-6 are screened in the bedrock, well 4-7 is screened at the contact of overburden material and bedrock and well 4-8 is screened above the bedrock (ES 1985). Wells 4-7 and 4-8 are often reported as "dry" during sampling events.

Groundwater at Site 4 occurs at a depth of about 40 feet near the contact between the unconsolidated overburden material and the Bigby-Cannon Limestone. The variation in depth at which the water table is encountered appears to relate to topographic variations in the area. Groundwater flow directions in the shallow bedrock are downward and radially away from the site toward the east, west and north. Wells completed between Site 4 and the Duck River indicate that the water table slopes away from the site. Also, water levels in two closely spaced wells completed at different elevations indicate flow is also downward (ES 1985).

The phosphorus concentrations in groundwater samples have been consistently less than 0.03 ppb since 1987 with the exception of monitoring well 4-7 in the third quarter of 1989 when the phosphorus concentration was 0.12 ppb (Subsection 2.3.2). These results indicate no migration of contamination from the site is occurring in groundwater. The lead, chromium, and arsenic concentrations in the groundwater samples do not exhibit any increasing trends, thereby indicating no significant migration of these contaminants is occurring.

### 2.4.3 No. 1 Pond Disposal Facility (Site 5)

Wells 5-15 and 5-16 (Figure 2.18) are located north and downgradient of Site 5 between the site and the Duck River.

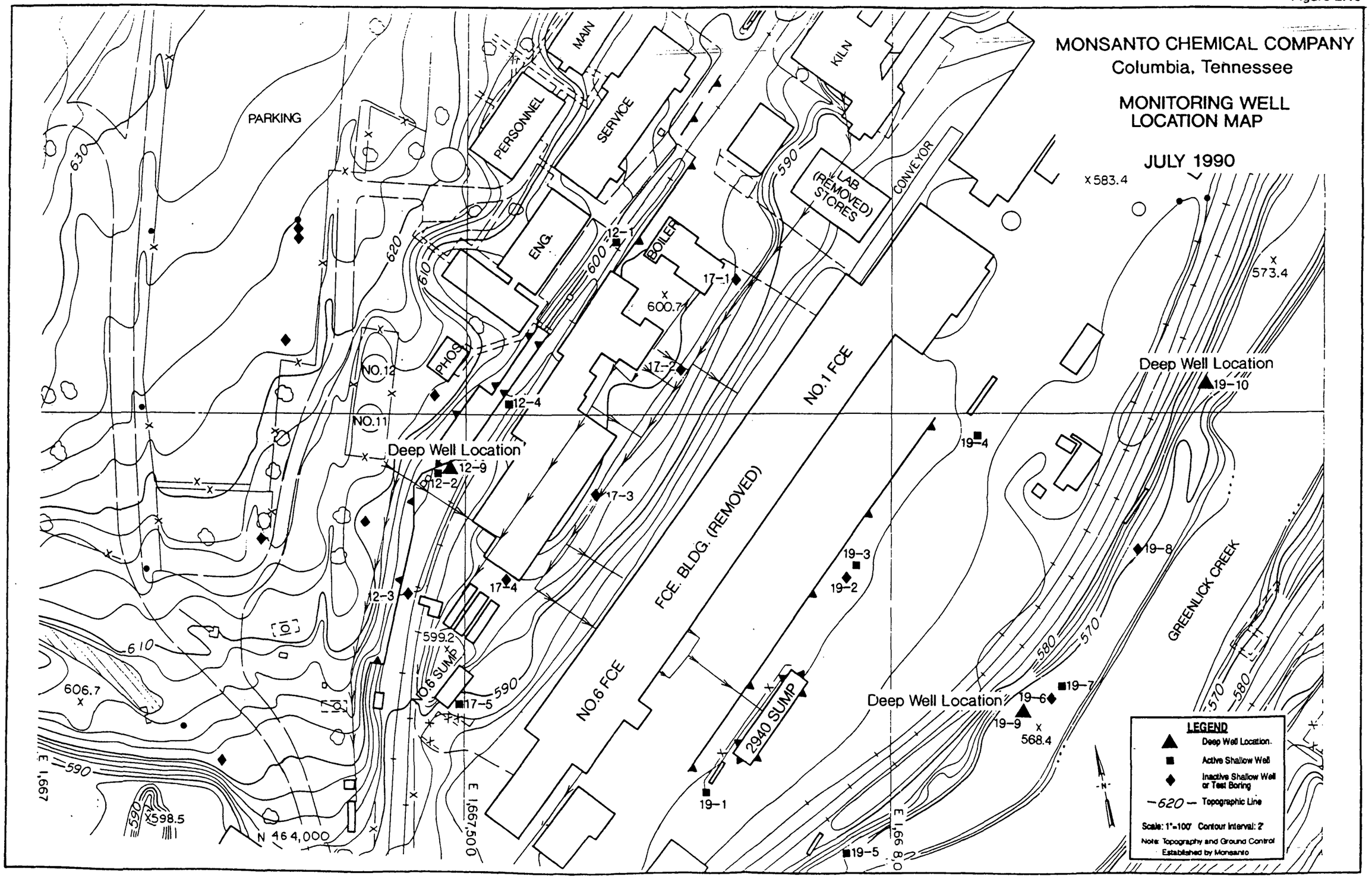
The elemental phosphorus concentrations have fluctuated between 0.002 ppb (well 5-15 1st Quarter 1988, 2nd Quarter 1989, and 4th Quarter 1989; well 5-16 1st Quarter 1988) and 0.205 ppb (well 5-15, 3rd Quarter 1989). The elemental phosphorus concentrations in samples collected from wells 5-15 and 5-16 during 2nd Quarter of 1990 were 0.016 ppb and 0.011 ppb, respectively (Subsection 2.3.3). These results suggest no significant migration of phosphorus is occurring in groundwater.

### 2.4.4 Old Tank Farm (Site 12)

Wells 12-1, 12-2, and 12-4 monitor the shallow groundwater at Site 12 (Figure 2.19). Wells 17-5, 19-1, 19-3, 19-4, 19-5, and 19-7 monitor the shallow groundwater between Site 12 and Greenlick Creek. The 1985 ES study and this study indicate that groundwater flow is generally from Site 12 toward Greenlick Creek.

Based on the results of the aquifer pump test, two distinct water bearing zones exist in the vicinity of Site 12 and Greenlick Creek with a relative lack of vertical communication between them. This is also supported by analytical results from the

Figure 2.19


MONSANTO CHEMICAL COMPANY
Columbia, Tennessee
MONITORING WELL LOCATION MAP
JULY 1990
PARKING
MAIN
PERSONNEL
SERVICE
ENG.
BOILER
KILN
LAB (REMOVED) STORES
CONVEYOR
PHOS.
NO.12
NO.11
NO.1 FCE
FCE. BLDG. (REMOVED)
NO.6 FCE
NO.6 SUMP
2940 SUMP
GREENLICK CREEK
Deep Well Location
12-1
12-2
12-3
12-4
12-9
17-1
17-2
17-3
17-4
17-5
19-1
19-2
19-3
19-4
19-5
19-6
19-7
19-8
19-9
19-10
630
620
610
600
590
580
570
583.4
573.4
600.7
599.2
606.7
598.5
568.4
E 1,667
E 1,667,500
E 1,668,0
N 464,000
LEGEND
Deep Well Location
Active Shallow Well
Inactive Shallow Well or Test Boring
620 Topographic Line
Scale: 1"=100' Contour Interval: 2'
Note: Topography and Ground Control Established by Monsanto

deep bedrock monitoring wells which do not exhibit evidence of phosphorus contamination.

The upper zone is an unconfined or water table unit which occurs within the overburden and the upper few feet of bedrock. Wells 19-1, 19-3, 19-5, and 19-7 monitor this zone. Wells 19-5 and 19-7 are located downgradient of wells 19-1 and 19-3 (Figure 2.19). Since 1987, none of the wells have exhibited any increasing trend in phosphorus concentration or any other contaminant monitored, thereby indicating a lack of significant contaminant migration in the unconfined overburden aquifer.

The lower zone is a semi-confined aquifer or confined within the unweathered Hermitage Formation and Carters Formation. Wells 12-1, 12-2, 12-4, 17-5, 19-2 and 19-4 monitor this zone. Wells 12-1, 12-2, and 12-4 are upgradient of well 17-5 which is upgradient of wells 19-2 and 19-4 (Figure 2.19). None of the wells, except 12-4, have exhibited an increasing trend in phosphorus or other contaminant concentrations (Subsection 2.3.4). Well 12-4 has exhibited as steady increase in phosphorus concentration since the third quarter of 1988. Apparently, migration is occurring from Site 12 towards well 12-4. The results from the other wells indicate that in those areas no additional contaminant migration is occurring in the aquifer.

The new monitoring wells, 12-9, 19-9 and 19-10 also monitor this lower zone (Figure 2.19). Based on the extremely poor groundwater yield and recharge rates measured during packer sampling of well 12-9 and pump test of well 19-9, the deep bedrock at the site is a very poor aquifer. One notable exception is a major flow zone that coincides with unconformity between the Hermitage and Carters Formations. This is an erosional contact with sufficient connected porosity to transmit water.

Figures 2.20 and 2.21 are hydrogeologic cross-sections which summarize much of the data collected from the new monitoring wells. Table 2.12 summarizes the water level elevations used to construct the cross-sections.

Preliminary water level data suggests a gentle gradient from 12-9 to wells 19-9 and 19-10. The water levels in 19-9 and 19-10 are indicative of flow toward Greenlick Creek, as suggested earlier. Heads in well 19-9 are about 2 feet higher than nearby well 19-6 (Figure 2.20) and about 3 feet higher than the creek indicating an upward gradient and discharge toward the creek. Likewise, heads in well 19-10 are about 4 feet higher than levels in Greenlick Creek (Figure 2.21). Direct comparison of water levels in wells 19-9 and 19-10 is complicated by the fact that wells are open to fractures in different hydrogeologic units and that well 19-10 is deeper (see Figure 2.21). The available information confirms the conceptual model of flow from Site 12 to Greenlick Creek and the necessity to continue monitoring the creek.

Figure 2.20

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENN

# HYDROGEOLOGIC CROSS-SECTION
## A – A'

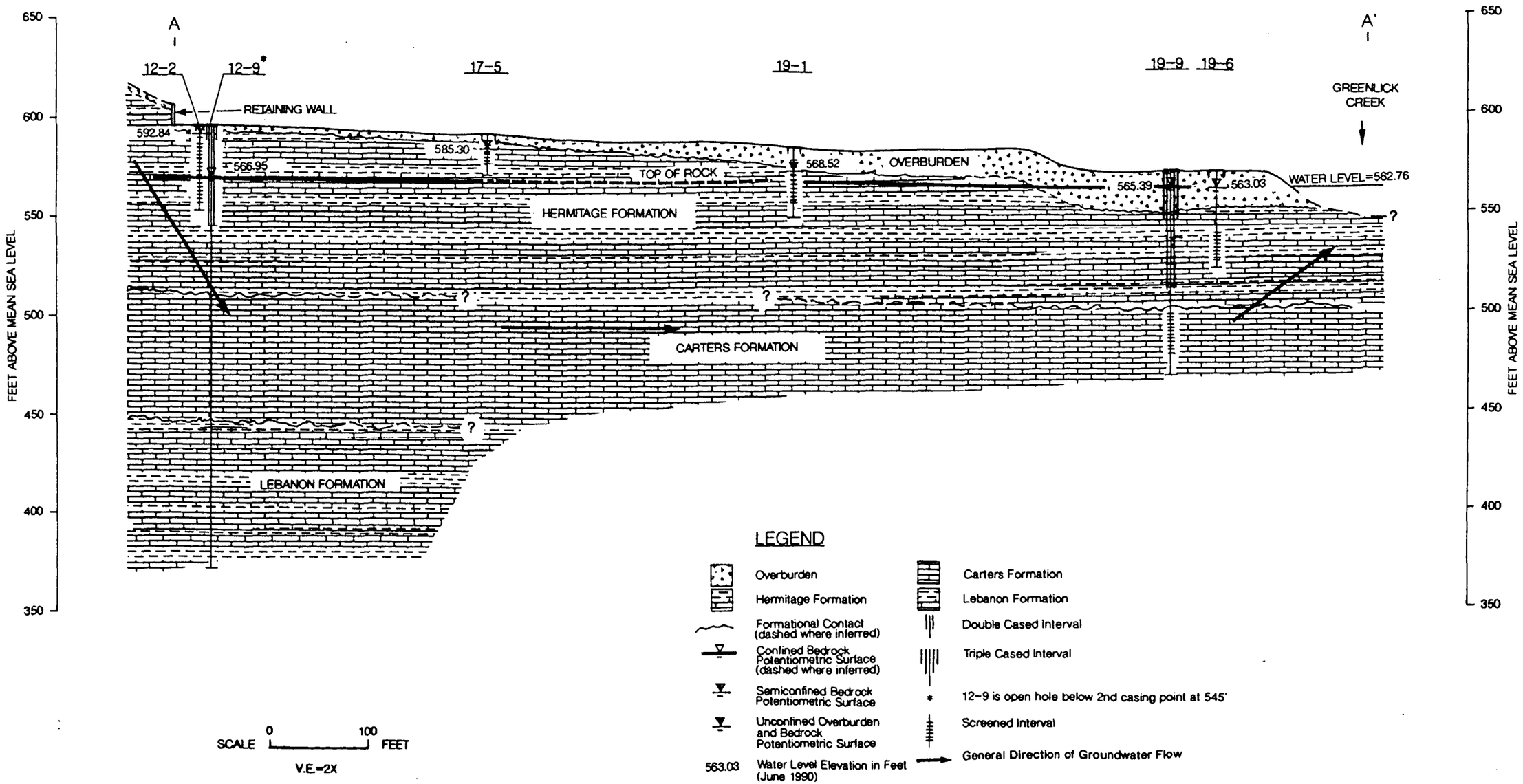





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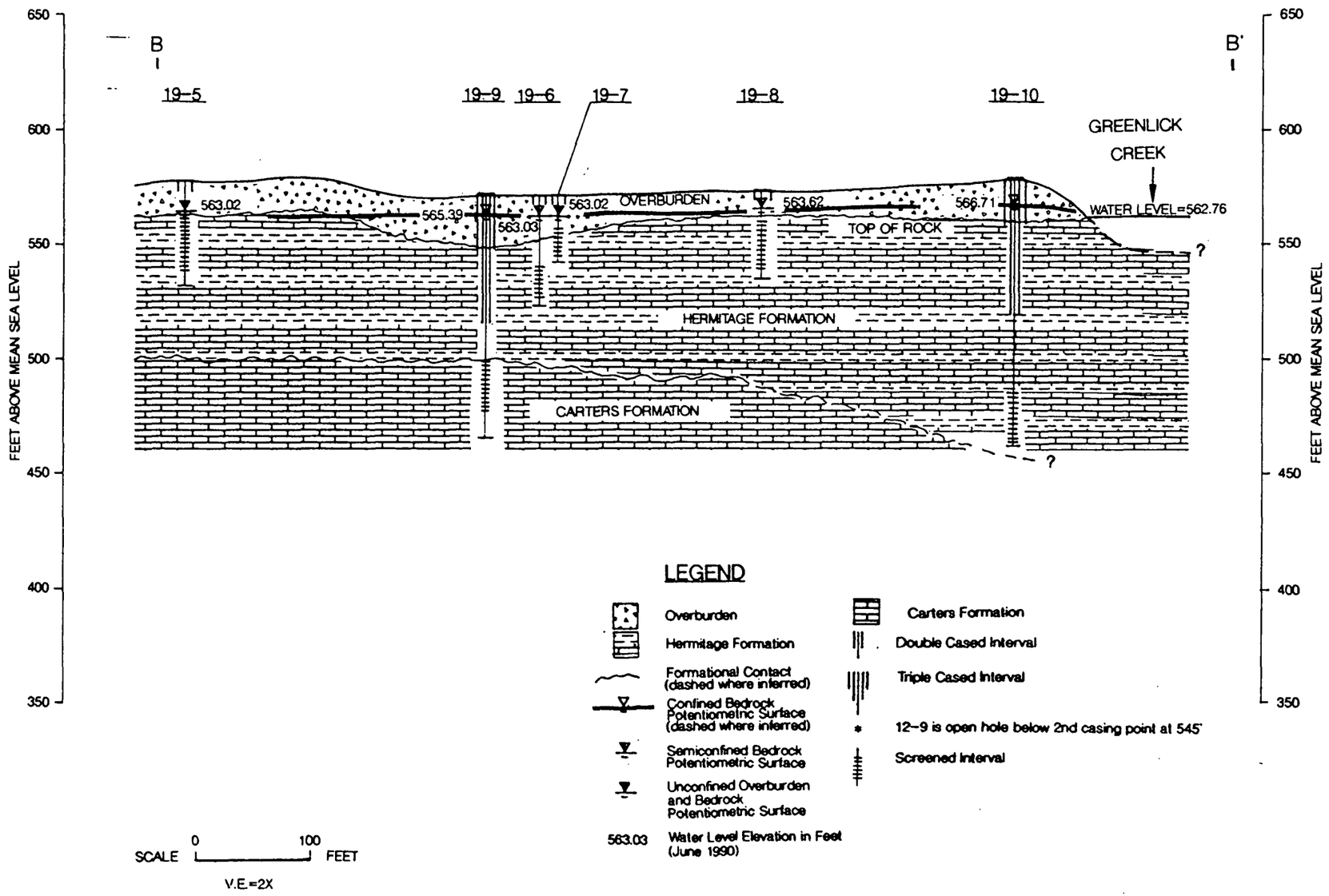
Figure 2.21

MONSANTO CHEMICAL COMPANY
COLUMBIA, TENN

# HYDROGEOLOGIC CROSS-SECTION
## B – B'



## TABLE 2.12
## GROUNDWATER LEVEL ELEVATIONS
## JUNE 1990

| Well I.D. | Measured Depth (ft) | Elevation of Measuring Evaluations (ft) | Water Table Elevation (ft) | Date of Measurement |
|---|---|---|---|---|
| 17-5 | 6.09 | 591.39 | 585.30 | June 90 |
| 19-1 | 16.14 | 584.60 | 568.52 | 6-12-90 |
| 19-2 | 21.51 | 584.52 | 563.01 | 6-12-90 |
| 19-3 | 14.20 | 583.85 | 569.65 | 6-12-90 |
| 19-4 | 20.43 | 584.73 | 564.30 | 6-12-90 |
| 19-5 | 13.51 | 576.53 | 563.02 | 6-12-90 |
| 19-6 | 8.62 | 571.65 | 563.03 | 6-12-90 |
| 19-7 | 9.33 | 572.35 | 563.02 | 6-12-90 |
| 19-8 | 9.32 | 572.94 | 563.62 | 6-12-90 |
| 19-9 | 7.06 | 572.45 | 565.39 | 6-12-90 |
| 19-10 | 10.61 | 577.32 | 566.71 | 6-12-90 |
| 12-2 | 3.57 | 596.41 | 592.84 | 6-12-90 |
| *12-9 | 30.28 | 597.23 | 566.95 | 6-12-90 |

*Final casing not installed. Well left open for possible additional packer sampling.

In the vicinity of Site 12, the water levels of monitoring wells in the unconfined and semi-confined aquifer are higher than the water levels of the confined aquifer monitoring well, 12-9 (Figure 2.20.) This suggests potential recharge to the deep bedrock occurs in this area although pump test data and analytical data show very little water actually migrates.

Wells 12-9, 19-9, and 19-10 were sampled extensively during the packer sampling and aquifer test operations and are now on the quarterly sampling program. The results of ES groundwater sampling indicated that phosphorus, lead, chromium, arsenic, and cyanide concentrations were all below their respective detection limits. The analytical results from well 12-9 which is located immediately adjacent to well 12-2 (consistently yielding the highest phosphorus concentration levels in the area) supports the idea that vertical migration of phosphorus contamination from the near surface bedrock semi-confined aquifer to the deeper bedrock aquifer is not occurring.

## 2.5 BASELINE RISK ASSESSMENT

Engineering-Science has performed a baseline risk assessment of Sites 3, 4, 5, and 12 using information obtained from the Site Investigation Report (ES 1985) and the quarterly hydrogeologic monitoring program and recent studies of Site 12. The following factors were addressed in the baseline risk assessment:

- General information
  - media of concern
  - area(s) of concern
  - types of chemicals
  - routes of contaminant transport
- Types and duration of possible exposure
- Potential exposure routes and key exposure points

The concentrations of lead, chromium, arsenic, and cyanide in groundwater and surface water are less than the Safe Drinking Water Act (SDWA) Maximum Contaminant Levels (MCLs). Therefore, there is no risk to human health or the environment by these parameters.

Elemental phosphorus is the only contaminant of concern. Physical data on elemental phosphorus is presented in Table 2.13. As indicated, elemental phosphorus is a waxy solid, normally pale yellow to straw-colored. It ignites spontaneously on contact with air at temperatures at or above 86°F. The melting point and solubility in water of elemental phosphorus are 111°F (44.1°C) and 3 mg/L (at 54°F), respectively.

## TABLE 2.13
## DATA ON ELEMENTAL PHOSPHORUS ($P_4$)

| | |
|---|---|
| | Waxy solid, normally pale yellow to straw-colored |
| DOT Hazard Class: | Flammable Solid/UN1381 |
| Autoignition Temperature: | 86°F |
| Molecular Weight: | 123.89 |
| Specific Gravity at 68°F: | 1.82 |
| Melting Point: | 111°F |
| Boiling Point: | 536°F |
| Solubility in water at 59°F: | 0.0003 gm/100 cc |
| Solubility in alcohol: | 0.3 gms/100 cc |
| Solubility in $CS_2$: | 880 gms/100 cc |
| Airborne Exposure Limit: | |
| OSHA PEL 8 hr TWA: | 0.1 mg/m$^3$ |
| STEL: | 0.3 mg/m$^3$ |
| EPA Quality Criteria for Water: | 0.1 $\mu$g/L (yellow phosphorus in marine/estuarine waters) |
| $LC_{50}$ for bluegill sunfish: | |
| at 48 hours: | 0.105 mg/L |
| at 160 hours: | 0.025 mg/L |

Engineering-Science examined toxicity and environmental health effects data in the EPA Integrated Risk Information System (IRIS) database, contacted EPA Washington, D.C., and Monsanto, St. Louis, then concluded that there is no published human toxicity or health effects data for elemental phosphorus. Information on toxicity of phosphorus to aquatic species has been developed, mainly from studies initiated in late 1960's in response to a massive fish kill caused by wastewater discharged from the ERCO plant in Newfoundland, which produced elemental phosphorus. As the ERCO fish kill occurred in marine/estaurine waters, the recommended standard of 0.1 $\mu$g/L for yellow phosphorus is for marine/estuarine waters (EPA 1986). EPA has published $LC_{50}$ concentrations for bluegill sunfish (freshwater species) of 0.105 mg/L at 48 hours and 0.025 mg/L at 160 hours (EPA 1986). Phosphorus is not included in the Resource Conservation and Recovery Act (RCRA) and SDWA (MCLs).

Tables 2.14, 2.15, 2.16, and 2.17 present a qualitative exposure pathway analysis for Sites 3, 4, 5, and 12, respectively. A quantitative risk assessment is not possible because there is not published health effects data for elemental phosphorus. For each transport medium (viz., air, soils) the following factors have been evaluated:

- Release source and mechanism
- Primary exposure point/route
- Assessment status
- Probability of pathway completion

With the exception of contaminated soils at Site 12, the probability of pathway completion for all other media at these sites is very low. At Site 12, the primary or key exposure points are site workers who may excavate contaminated soils. The routes of exposure will be inhalation, dermal, and oral. The implementation of closure plans for Site 12 which include capping will reduce the probability of pathway completion from medium to very low.

TABLE 2.14
EXPOSURE PATHWAY ANALYSIS
OLD PHOSPHORUS DISPOSAL AREA - SITE NO. 3
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Transport Medium | Release Source and Mechanism | Primary Exposure Point/Route | Assessment Status | Probability of Pathway Completion |
|---|---|---|---|---|
| Air | Surface soils/fugitive dust generation. | Trespassers, site workers/inhalation (of dusts), dermal. | Site was covered with a clay cap in 1978. | None |
| Soil | Contaminated soils, groundwater, buried wastes/site leaching. | Site workers digging in affected areas/ inhalation, dermal, oral. | Use of proper personal protection equipment will minimize exposure to site workers. Site cap will prevent casual exposure. | Very low |
| | Contaminated surface soils/ tracking, runoff. | Site workers, trespassers/dermal, oral. | Site capping will prevent casual exposure, P4 oxidizes rapidly in the air. | None |
| Groundwater | Soils, buried wastes/leaching. | Current well users/oral, inhalation, dermal. | Closest downgradient well is approximately one mile from Site 3. | Very low |

TABLE 2.15
EXPOSURE PATHWAY ANALYSIS
PHOSPHORUS SLURRY DISPOSAL - SITE NO. 4
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Transport Medium | Release Source and Mechanism | Primary Exposure Point/Route | Assessment Status | Probability of Pathway Completion |
|---|---|---|---|---|
| Air | Surface soils/fugitive dust generation. | Trespassers, site workers/inhalation (of dusts), dermal. | Site was covered with a clay cap in 1978. | None |
| Soil | Contaminated soils, groundwater, buried wastes/site leaching. | Site workers digging in affected areas/ inhalation, dermal, oral. | Site was covered with a clay cap in 1978. Also, the use of proper personal protection equipment will minimize exposure to workers. | Very low |
| | Contaminated surface soils/ tracking, runoff. | Site workers, trespassers/dermal, oral. | Site will prevent casual exposure, P4 oxidizes rapidly in the air. | None |
| Surface Water | Soils, groundwater, buried wastes and groundwater seepage. | Contact with water in the unnamed tributary between the site and Duck River/oral, inhalation, dermal. | Tributary banks have controlled access. Also, the tributary is inaccessible to boaters and is not used for swimming. | None |
| Groundwater | Soils, buried wastes/leaching. | Current well users/oral, inhalation, dermal. | Closest downgradient well is approximately one mile from Site 4. | Very low |

## TABLE 2.16
## EXPOSURE PATHWAY ANALYSIS
## NO. 1 POND DISPOSAL FACILITY - SITE 5
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Transport Medium | Release Source and Mechanism | Primary Exposure Point/Route | Assessment Status | Probability of Pathway Completion |
|---|---|---|---|---|
| Air | Surface soils/fugitive dust generation. | Trespassers, site workers/inhalation (of dusts), dermal. | Site was covered with a clay cap in 1978. | None |
| Soil | Contaminated soils, groundwater, buried wastes/site leaching. | Site workers digging in affected areas/ inhalation, dermal, oral. | Site was covered with a clay cap in 1978. Also, the use of proper personal protection equipment will minimize exposure to workers. | Very low |
| | Contaminated surface soils/ tracking, runoff. | Site workers, trespassers/dermal, oral. | Site capping will prevent casual exposure, P4 oxidizes rapidly in the air. | None |
| Surface Water | Soils, groundwater, buried wastes and groundwater seepage. | Recreational users of Greenlick Creek/ oral, inhalation, dermal. | Creek banks have controlled access, creek is inaccessible to boaters, and not used for swimming. | None |

TABLE 2.16--Continued
EXPOSURE PATHWAY ANALYSIS
NO. 1 POND DISPOSAL FACILITY - SITE 5
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Transport Medium | Release Source and Mechanism | Primary Exposure Point/Route | Assessment Status | Probability of Pathway Completion |
|---|---|---|---|---|
| Surface Water (continued) | | Persons ingesting aquatic life raised in the creek/oral. | P4 does distribute to muscle tissue in fish. Studies at Monsanto indicate a bioconcentration factor of 10, which is very low. Using the highest concentration of P4 measured in fish tissue and an ingestion rate of 0.5 Kg/day, the resulting human intake falls well below no-effect-levels determined in available chronic animal toxicity studies. | Very low |
| Groundwater | Soils, buried wastes/leaching. | Current well users/oral, inhalation, dermal. | Closest downgradient well is two miles from Site 5. | None |

## TABLE 2.17
## EXPOSURE PATHWAY ANALYSIS
## OLD TANK FARM - SITE NO. 12
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Transport Medium | Release Source and Mechanism | Primary Exposure Point/Route | Assessment Status | Probability of Pathway Completion |
|---|---|---|---|---|
| Air | P4 in surface waters/ volatilization. | Site workers, trespassers/ inhalation. | Elemental P4 in vapor phase reacts rapidly with atmospheric $O_2$ to produce phosphorus oxides. These oxides will be removed from the air during precipitation. | Very low |
| | Surface soils/fugitive dust generation. | Trespassers, site workers/inhalation (of dusts), dermal. | Elemental P4 will react rapidly in the air and will not persist. | Very low |
| Soil | Contaminated soils, groundwater, buried wastes/site leaching. | Site workers digging in affected areas/ inhalation, dermal, oral. | Closure plans for plant site include capping to prevent casual exposure. | Medium |
| | Contaminated surface soils/ tracking, runoff. | Site workers, trespassers/dermal, oral. | Site capping will prevent casual exposure, P4 oxidizes rapidly in the air. | Very low |
| Surface Water | Soils, groundwater, buried wastes and groundwater seepage. | Recreational users of Greenlick Creek/ oral, inhalation, dermal. | Creek banks have controlled access, creek is inaccessible to boaters, and not used for swimming. | None |

TABLE 2.17--Continued
EXPOSURE PATHWAY ANALYSIS
OLD TANK FARM - SITE NO. 12
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Transport Medium | Release Source and Mechanism | Primary Exposure Point/Route | Assessment Status | Probability of Pathway Completion |
|---|---|---|---|---|
| Surface Water (continued) | | Persons ingesting aquatic life raised in the creek/oral. | P4 does distribute to muscle tissue in fish. Studies at Monsanto indicate a bioconcentration factor of 10, which is very low. Using the highest concentration of P4 measured in fish tissue and an ingestion rate of 0.5 Kg/day, the resulting human intake falls well below no-effect-levels determined in available chronic animal toxicity studies. | Very low |
| Groundwater | Soils, buried wastes/leaching. | Current well users/oral, inhalation, dermal. | Closest downgradient well is two miles from Site 12. | Very low |

# SECTION 3
# IDENTIFICATION AND SCREENING OF TECHNOLOGIES

# SECTION 3
# IDENTIFICATION AND SCREENING OF TECHNOLOGIES

## 3.1 INTRODUCTION

This section presents the methodology utilized to identify and screen remediation technologies for Sites 3, 4, 5, and 12 at Monsanto Chemical Company, Columbia, Tennessee. These sites are listed on the Tennessee Superfund Promulgated List as follows:

- Site 3 - Old Phosphorus Disposal Area
- Site 4 - Phosphorus Slurry Disposal
- Site 5 - No. 1 Pond Disposal Facility
- Site 12 - Old Tank Farm

Potentially applicable remediation technologies were identified for each site on the basis of medium-specific remedial action objectives and general response actions. For each site, the remedial technologies and process options were screened with respect to their technical implementability. The technically implementable remedial technologies and process options were then evaluated on the basis of effectiveness, implementability (technical and administrative), and cost. The applicable remedial technologies and process options for each site were then retained for development and screening of alternatives.

## 3.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives, as defined in the EPA RI/FS Guidance (EPA 1988), consist of medium-specific or operable unit-specific goals for protecting human health and the environment. Tables 3.1, 3.2, 3.3, and 3.4 present the remedial action objectives for Sites 3, 4, 5, and 12, respectively. For each site, the medium-specific remedial action objectives specify the following:

- Contaminant of concern
- Exposure route(s) and receptor(s)
- Preliminary remediation goal(s)

The remedial action objectives presented in Tables 3.1 through 3.4 apply to both human health and the environment.

## TABLE 3.1
## REMEDIAL ACTION OBJECTIVES
## OLD PHOSPHORUS DISPOSAL AREA - SITE 3
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Medium | Contaminant(s) of Concern | Exposure Routes and Receptor(s) | Preliminary Remediation Goal |
|---|---|---|---|
| Goundwater | Elemental Phosphorus | Oral, inhalation, and dermal/current well users. Nearest downgradient well is approximately one mile from Site 3. | There is no published MCL for phosphorus in groundwater. |
| Soil | Elemental Phosphorus | Inhalation, dermal, and oral/site workers digging in affected areas. | Prevent site workers from direct contact (including inhalation and ingestion) with contaminated soil. |

TABLE 3.2
REMEDIAL ACTION OBJECTIVES
PHOSPHORUS SLURRY DISPOSAL - SITE 4
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Medium | Contaminant(s) of Concern | Exposure Routes and Receptor(s) | Preliminary Remediation Goal |
|---|---|---|---|
| Goundwater | Elemental Phosphorus | Oral, inhalation, and dermal/current well users. Nearest downgradient well is approximately one mile from Site 4. | There is no published MCL for phosphorus in groundwater. |
| Soil | Elemental Phosphorus | Inhalation, dermal, and oral/site workers digging in affected areas. | Prevent site workers from direct contact (including inhalation and ingestion) with contaminated soil. |

## TABLE 3.3
## REMEDIAL ACTION OBJECTIVES
## NO. 1 POND DISPOSAL FACILITY- SITE 5
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Medium | Contaminant(s) of Concern | Exposure Routes and Receptor(s) | Preliminary Remediation Goal |
|---|---|---|---|
| Goundwater | Elemental Phosphorus | Oral, inhalation, and dermal/current well users. Nearest downgradient well is approximately two miles from Site 5. Also, the nearest well is located across Greenlick Creek. Therefore, the probability of pathway completion is considered as virtually non-existent. | There is no published MCL for phosphorus in groundwater. |
| Surface Water | Elemental Phosphorus | dermal? Oral/persons ingesting aquatic life raised in the creek. Phosphorus, however, has a bioconcentration factor of 10 (for fish) which is very low. | Phosphorus concentration for marine/estuarine waters is 0.1 $\mu g/L$. This standard is not applicable to fresh water environment. |
| Soil | Elemental Phosphorus | Inhalation, dermal, and oral/site workers digging in affected areas. | Prevent site workers from direct contact (including inhalation and ingestion) with contaminated soil. |

## TABLE 3.4
## REMEDIAL ACTION OBJECTIVES
## OLD TANK FARM - SITE 12
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Medium | Contaminant(s) of Concern | Exposure Routes and Receptor(s) | Preliminary Remediation Goal |
|---|---|---|---|
| Goundwater | Elemental Phosphorus | Oral, inhalation, and dermal/closest downgradient well is approximately two miles away from the site. Also, the nearest well is located across Greenlick Creek. Therefore, the probability of pathway completion is virtually non-existent. | There is no published MCL for phosphorus in groundwater. |
| Surface Water | Elemental Phosphorus | Oral/persons ingesting aquatic life raised in the creek. Phosphorus, however, has a bioconcentration factor of 10 (for fish) which is very low. | Phosphorus concentration for marine/estuarine waters is 0.1 μg/L. This standard is not applicable to fresh water environment. |
| Soil | Elemental Phosphorus | Inhalation, dermal, oral/site workers digging in affected areas. Site workers and trespassers coming in contact with contaminated surface soils. | Prevent site workers and trespassers from direct contact with contaminated soil. Also, capping the site will prevent accidental contact with contaminated soils. |
| Air | Elemental Phosphorus | Inhalation of dusts, dermal/trespassers, site workers. | Capping the site will prevent releases of fugitive dust to the atmosphere. This will prevent receptors from inhalation of dusts and dermal contact. |

As indicated in Tables 3.1 and 3.2, the media of interest for Old Phosphorus Disposal Area (Site 3) and Phosphorus Slurry Disposal (Site 4) are groundwater and soils. The contaminant of concern for groundwater at both sites is elemental phosphorus. The exposure routes are oral, inhalation, and dermal for the current well users. The nearest downgradient well is approximately one mile from both sites.

Regarding soils at both Sites 3 and 4, the exposure routes for contaminants to affect site workers are inhalation, dermal, and oral. As these sites were covered with clay caps in 1978, the likelihood of site workers coming in direct contact with contaminated soil is minimal.

The media of interest for No. 1 Pond Disposal Facility (Site 5) are groundwater, surface water, and soils. As indicated in Table 3.3, the remedial action objectives for groundwater and soils are similar to those for Sites 3 and 4. The contaminant of concern is elemental phosphorus. For surface water, the exposure route is oral and the potential receptors are persons who may ingest aquatic life raised in the creek. The probability of pathway completion is very low as phosphorus has a very low bioconcentration factor in fish.

Table 3.4 presents the remedial action objectives for the Old Tank Farm (Site 12). The remedial action objectives for groundwater and surface water are similar to those for the No. 1 Pond Disposal Facility (Site 5). The contaminant of concern for soils is elemental phosphorus. The exposure routes are inhalation, dermal, and oral, and the potential receptors are site workers. The preliminary remediation goal is to prevent site workers and trespassers from direct contact including inhalation and ingestion with contaminated soils.

The contaminant of concern for air at Site 12 is phosphorus. As indicated in Table 3.4, the preliminary remediation goal is to prevent releases of fugitive dust to the atmosphere. This goal will prevent receptors from inhaling fugitive dust and dermal contact with the airborne elemental phosphorus.

## 3.3 GENERAL RESPONSE ACTIONS

Based on the remedial action objectives, medium-specific general response actions were identified for each site. Table 3.5 presents the medium-specific general response actions on a site-by-site basis. The media of interest for Sites 3, 4, and 5 are groundwater and soil, whereas for Site 12 the media of interest are groundwater, soil, and surface water. As Monsanto has been monitoring groundwater and surface water since 1987, a "No Action" response action was not evaluated for groundwater and surface water at each site.

## 3.4 REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS

Potentially applicable remedial technologies and process options were identified for each site on the basis of medium-specific general response actions.

## TABLE 3.5
## GENERAL RESPONSE ACTIONS
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Site No. | Site Name | Media | Process Options |
|---|---|---|---|
| 3 | Old Phosphorus Disposal Area | Groundwater | Monitoring<br>Containment<br>Collection |
| | | Soil | No Action<br>Containment<br>Source Removal<br>Treatment |
| 4 | Phosphorus Slurry Disposal | Groundwater | Monitoring<br>Containment<br>Collection |
| | | Soil | No Action<br>Containment<br>Source Removal<br>Treatment |
| 5 | No. 1 Pond Disposal Facility | Groundwater | Monitoring<br>Containment<br>Collection |
| | | Soil | No Action<br>Containment<br>Source Removal<br>Treatment |

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TABLE 3.5--Continued
GENERAL RESPONSE ACTIONS
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Site No. | Site Name | Media | Process Options |
|---|---|---|---|
| 12 | Old Tank Farm | Groundwater | Monitoring<br>Containment<br>Collection<br>Treatment |
| | | Soil | No Action<br>Containment<br>Source Removal<br>Treatment |
| | | Surface Water | Monitoring |

For example, if collection of groundwater is a general response action, then extraction is a remedial technology and use of interceptor trenches is a corresponding process option. For each site, the remedial technologies and process options were initially screened for their technical implementability. The technically implementable remedial technologies and process options were further evaluated on the basis of effectiveness, implementability (including administrative), and cost. As a result of this screening, remedial technologies and process options were retained for development of alternatives for each site.

### 3.4.1 Old Phosphorus Disposal Area (Site 3)

Table 3.6 presents information obtained from the initial screening of remedial technologies and process options for Site 3. The process options which were not technically feasible include slurry walls, grout injection, interceptor trenches, and on-site oxidation of excavated material. These process options were eliminated from further evaluation. Extraction wells, though feasible, are not warranted on the basis of quarterly monitoring data.

The information obtained from further evaluation of remaining process options is presented in Table 3.7. For groundwater, the process options retained for development of alternatives include monitoring and clay cap. If in the future, monitoring data indicate migration of elemental phosphorus, extraction of contaminated groundwater may be necessary. For soil, the process options retained for development of alternatives include clay cap, excavation of contaminated soils and placement in the permitted on-site landfill, and treatment of excavated material in an ERCO still.

### 3.4.2 Phosphorus Slurry Disposal (Site 4)

The results of initial screening of remedial technologies and process options for Site 4 are presented in Table 3.8. As indicated, the process options which were not retained for further evaluation include slurry walls, grout injection, interceptor trenches, and on-site oxidation of excavated material. Extraction wells, though feasible, are not required on the basis of available monitoring data.

The information obtained from further evaluation of the remaining process options is presented in Table 3.9. The process options retained for alternative development include groundwater monitoring, clay cap, excavation of contaminated soils and placement in the permitted on-site landfill, and treatment of excavated material in an ERCO still.

### 3.4.3 No. 1 Pond Disposal Facility (Site 5)

The results of initial screening of remedial technologies and process options for Site 5 are presented in Table 3.10. As indicated, slurry walls, grout injection, interceptor trenches, and on-site oxidation of excavated material were not retained for further evaluation. Extraction wells, though feasible, are not required on the

## TABLE 3.6
## INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
## OLD PHOSPHORUS DISPOSAL AREA - SITE NO. 3
## MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | Groundwater Monitoring | Ongoing program since 1987. Groundwater samples are collected quarterly and analyzed for temperature, pH, conductivity, lead, chromium, arsenic, cyanide, fluoride, phosphate, and elemental phosphorus. | Applicable - would function as an early warning system. To date, analysis of groundwater samples has not indicated any significant increase in elemental phosphorus concentration. |
| | Containment | Capping | Clay Cap | Site was covered with a clay cap in 1978. | Clay cap minimizes infiltration due to incidental rainfall and surface runoff. |
| | | Vertical Barriers | Slurry Walls | Soil-bentonite or cement-bentonite slurry wall around areas of contamination. | Not effective because of fractured bedrock (Karst topography). |
| | | Horizontal barriers | Grout Injection | Pressure injection of grout through closely spaced drilled holes. | Not effective because of fractured bedrock (Karst topography). |
| | Collection | Extraction | Extraction Wells | Recovery wells to extract contaminated groundwater. | Potentially Applicable. However, the analysis of groundwater samples collected to date do not indicate any significant levels of indicator parameters. |

TABLE 3.6--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
OLD PHOSPHORUS DISPOSAL AREA - SITE NO. 3
MONSANTO INDUSTRIAL CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater--Continued | | | Interceptor trenches | Interceptor trenches in bedrock--perforated pipes to collect contaminated groundwater. | Not feasible because bedrock depth varies between 25 and 50 feet below ground surface. |
| | | | Interceptor trenches | Interceptor trenches in unconsolidated material to collect contaminated groundwater. | Not effective since groundwater table generally in bedrock. |
| Soil | Containment | Capping | Clay Cap | Site was covered with clay cap in 1978. | Clay cap minimizes infiltration due to incidental rainfall and surface runoff. |
| | Source Removal | Excavation | Excavation of drummed wastes. | Excavate drums and either place the excavated material in the permitted on-site landfill or treat the excavated material in a ERCO still. | Potentially applicable. |
| | Treatment | On-site Treatment | Oxidation of excavated material. | Excavated material turned so that elemental phosphorus is oxidized (smoked). | Not feasible, because minimum EPA release quantities may be exceeded. |
| | | | ERCO Still | Feed the contaminated excavated material in a slurry form into the ERCO Still. The Still uses a molten lead bath to drive off phosphorus as a vapor. | Potentially Applicable. |

## TABLE 3.7
## EVALUATION OF PROCESS OPTIONS
## OLD PHOSPHORUS DISPOSAL AREA - SITE 3
## MONSANTO INDUSTRIAL CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | GW Monitoring | Does not reduce contamination. Useful for documenting historical condition. | Currently being implemented. | Both capital and O&M costs are low. |
| | Containment | Capping | Clay Cap | Clay cap will minimize surface filtration and direct contact with any waste present. However, any P4 present is below the water table and will continue to leach in the future. | Site was capped in 1978. | Low maintenance. |
| Soil | Containment | Capping | Clay Cap | See capping under "Groundwater" | | |
| | Source Removal | Excavation/ Landfilling | Excavation of contaminated soils and placement in the permitted on-site landfill. | Long-term effectiveness. There will be exposures during excavation which may exceed EPA reportable quantities. | Drums/soils containing P4 will oxidize during excavation. | High capital costs. |
| | Treatment | | ERCO Still | Effective; however, will only allow small volumes of charge (500 gallons) to the still and a long cycle time (2 days/ batch). It will take an extremely long time to treat the contaminated material. | Drums/soils containing P4 will oxidize during excavation. | Very high capital and O&M costs. |

## TABLE 3.8
## INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
## PHOSPHORUS SLURRY DISPOSAL - SITE NO. 4
## MONSANTO INDUSTRIAL CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | Groundwater Monitoring | Ongoing program since 1987. Groundwater samples are collected quarterly and analyzed for temperature, pH, conductivity, lead, chromium, arsenic, cyanide, fluoride, phosphate, and elemental phosphorus. In 1988 and 1989, two monitoring wells (4-7 and 4-8) were dry during three quarterly sampling events. | Potentially Applicable - would function as an early warning system of elemental phosphorus migration. To date, the analysis of groundwater samples collected from monitoring wells has not indicated any significant increase in elemental phosphorus concentration. |
| | Containment | Capping | Clay Cap | The site was capped with a 3-feet thick clay cap in 1978. | Clay cap minimizes infiltration due to incidental rainfall and surface runoff. |
| | | Vertical Barriers | Slurry Walls | Soil-bentonite or cement-bentonite slurry wall around areas of contamination. | Not effective because of fractured bedrock (Karst topography). |
| | | Horizontal barriers | Grout Injection | Pressure injection of grout through closely spaced drilled holes. | Not effective because of fractured bedrock (Karst topography). |

TABLE 3.8--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
PHOSPHORUS SLURRY DISPOSAL - SITE NO. 4
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater--Continued | Collection | Extraction | Extraction Wells | Recovery wells to extract contaminated groundwater. | Potentially Applicable. However, the analysis of groundwater samples collected to date do not indicate any significant levels of indicator parameters. |
| | | | Interceptor trenches | Interceptor trenches in bedrock--perforated pipes to collect contaminated groundwater. | Not possible because bedrock depth varies between 15 feet and 40 feet below ground surface. |
| | | | Interceptor trenches | Interceptor trenches in unconsolidated material to collect contaminated groundwater. | Not effective since groundwater table generally in bedrock. |
| Soil | Containment | Capping | Clay Cap | Site was capped with a 3-feet thick clay cap in 1978. | Clay cap minimizes infiltration due to incidental rainfall and surface runoff. |
| | Source Removal | Excavation | Excavation of contaminated soils. | Excavate contaminated soils and either place the excavated material in the permitted on-site landfill or treat the excavated material in a ERCO still. | Potentially applicable. |

TABLE 3.8--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
PHOSPHORUS SLURRY DISPOSAL - SITE NO. 4
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Soil--Continued | Treatment | On-site Treatment | Oxidation of excavated material. | Excavated material turned so that elemental phosphorus is oxidized (smoked). | Not feasible because minimum EPA release quantities may be exceeded. |
| | | | ERCO Still | Feed the contaminated excavated material in a slurry form into the ERCO Still. The Still uses a molten lead bath to drive off phosphorus as a vapor. | Potentially Applicable. |

## TABLE 3.9
## EVALUATION OF PROCESS OPTIONS
## NO. 1 POND DISPOSAL FACILITY - SITE 5
## MONSANTO INDUSTRIAL CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | GW Monitoring | Does not reduce contamination. Useful for documenting historical condition. | Currently being implemented. | Both capital and O&M costs are low. |
| | Containment | Capping | Clay Cap | Clay cap minimizes surface filtration and direct contact with any waste present. However, any P4 present is below the water table and will continue to leach in the future. | Site was capped in 1978. | Low maintenance. |
| Soil | Containment | Capping | Clay Cap | See capping under "Groundwater" | | |
| | Source Removal | Excavation/ Landfilling | Excavation of contaminated soils and placement in the permitted on-site landfill. | Long-term effectiveness. There will be exposures during excavation which may exceed EPA reportable quantities. | Soils contain P4 which will oxidize during excavation. | High capital costs. |
| | Treatment | | ERCO Still | Effective; however, will only allow small volumes of charge (500 gallons) to the still and a long cycle time (2 days/ batch). It will take an extremely long time to treat the contaminated soil. | Soils contain P4 which will oxidize during excavation. | Very high capital and O&M costs. |

TABLE 3.10
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
NO. 1 POND DISPOSAL FACILITY - SITE NO. 5
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | Groundwater Monitoring | Ongoing program since 1987. Groundwater samples are collected from monitoring wells and analyzed for temperature, pH, conductivity, lead, chromium, arsenic, cyanide, fluoride, phosphate, and elemental phosphorus. | Potentially Applicable - would function as an early warning system of elemental phosphorus migration. To date, the analysis of groundwater samples collected from monitoring wells has not indicated any significant increase in elemental phosphorus concentration. |
| | Containment | Capping | Clay Cap | The site was covered with a clay cap in 1986. | Clay cap minimizes infiltration due to surface runoff and incidental rainfall. |
| | | Vertical Barriers | Slurry Walls | Soil-bentonite or cement-bentonite slurry wall around areas of contamination. | Not effective because of fractured bedrock (Karst topography). |
| | | Horizontal barriers | Grout Injection | Pressure injection of grout through closely spaced drilled holes. | Not effective because of fractured bedrock (Karst topography). |

TABLE 3.10--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
NO. 1 POND DISPOSAL FACILITY - SITE NO. 5
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater--Continued | Collection | Extraction | Extraction Wells | Recovery wells to extract contaminated groundwater. | Potentially applicable. However, the analysis collected from monitoring wells has not indicated any significant increase in elemental phosphorus concentration. |
| | | | Interceptor trenches | Interceptor trenches in bedrock--perforated pipes to collect contaminated groundwater. | Not possible because bedrock depth varies between 50 and 60 feet below ground surface. |
| | | | Interceptor trenches | Interceptor trenches in unconsolidated material to collect contaminated groundwater. | Not effective since groundwater table generally in bedrock. |
| Soil | Containment | Capping | Clay Cap | The site was covered with a clay cap in 1986. | Clay cap minimizes infiltration due to incidental rainfall and surface runoff. |
| | Source Removal | Excavation | Excavation of contaminated soils. | Excavate wastes/contaminated soils and either place the excavated material in the permitted on-site landfill or treat the excavated material in a ERCO still. | Potentially applicable. |

TABLE 3.10--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
NO. 1 POND DISPOSAL FACILITY - SITE NO. 5
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Soil--Continued | Treatment | On-site Treatment | Oxidation of excavated material. | Excavated material turned so that elemental phosphorus is oxidized (smoked). | Not feasible because minimum EPA release quantities may be exceeded. |
| | | | ERCO Still | Feed the contaminated excavated material in a slurry form into the ERCO Still. The Still uses a molten lead bath to drive off phosphorus as a vapor. | Potentially Applicable. |

basis of available monitoring data. The remaining process options, namely groundwater monitoring, clay cap, excavation of contaminated soils and placement in the permitted on-site landfill, treatment of excavated material in an ERCO still, and monitoring of surface waters were further evaluated on the basis of effectiveness, implementability, and cost. The results are presented in Table 3.11.

### 3.4.4 Old Tank Farm (Site 12)

Table 3.12 presents the results of initial screening of remedial technologies and process options for Site 12. The process options which were not considered as technically implementable included slurry walls, grout injection, interceptor trenches, in-situ chemical detoxification, excavation of contaminated bedrock, and on-site oxidation of excavated material. As indicated in the screening comments, the Karst topography at the site would likely render slurry walls, grout injection, and in-situ chemical detoxification as infeasible. The placement of interceptor trenches and excavation of contaminated bedrock were not retained for further evaluation due to safety issues and the likelihood of driving elemental phosphorus deeper into the bedrock.

The results of further evaluation of process options on the basis of effectiveness, implementability, and cost are presented in Table 3.13. Monsanto currently conducts quarterly groundwater and surface water monitoring in accordance with the Hydrogeologic Monitoring Plan dated October 1986. Monitoring will not reduce contamination; however, it will serve as an early warning system for migration of contaminants from the site. Groundwater flows from the site towards Greenlick Creek. To date, phosphorus concentrations in the surface water samples collected quarterly from Greenlick Creek have not exhibited a significant increase. The process options retained for alternative development include groundwater monitoring, clay cap, multi-media cap, extraction wells, chemical detoxification of extracted groundwater, diversion of surface runoff, excavation of contaminated material and placement in on-site landfill, treatment of excavated material in an ERCO still, and monitoring of Greenlick Creek.

The process options retained for alternative development are summarized on a site-by-site basis in Table 3.14. Development of alternatives is presented in Section 4.

# TABLE 3.11
# EVALUATION OF PROCESS OPTIONS
# NO. 1 POND DISPOSAL FACILITY - SITE 5
# MONSANTO INDUSTRIAL CHEMICAL COMPANY
# COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | GW Monitoring | Does not reduce contamination. Useful for documenting historical condition. | Currently being implemented. | Both capital and O&M costs are low. |
| | Containment | Capping | Clay Cap | Clay cap reduces surface filtration and direct contact with any waste present. However, any P4 present is below the water table and will continue to leach in the future. | Site was capped in 1986. | Low maintenance. |
| Soil | Containment | Capping | Clay Cap | See capping under "Groundwater" | | |
| | Source Removal | Excavation/ Landfilling | Excavation of contaminated soils and placement in the permitted on-site landfill. | Long-term effectiveness. There will be exposures during excavation which may exceed EPA reportable quantities. | Soils contain P4 which will oxidize during excavation. | High capital costs. |
| | Treatment | | ERCO Still | Effective; however, will only allow small volumes of charge (500 gallons) to the still and a long cycle time (2 days/ batch). It will take an extremely long time to treat the contaminated soil. | Soils contain P4 which will oxidize during excavation. | Very high capital and O&M costs. |

TABLE 3.11--Continued
EVALUATION OF PROCESS OPTIONS
NO. 1 POND DISPOSAL FACILITY - SITE 5
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|---|
| Surface Water | Monitoring | Monitoring | Monitoring of Greenlick Creek | Useful to document historical conditions. To date, phosphorus concentrations in surface water samples collected from Greenlick Creek have not exhibited a significant increase. | Readily implementable. | Low capital and O&M costs. |

TABLE 3.12
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
OLD TANK FARM - SITE NO. 12
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | Groundwater Monitoring | Ongoing program since 1987. Groundwater samples are collected quarterly from nine monitoring wells (12-1, 12-2, 12-4, 17-5, 19-1, 19-3, 19-4, 19-5, and 19-7). Groundwater samples are monitored for temperature, pH, conductivity, lead, chromium, arsenic, cyanide, fluoride, phosphate, and elemental phosphorus. | Potentially Applicable - would function as an early warning system of contaminant movement. |
| | Containment | Capping | Clay Cap | Compacted clay layer covered with top soil over areas of contamination. | Potentially Applicable |
| | | | Multi-media Cap | Clay and synthetic membrane covered by top soil over areas of contamination. | Potentially Applicable |
| | | Vertical Barriers | Slurry Walls | Soil-bentonite or cement-bentonite slurry wall around areas of contamination. | Not effective because of fractured bedrock (Karst topography). |
| | | Horizontal barriers | Grout Injection | Pressure injection of grout through closely spaced drilled holes. | Not effective because of fractured bedrock (Karst topography). |
| | Collection | Extraction | Extraction Wells | Recovery wells to extract contaminated groundwater. | Potentially Applicable. |

TABLE 3.12--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
OLD TANK FARM - SITE NO. 12
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Groundwater--Continued | | | Interceptor trenches | Interceptor trenches in bedrock--perforated pipes to collect contaminated groundwater. | Not effective because of high release, safety issues associated with blasting contaminated bedrock and the likelihood of driving P4 deeper into the bedrock. |
| | | | Interceptor trenches | Interceptor trenches in unconsolidated material to collect contaminated groundwater. | Not effective since groundwater table generally in bedrock. |
| | Treatment | In-situ treatment | Chemical detoxification | Introduce an oxidant (e.g., hydrogen peroxide) through injection wells to oxidize the elemental phosphorus contamination in groundwater. | Karst topography (i.e., fractured bedrock with solution channels) will render this alternative infeasible. |
| | | Treatment of extracted groundwater | Chemical detoxification through oxidation | Treat extracted groundwater then discharge on site or off site. | Potentially applicable. |
| Soil | Containment | Capping | Clay Cap | Compacted clay layer covered with top soil (over areas of contamination). | Potentially applicable. |
| | | | Multi-media Cap | Clay and synthetic membrane covered by top soil (over areas of contamination). | Potentially Applicable. |
| | | Surface Controls | Diversion of runoff/interception of runoff. | Dikes, diversion channels constructed upslope of Site 12. | Potentially Applicable. |

TABLE 3.12--Continued
INITIAL SCREENING OF REMEDIAL TECHNOLOGIES AND PROCESS OPTIONS
OLD TANK FARM - SITE NO. 12
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Description | Screening Comments |
|---|---|---|---|---|---|
| Soil--Continued | Source Removal | Excavation | Excavation of contaminated soils. | Excavate contaminated soils and either place the excavated material in the permitted on-site landfill or treat the excavated material in a ERCO still. | Potentially applicable. |
| | | | Excavation of contaminated bedrock. | Excavate contaminated bedrock and either place in the permitted on-site landfill or treat in ERCO still. | Not feasible because of high air release, safety issues associated with blasting contaminated bedrock and likelihood of driving contamination deeper into bedrock. |
| | Treatment | On-site Treatment | Oxidation of excavated material. | Excavated material turned so that elemental phosphorus is oxidized (smoked). | Not feasible because minimum EPA release quantities may be exceeded. |
| | | | ERCO Still | Feed the contaminated excavated material in a slurry form into the ERCO Still. The Still uses a molten lead bath to drive off phosphorus as a vapor. | Potentially Applicable. |
| Surface Water | Monitoring | Monitoring | Monitoring of Greenlick Creek | Ongoing program since 1978. Samples of surface water are collected quarterly from Greenlick Creek and monitored for temperature, conductivity, pH, lead, chromium, arsenic, cyanide, fluoride, phosphate, and elemental phosphorus. | Potentially Applicable. |

# TABLE 3.13
# EVALUATION OF PROCESS OPTIONS
# OLD TANK FARM - SITE 12
# MONSANTO INDUSTRIAL CHEMICAL COMPANY
# COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|---|
| Groundwater | Monitoring | Monitoring | GW Monitoring | Does not reduce contamination. Useful for documenting historical condition. | Currently being implemented. | Both capital and O&M costs are low. |
| | Containment | Capping | Clay Cap<br>Multi-media Cap | Will prevent surface filtration and direct contact with waste. However, the P4 is below the water table and will continue to leach in the future. | Easy implementation | High capital, low maintenance. |
| | Collection | Extraction | Wells | Effective at removing contaminated groundwater. | Easy implementation. | Moderate capital cost, low O&M provided treatment plant expansion not required. |
| | Treatment | Treatment of extracted groundwater | Chemical detoxification through oxidation | Effective and reliable; some capacity available at existing treatment plant. | Readily implementable. | Moderate capital and O&M costs provided treat-ment plant expansion is not required. |
| Soil | Containment | Capping | Clay Cap<br>Multi-media Cap | See capping under "Groundwater" | | |
| | | Surface Controls | Diversion of Runoff | Effective; will divert surface runoff from Site 12. | Easily implementable. | Low capital and O&M cost. |
| | Source Removal | Excavation/ Landfilling | Excavation of contaminated soils and placement in the permitted on-site landfill. | Long-term effectiveness. There will be exposures during excavation which may exceed EPA reportable quantities. | Soils contain P4 which will oxidize during excavation. | High capital costs. |

TABLE 3.13--Continued
EVALUATION OF PROCESS OPTIONS
OLD TANK FARM - SITE 12
MONSANTO INDUSTRIAL CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Media | Response Action | Remedial Technology | Process Option | Effectiveness | Implementability | Cost |
|---|---|---|---|---|---|---|
| Soil (continued) | Treatment | | ERCO Still | Effective; however, will only allow small volumes of charge (500 gallons) to the still and a long cycle time (2 days/ batch). It will take an extremely long time to treat the contaminated soil. | Soils contain P4 which will oxidize during excavation. | Very high capital and O&M costs. |
| Surface Water | Monitoring | Monitoring | Monitoring of Greenlick Creek | Useful to document historical conditions. To date, phosphorus concentrations in surface water samples collected from Greenlick Creek have not exhibited a significant increase. | Currently being implemented. | Low capital and O&M costs. |

## TABLE 3.14
## PROCESS OPTIONS RETAINED FOR DEVELOPMENT OF ALTERNATIVES
## MONSANTO CHEMICAL COMPANY
## COLUMBIA, TENNESSEE

| Site No. | Site Name | Media | Process Options |
|---|---|---|---|
| 3 and 4 | Old Phosphorus Disposal Area and Phosphorus Slurry Disposal | Groundwater | • Monitoring (currently being implemented) |
| | | Soil | • Clay cap (Sites were capped in 1978)<br>• Excavation of contaminated soils and placement in on-site landfill<br>• Treatment of excavated material in an ERCO still |
| 5 | No. 1 Pond Disposal Facility | Groundwater | • Monitoring (currently being implemented) |
| | | Soil | • Clay cap (Site was capped in 1986)<br>• Excavation of contaminated soils and placement in on-site landfill<br>• Treatment of excavated material in an ERCO still |
| | | Surface Water | • Monitoring (currently being implemented) |
| 12 | Old Tank Farm | Groundwater | • Monitoring (currently being implemented)<br>• Extraction of groundwater using wells<br>• Treatment of extracted groundwater using chemical detoxification |

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TABLE 3.14--Continued
PROCESS OPTIONS RETAINED FOR DEVELOPMENT OF ALTERNATIVES
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Site No. | Site Name | Media | Process Options |
|---|---|---|---|
| Site 12--Continued | Old Tank Farm | Soil | • Clay cap<br>• Multi-media cap<br>• Diversion of surface runoff<br>• Excavation of contaminated soils and placement in on-site landfill<br>• Treatment of excavated material in an ERCO still |
| | | Surface Water | • Monitoring (currently being implemented) |

# SECTION 4
# DEVELOPMENT AND SCREENING OF ALTERNATIVES

# SECTION 4
# DEVELOPMENT AND SCREENING OF ALTERNATIVES

## 4.1 INTRODUCTION

This section presents the alternatives which have been developed and screened for Sites 3, 4, 5, and 12 at Monsanto Chemical Company, Columbia, Tennessee. For each site, alternatives were developed using technically feasible process options for the media of interest.

The following alternatives were developed for the Old Phosphorus Disposal Area (Site 3), the Phosphorus Slurry Disposal (Site 4), and the No. 1 Pond Disposal Facility (Site 5):

- Alternative 1 - No action with the exception of long term monitoring of groundwater (Sites 3, 4, and 5) and surface water (Site 5).
- Alternative 2 - Excavation of contaminated material, placement of excavated material in the on-site permitted landfill, backfill excavated area with clean fill, cap, regrade, and long-term monitoring of groundwater (Sites 3, 4, and 5) and surface water (Site 5).
- Alternative 3 - Excavation of contaminated material, treatment of excavated material in ERCO still(s), backfill excavated area with clean fill, cap, regrade, and long-term monitoring of groundwater (Sites 3, 4, and 5) and surface water (Site 5).

At Site 3, waste material was buried in drums. Therefore, for Alternatives 2 and 3 the excavation of contaminated material at Site 3 would also include excavation of drums containing waste material.

The following alternatives were developed for the Old Tank Farm (Site 12):

- Alternative 1 - No Action with the exception of long-term monitoring of groundwater and surface water.
- Alternative 2 - Covering the site with either a clay cap or a multi-media cap and long-term monitoring of groundwater and surface water.
- Alternative 3 - Covering the site with either a clay cap or a multi-media cap, extraction of shallow groundwater, treatment of extracted groundwater, and long-term monitoring of groundwater and surface water.

- Alternative 4 - Excavation of contaminated material, placement of excavated material in the on-site permitted landfill, backfill excavated area with clean fill, cap, regrade, and long-term monitoring of groundwater and surface water.
- Alternative 5 - Excavation of contaminated material, treatment of excavated material in ERCO still(s), backfill excavated area with clean fill, cap, regrade, and long-term monitoring of groundwater and surface water.

## 4.2 SCREENING OF ALTERNATIVES

The alternatives for Sites 3, 4, 5, and 12 were screened on the basis of their effectiveness, implementability, and cost. The purpose of screening alternatives was to reduce the number of alternatives which would undergo detailed analysis. The contaminant of concern at each site is elemental phosphorus. The results of screening of alternatives are presented on a site-by-site basis in Subsections 4.2.1, 4.2.2, 4.2.3, and 4.2.4.

### 4.2.1 Old Phosphorus Disposal Area (Site 3)

Alternative 1 for this site recommends No Action with the exception of long-term monitoring of groundwater. The site was covered with a clay cap in 1978. This alternative will not be effective in reducing levels of phosphorus in groundwater. The phosphorus concentration in groundwater, however, has not increased since fourth quarter of 1987. Furthermore, the probability of pathway completion, as indicated in Table 2.14, is very low. This alternative is currently being implemented. The capital and O&M costs for implementing this alternative are low.

Alternatives 2 and 3 would require excavation of contaminated material including drums containing waste material. While this action may result in reduction of source contamination, it will be fraught with difficult safety issues which may impair short-term effectiveness. Also, any phosphorus present in bedrock will not be removed by such an excavation.

The treatment of contaminated material in an ERCO still would require an extremely long time as the still can only handle a small volume (500 gallons) of charge per batch. Also, the cycle time per batch is two days. This operation would require high capital and O&M costs.

The quarterly monitoring data collected since 1987 do not indicate any significant increase in phosphorus concentration in groundwater samples. Based on this evaluation, only Alternative 1 has been retained for a detailed analysis.

### 4.2.2 Phosphorus Slurry Disposal (Site 4)

Alternatives 1, 2, and 3 for Site 4 are similar to Alternatives 1, 2, and 3 for Site 3. The site was covered with a clay cap in 1978.

The quarterly monitoring data collected since 1987 do not indicate any significant increase in phosphorus concentration in groundwater samples. This indicates a low probability of cross-media contamination, i.e., leaching of phosphorus from contaminated soils into groundwater. Therefore, only Alternative 1 has been retained for a detailed analysis.

### 4.2.3 No. 1 Pond Disposal Facility (Site 5)

Alternatives 1, 2, and 3 for Site 5 are similar to Alternatives 1, 2, and 3 for Sites 3 and 4 with the only exception that Alternative 1 for Site 5 also includes long-term monitoring of surface water. The site was covered with a clay cap in 1986.

The quarterly data collected since 1987 do not indicate a consistently increasing trend in phosphorus concentrations in groundwater samples. The lack of an increasing trend in elemental phosphorus concentration suggests that the probability of cross-media contamination is low. The phosphorus concentration in samples collected from Greenlick Creek has always been less than 0.05 ppb since 1987. Based on this evaluation, only Alternative 1 has been retained for a detailed analysis.

### 4.2.4 Old Tank Farm (Site 12)

Alternative 1 for Site 12 consists of No Action with the exception of long-term monitoring of groundwater and surface water. Monsanto has been monitoring groundwater and surface water in accordance with a hydrogeologic monitoring plan since 1987. This alternative does not effectively reduce contaminants at source; however, it serves as an early warning system for migration of elemental phosphorus.

The exposure pathway analysis for this site indicates that there is a possibility of site workers being exposed to elemental phosphorus through inhalation, oral, and dermal routes. Covering the site with a clay cap or a multi-media cap, as indicated in Alternative 2, will prevent site workers from accidental contact with contaminated soils and fugitive dust. Both Alternative 1 and Alternative 2 are implementable. The costs, however, will vary as implementation of Alternative 2 will incur higher capital costs than Alternative 1 because of the cap.

The elemental phosphorus concentration in samples collected from monitoring wells at Site 12 (wells 12-1, 12-2, and 12-4) has always been higher than phosphorus concentration in samples collected from other monitoring wells at Monsanto. Groundwater samples collected quarterly from well 12-2 have contained phosphorus concentrations between 148 ppb (3rd Quarter 1987) and 1,440 ppb (2nd Quarter 1990). The groundwater samples from this well have not exhibited either an increasing or a decreasing trend in phosphorus concentration.

Phosphorus concentrations in groundwater samples collected from wells 12-1 and 12-4 have varied between 0.003 ppb (well 12-1, 1st Quarter 1989) and 265 ppb (well 12-4, 2nd Quarter 1990). The phosphorus concentration in groundwater

samples collected from well 12-4 has steadily increased since Fourth Quarter 1988. The highest phosphorus concentration in samples collected from well 12-4, however, is approximately one-fifth of the highest phosphorus concentration reported for well 12-2.

The shallow groundwater flows from this site towards Greenlick Creek. There are three rows of groundwater monitoring wells between the site and the creek. The quarterly monitoring data collected since 1987 do not indicate consistent increases in phosphorus concentrations in groundwater and surface water samples. This indicates a probable lack of migration of elemental phosphorus in significant quantities along with groundwater towards Greenlick Creek.

Alternative 3 consists of extraction and treatment of shallow groundwater. The implementation of this alternative will be necessary when there are unacceptably high concentrations of elemental phosphorus in Greenlick Creek. Prolonged implementation of this alternative will eventually reduce contamination at the source. The groundwater extracted may be chemically detoxified through oxidation. The proposed treatment of groundwater is effective and reliable. The capital and O&M costs for this alternative will be moderate to high.

Alternatives 4 and 5 are similar to Alternative 3 for Sites 3, 4, and 5. Complete source removal at Site 12 is not feasible as phosphorus has migrated into the bedrock. Also, the depth of overburden at Site 12 is approximately three feet at well 12-2. Packer sampling of deep well 12-9 at Site 12 indicated phosphorus concentrations below detection limit. Samples collected from other deep wells namely, 19-9 and 19-10 also indicated phosphorus concentrations below the detection limit. Implementation of Alternatives 4 and 5 will incur high capital and O&M costs and not achieve complete source removal. Therefore, these alternatives have not been retained for a detailed analysis. Alternative 1, 2, and 3 have been retained for a detailed analysis.

# SECTION 5
# DETAILED ANALYSIS OF ALTERNATIVES

# SECTION 5
# DETAILED ANALYSIS OF ALTERNATIVES

## 5.1 INTRODUCTION

The alternatives retained for Sites 3, 4, 5, and 12 after a screening based on effectiveness, implementability, and cost were analyzed in detail using the following assessment criteria:

- Long-term effectiveness and permanence
- Reduction in mobility, toxicity, or volume through treatment
- Short-term effectiveness
- Implementability
- Compliance with ARARs
- Overall protection of human health and the environment
- Cost

The assessment criteria used for the detailed analysis of alternatives are recommended by the EPA Guidance for conducting RI/FS under CERCLA (EPA 1988). The information obtained from the detailed analysis of alternatives is presented on a site-by-site basis in this section.

## 5.2 OLD PHOSPHORUS DISPOSAL AREA (SITE 3)

Based on screening of alternatives, the alternative retained for this site is comprised of no action with the exception of long-term monitoring of groundwater. The site was covered with a clay cap in 1978.

Table 5.1 presents a detailed analysis of no action with the exception of long-term monitoring of groundwater for Site 3. The media of interest are groundwater and soil. Quarterly monitoring data indicate that phosphorus concentration in groundwater samples has not increased since 1988. The presence of a cap on the site has prevented site workers from direct contact with contaminated material. Therefore, in the event of phosphorus migration in the future, the feasibility of shallow groundwater recovery using a pump and treat system may be examined. For a monitoring period of 10 years the present worth of the cost for this alternative is $15,500.

## TABLE 5.1
## DETAILED ANALYSIS OF ALTERNATIVES
## OLD PHOSPHORUS DISPOSAL AREA - SITE 3
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| LONG-TERM EFFECTIVENESS AND PERMANENCE | |
| **Magnitude of residual risk** | |
| - Soil/direct contact, ingestion, inhalation | Cap will prevent site workers from direct contact with contaminated soil, ingestion of contaminated soil and inhalation of fugitive dust. The current magnitude of residual risk, however, will not be diminished as the contamination source will continue to exist. |
| - Groundwater/current well users | The current magnitude of risk will remain. Monitoring, however, will serve as an early warning of migration of contaminants. Furthermore, the exposure analysis indicates that the probability of pathway completion is very low. |
| **Adequacy and reliability of controls** | Cap will reduce infiltration thereby attenuating the possibility of migration of contaminants present above the groundwater table. No control over elemental phosphorus present below groundwater table. Reliability of a cap can be high if maintained. |
| **Need for periodic reviews** | Review of quarterly monitoring data will indicate the occurrence of contaminant migration. |
| REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT | |
| - Treatment used | None |
| - Reduction of toxicity, mobility or volume | Cap will reduce infiltration thereby reducing mobility of elemental phosphorus present above the groundwater table. No reduction of toxicity, mobility, or volume of elemental phosphorus present below the water table. |
| - Type and quantity of residuals remaining after treatment | Not applicable. |
| SHORT-TERM EFFECTIVENESS | |
| - Community protection | Risk to the community is not increased by implementation of this alternative. |
| - Worker protection | No significant risk to site workers. |

TABLE 5.1--Continued
DETAILED ANALYSIS OF ALTERNATIVES
OLD PHOSPHORUS DISPOSAL AREA - SITE 3
MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| IMPLEMENTABILITY | |
| - Ability to construct and operate | No construction is required. Monitoring has been operational since 1987. |
| - Ability to monitor effectiveness | Review of quarterly monitoring will indicate migration of contaminants. |
| - Ability to obtain approval from regulatory agencies | Monitoring plan has been approved by TDHE. No other approvals are necessary |
| - Availability of technologies | Not applicable |
| COMPLIANCE WITH ARARs | |
| - Chemical-specific ARARs | No ARARs for elemental phosphorus. |
| - Location-specific ARAR | Not Relevant. |
| - Action-specific ARAR | Not applicable. |
| OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT | |
| Human Health Protection | |
| - Soil/direct contact, ingestion, inhalation | Cap will prevent site workers from direct contact with contaminated soil and inhalation of fugitive dust. |
| - Groundwater/current well users | No reduction in the magnitude of risk. The magnitude of risk, however, is minimal because the probability of pathway completion is very low. |
| - Environmental protection | Phosphorus concentration in groundwater samples have not increased consistently since 1988. |
| COST | |
| - Capital | Not applicable. |
| - O&M (annual) | $2,300 |
| - Present worth | $15,500 |

## 5.3 PHOSPHORUS SLURRY DISPOSAL (SITE 4)

The alternative retained for Site 4 is comprised of no action with exception of long-term monitoring of groundwater. This alternative was selected for detailed analysis because the site was covered with a cap in 1978 and quarterly monitoring data collected since 1987 do not indicate any significant increases in phosphorus concentration in groundwater samples.

Table 5.2 presents a detailed analysis of no action with the exception of long-term monitoring of groundwater. As indicated, the magnitude of risk to human health is minimal because the probability of pathway completion is very low. In addition, the cap prevents site workers from direct contact with contaminated material. Regarding environmental protection, elemental phosphorus in groundwater samples collected since 1987 has not exhibited any significant increase. Also, cap reduces infiltration thereby attenuating migration of phosphorus present above the groundwater table. The present worth of the total cost for a 10-year monitoring period is $61,000.

## 5.4 NO. 1 POND DISPOSAL FACILITY (SITE 5)

The alternative retained for Site 5 is similar to the alternatives for Sites 3 and 4. The media of interest at this site are groundwater, surface water, and soil. A detailed analysis of no action with exception of long-term monitoring of groundwater and surface water is presented in Table 5.3. As indicated, the magnitude of residual risk to human health is minimal because the probability of pathway completion is very low. This alternative does not attempt to reduce contamination at source. The quarterly monitoring data obtained since 1987 do not indicate any increasing trends in elemental phosphorus concentration in groundwater and surface water. The present worth of total costs for a 10-year monitoring period is $31,500.

## 5.5 OLD TANK FARM (SITE 12)

A detailed analysis of the alternatives retained for Site 12 after screening is presented in Table 5.4. The three alternatives are: no action with long-term monitoring, capping with long-term monitoring, and capping, pump and treat groundwater along with long-term monitoring.

The phosphorus concentration in groundwater samples do not exhibit a consistently increasing trend (with the exception of well 12-4). Also, the samples collected from the three rows of wells between the site and Greenlick Creek do not exhibit any increasing trends in phosphorus concentrations. This is important because the shallow groundwater flows from the site towards Greenlick Creek. Therefore, the lack of an increase in phosphorus concentration in groundwater samples collected quarterly since 1987 indicates a probable lack of phosphorus migration from the site.

## TABLE 5.2
## DETAILED ANALYSIS OF ALTERNATIVES
## PHOSPHORUS SLURRY DISPOSAL - SITE 4
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| **LONG-TERM EFFECTIVENESS AND PERMANENCE** | |
| **Magnitude of residual risk** | |
| - Soil/direct contact, ingestion, inhalation | Cap will prevent site workers from direct contact with contaminated soil, ingestion of contaminated soil and inhalation of fugitive dust. The current magnitude of residual risk, however, will not be diminished as the contamination source will continue to exist. |
| - Groundwater/current well users | The current magnitude of risk will remain. Monitoring, however, will serve as an early warning of migration of contaminants. Furthermore, the exposure analysis indicates that the probability of pathway completion is very low. |
| **Adequacy and reliability of controls** | Cap will reduce infiltration thereby attenuating the possibility of migration of contaminants present above the groundwater table. No control over elemental phosphorus present below groundwater table. Reliability of a cap can be high if maintained. |
| **Need for periodic reviews** | Review of quarterly monitoring data will indicate the occurrence of contaminant migration. |
| **REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT** | |
| - Treatment used | None |
| - Reduction of toxicity, mobility or volume | Cap will reduce infiltration thereby reducing mobility of elemental phosphorus present above the groundwater table. No reduction of toxicity, mobility, or volume of elemental phosphorus present below the water table. |
| - Type and quantity of residuals remaining after treatment | Not applicable. |
| **SHORT-TERM EFFECTIVENESS** | |
| - Community protection | Risk to the community is not increased by implementation of this alternative. |
| - Worker protection | No significant risk to site workers. |

## TABLE 5.2--Continued
## DETAILED ANALYSIS OF ALTERNATIVES
## PHOSPHORUS SLURRY DISPOSAL - SITE 4
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| **IMPLEMENTABILITY** | |
| - Ability to construct and operate | No construction is required. Monitoring has been operational since 1987. |
| - Ability to monitor effectiveness | Review of quarterly monitoring will indicate migration of contaminants. |
| - Ability to obtain approval from regulatory agencies | Monitoring plan has been approved by TDHE. No other approvals are necessary |
| - Availability of technologies | Not applicable |
| **COMPLIANCE WITH ARARS** | |
| - Chemical-specific ARARs | No ARARs for elemental phosphorus. |
| - Location-specific ARAR | Not Relevant. |
| - Action-specific ARAR | Not applicable. |
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | |
| **Human Health Protection** | |
| - Soil/direct contact, ingestion, inhalation | Cap will prevent site workers from direct contact with contaminated soil and inhalation of fugitive dust. |
| - Groundwater/current well users | No reduction in the magnitude of risk. The magnitude of risk is minimal because the probability of pathway completion is very low. |
| - Environmental protection | Phosphorus concentration in groundwater samples have not increased consistently since 1988. |
| **COST** | |
| - Capital | Not applicable. |
| - O&M (annual) | $9,000 |
| - Present worth | $61,000 |

## TABLE 5.3
## DETAILED ANALYSIS OF ALTERNATIVES
## NO. 1 POND DISPOSAL FACILITY - SITE 5
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| **LONG-TERM EFFECTIVENESS AND PERMANENCE** | |
| **Magnitude of residual risk** | |
| - Soil/direct contact, ingestion, inhalation | Cap will prevent site workers from direct contact with contaminated soil, ingestion of contaminated soil and inhalation of fugitive dust. The current magnitude of residual risk, however, will not be diminished as the contamination source will continue to exist. |
| - Groundwater/current well users | The current magnitude of risk will remain. Monitoring, however, will serve as an early warning of migration of contaminants. Furthermore, the exposure analysis indicates that the probability of pathway completion is very low. |
| - Surface water | Magnitude of risk will not be diminished. However, probability of pathway completion is very low. |
| **Adequacy and reliability of controls** | Cap will reduce infiltration thereby attenuating the possibility of migration of contaminants present above the groundwater table. No control over elemental phosphorus present below groundwater table. Reliability of a cap can be high if maintained. |
| **Need for periodic reviews** | Review of quarterly monitoring data will indicate the occurrence of contaminant migration. |
| **REDUCTION OF TOXICITY, MOBILITY OR VOLUME THROUGH TREATMENT** | |
| - Treatment used | None |
| - Reduction of toxicity, mobility or volume | Cap will reduce infiltration thereby reducing mobility of elemental phosphorus present above the groundwater table. No reduction of toxicity, mobility, or volume of elemental phosphorus present below the water table. |
| - Type and quantity of residuals remaining after treatment | Not applicable. |

TABLE 5.3--Continued
DETAILED ANALYSIS OF ALTERNATIVES
NO. 1 POND DISPOSAL FACILITY - SITE 5
MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| **SHORT-TERM EFFECTIVENESS** | |
| - Community protection | Risk to the community is not increased by implementation of this alternative. |
| - Worker protection | No significant risk to site workers. |
| **IMPLEMENTABILITY** | |
| - Ability to construct and operate | No construction is required. Monitoring has been operational since 1987. |
| - Ability to monitor effectiveness | Review of quarterly monitoring will indicate migration of contaminants. |
| - Ability to obtain approval from regulatory agencies | Monitoring plan has been approved by TDHE. No other approvals are necessary |
| - Availability of technologies | Not applicable |
| **COMPLIANCE WITH ARARS** | |
| - Chemical-specific ARARs | No ARARs for elemental phosphorus. |
| - Location-specific ARAR | Not relevant. |
| - Action-specific ARAR | Not applicable. |

TABLE 5.3--Continued
DETAILED ANALYSIS OF ALTERNATIVES
NO. 1 POND DISPOSAL FACILITY - SITE 5
MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative<br>No Action with the Exception of Long-term Monitoring of Groundwater |
|---|---|
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | |
| **Human Health Protection** | |
| - Soil/direct contact, ingestion, inhalation | Cap will prevent site workers from direct contact with contaminated soil and inhalation of fugitive dust. |
| - Groundwater/current well users | No reduction in the magnitude of risk. The magnitude of risk however, is minimal because the probability of pathway completion is very low. |
| - Surface water | No reduction in magnitude of risk. However, probability of pathway completion is very low. |
| - Environmental protection | Phosphorus concentration in groundwater and surface water samples have not increased consistently since 1988. |
| COST | |
| - Capital | Not applicable. |
| - O&M (annual) | $4,700 |
| - Present worth | $31,500 |

# TABLE 5.4
# DETAILED ANALYSIS OF ALTERNATIVES
# OLD TANK FARM - SITE 12
# MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| **LONG-TERM EFFECTIVENESS AND PERMANENCE** | | | |
| Magnitude of Residual Risk<br>- Soil/Direct contact, Ingestion | The magnitude of residual risk will exist as the contamination source has not been removed. Also, without a cap the probability of pathway completion exists. | Although contamination source has not been removed, covering the site with a cap will prevent site workers from direct contact with contaminated soil and inhalation of fugitive dust. | Cap will prevent site workers from direct contact with contaminated soil and inhalation of fugitive dust. Also, pump and treat will reduce source contamination with time. Complete removal of source contamination is infeasible. |
| - Groundwater/current well users | Magnitude of residual risk will be maintained. Monitoring will serve as an early warning system to detect the migration of contaminants. The probability of pathway completion, however, is low. | Cap will reduce infiltration due to incidental rainfall and surface runoff. Any elemental phosphorous present below the groundwater table will not be affected by the placement of a cap. The magnitude of risk is not diminished. | Cap will reduce infiltration due to incidental rainfall and surface run off. Magnitude of risk will be diminished by a pump and treat system. |
| - Surface Water | Magnitude of residual risk will not be diminished. However, the probability of pathway completion is very low. | Magnitude of residual risk may not be substantially reduced as any phosphorous present below the groundwater table will continue to leach. However, the probability of pathway completion is very low. | Pump and treat system will diminish the magnitude of residual risk. |

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## TABLE 5.4--Continued
## DETAILED ANALYSIS OF ALTERNATIVES
## OLD TANK FARM - SITE 12
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| Adequacy and Reliability of Controls | No control over remaining contaminants. Monitoring will serve as an early warning system to detect contaminant migration. | Cap will control contaminated soil. Reliability of a cap can be high if cap is maintained. No control over elemental phosphorus present below groundwater table. | As in alternative 2, cap will control contaminated soil/bedrock above the groundwater table. Groundwater pump and treat will control extent of contamination. Both process options are reliable. |
| Need for a periodic review | Review of quarterly monitoring data will reveal whether or not contaminant migration is occurring. | Same as in Alternative 1 | Same as in Alternative 1 |
| **REDUCTION OF TOXICITY, MOBILITY, OR VOLUME THROUGH TREATMENT** | | | |
| - Treatment used | None | None | Chemical detoxification of extracted groundwater through oxidation |
| - Reduction of toxicity, mobility, or volume | None | Cap will reduce infiltration thereby reducing mobility of contamination present above the water table. No reduction of toxicity, mobility, or volume of contaminants present below the water table. | Will reduce volume and toxicity through groundwater extraction and treatment |

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## TABLE 5.4--Continued
## DETAILED ANALYSIS OF ALTERNATIVES
## OLD TANK FARM - SITE 12
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| - Type and Quantity of Residuals remaining after treatment | Not applicable | Not applicable | Elemental phosphorus will be oxidized to phosphorus of oxides after treatment of extracted groundwater. |
| **SHORT-TERM EFFECTIVENESS** | | | |
| - Community Protection | Risk to the community not increased by implementation | May result in a temporary increase in fugitive dusts during installation of the cap. | Same as in Alternative 2 |
| - Worker Protection | No significant risk to site workers | Protection required against dermal contact and inhalation of contaminated dust during cap construction. | Same as in Alternative 2 |
| **IMPLEMENTABILITY** | | | |
| - Ability to construct and operate | No construction required. Monitoring has been operational since 1987. | Constructing a cap is feasible. Cap maintenance requirements are manageable. Monitoring in place since 1987. | Construction of a cap and groundwater pump and treat system are feasible. Operation of treatment system is feasible. Monitoring in place since 1987. |
| - Ease of implementing more action if necessary | If monitoring indicates migration of contaminants implement Alternative 3. | Same as in Alternative 1. | Simple to extend groundwater extraction system if necessary. Additional treatment capacity may be required. |

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## TABLE 5.4--Continued
## DETAILED ANALYSIS OF ALTERNATIVES
## OLD TANK FARM - SITE 12
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| - Ability to monitor effectiveness | Review of quarterly monitoring data will indicate migration of contaminants. | Same as in Alternative 1. | Same as in Alternative 1. |
| - Ability to obtain approval from Regulatory Agencies | Monitoring plan has been approved by TDHE. No other approvals are necessary. | Same as in Alternative 1. | NPDES permit may be required for discharge of treated groundwater. Facility already has a NPDES permit for discharge from treatment plant. |
| - Availability of Technologies | None required | Cap technology readily available | Technology for pump and treatment system is well developed. |
| **COMPLIANCE WITH ARARs**<br>- Chemical specific ARARs | No chemical specific ARAR exists for phosphorus concentration in groundwater. Exposure analysis of this site, however, indicates that the probability of pathway completion for contaminants in groundwater is virtually nonexistent. | Same as in Alternative 1 | Will reduce concentration of elemental phosphorus in groundwater. |
| - Location-specific ARARs | Not relevant. There are no location specific ARARs. | Same as in Alternative 1. | Same as in Alternative 1. |
| - Action-specific ARARs | Not applicable | Must meet RCRA requirements for a cap. | Must meet RCRA requirements for a cap and NPDES requirements for discharge of treated groundwater. |

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TABLE 5.4--Continued
DETAILED ANALYSIS OF ALTERNATIVES
OLD TANK FARM - SITE 12
MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| - To Be Considered. Phosphorus criteria for toxicity published in EPA Water Quality Criteria (0•1 ppb) | Criteria not relevant to phosphorus concentration in fresh water environment. Also not relevant to phosphorus concentration in groundwater samples. | Same as in Alternative 1. | Same as in Alternative 1. |
| **OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT** | | | |
| Human Health Protection | No reduction in risk. | Cap will prevent site workers from direct contact with contaminated soil and inhalation of fugitive dust. | Same as in Alternative 2. |
| - Soil/direct contact, ingestion, inhalation | | | |

## TABLE 5.4--Continued
## DETAILED ANALYSIS OF ALTERNATIVES
## OLD TANK FARM - SITE 12
## MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| - Groundwater/current well users | No reduction in the magnitude of residual risk. Exposure analysis, however, indicates that probability of pathway completion is very low as shallow groundwater flows into Greenlick Creek. | Cap will reduce infiltration due to incidental rainfall and surface runoff. There will be no significant reduction in risk due to any phosphorus present below the groundwater table. Exposure analysis, however, indicates that probability of pathway completion is very low. | Pump and treat will reduce phosphorus concentrations in groundwater thereby reducing the magnitude of residual risk. Exposure analysis, however, indicates that probability of pathway completion is very low. Therefore, unless there is evidence of phosphorus migration from the site, the reduction in magnitude of risk due to the implementation of this alternative may not be significant as compared to Alternative 2. |
| - Surface water | Exposure analysis indicates that probability of pathway completion is very low. | Same as in Alternative 1. | Same as in Alternative 1. |

TABLE 5.4--Continued
DETAILED ANALYSIS OF ALTERNATIVES
OLD TANK FARM - SITE 12
MONSANTO CHEMICAL COMPANY, COLUMBIA, TENNESSEE

| Assessment Criteria | Alternative 1<br>No action with the exception of long-term monitoring of groundwater and surface water | Alternative 2<br>Covering the site with a cap and long-term monitoring of groundwater and surface water. | Alternative 3<br>Covering the site with a cap, pump and treat shallow groundwater, and long-term monitoring of groundwater and surface water. |
|---|---|---|---|
| - Environmental Protection | Will not attenuate any migration of elemental phosphorus. Quarterly monitoring of groundwater and surface water will serve as an early warning system for migration of elemental phosphorus. | Cap will partially attenuate the migration of elemental phosphorus because it will minimize infiltration due to incidental rainfall and surface runoff. Phosphorus present below the groundwater table will have an opportunity to migrate. | Migration of elemental phosphorus will be attenuated by both the cap and the pump and treat system. Quarterly monitoring data collected since 1987 was not indicated a consistent increase in phosphorus concentration except in samples collected from Well 12-4. If migration of phosphorus is ascertained, then implementation of this alternative will have significant benefits over Alternatives 1 and 2. |
| COST | | | |
| - Capital | Not Applicable. | $336,000 (clay cap)<br>$840,000 (multi-media cap) | Alternative 2 plus cost of pump and treat system. |
| - O&M (Annual) | $18,800 | $24,800 | Alternative 2 plus cost of pump and treat system. |
| - Present worth | $126,000 | $1,428,000 (clay cap)*<br>$1,932,000 (multi-media cap)* | Alternative 2 plus cost of pump and treat system. |

*Present worth includes expenditures to date ($925,000).

Complete source removal through implementation of any alternative is infeasible because of the following reasons:

- phosphorus has migrated into the bedrock
- any attempt to remove phosphorus from the bedrock will entail the likelihood of phosphorus migrating deeper into the bedrock.

Covering the site with a cap and implementing a pump and treat system for contaminated groundwater will lead to a reduction in the magnitude of residual risk to human health and the environment. Selection between Alternatives 2 and 3 should be based on evidence of phosphorus migration from the site. Based on the information available to date, Alternative 2 is the recommended alternative for Site 12. In the event of phosphorus migration from the site, Alternative 3 will be the preferred alternative.

As discussed in Subsection 1.2.1, Monsanto has placed a clay cap on the area (approximately seven acres) located east of Site 12 towards Greenlick Creek. The expenditures to date for capping the seven-acre area is approximately $850,000. The majority of the phosphorus handling area (approximately one acre) is covered with concrete and asphalt. The estimated cost for covering the remaining part of the phosphorus handling area with concrete and asphalt is approximately $75,000. After termination of phosphorus drumming operations, the phosphorus handling area will be brought to grade and covered with a clay cap. Therefore the total area to be covered with a clay cap is approximately five acres (four acres at Site 12 and one acre at phosphorus handling area). The cost estimate (Appendix D) for covering Site 12 and phosphorus handling area reflects only five acres. The maintenance cost, however, has been estimated for the entire twelve acres.

The present worth of the costs for Alternatives 1 and 2 are $126,000 and $1,428,000. If a multi-media cap is selected instead of a clay cap then the present worth of Alternative 2 is $1,932,000.

Monsanto has historically utilized clay caps on-site to minimize infiltration and worker exposure. In comparison with a clay cap, the use of a multi-media cap at Site 12 would not result in any incremental benefit of reducing elemental phosphorus leaching to the shallow groundwater. Also, as indicated by the present worth of the costs a multi-media cap will be approximately 0.5 million dollars more expensive than a clay cap. Therefore, a clay cap with a modified concrete portion in the vicinity of the railroad and drumming areas is recommended.

# SECTION 6
# CONCLUSIONS

# SECTION 6
# CONCLUSIONS

Based on the HE/RA study of Sites 3, 4, 5, and 12, the following conclusions were inferred:

- Analysis of groundwater samples collected from deep wells do not indicate the presence of phosphorus above detection limit (8 parts per trillion) in deep groundwater.
- The observed response in deep wells during the 48-hour pump test is characteristic of a fracture-flow system. Transmissivities for the deep fracture bedrock flow system ranged from 115 to 130 gallons per day per foot (gpd/ft). The vertical hydraulic conductivity ranged from $6.6 \times 10^{-4}$ to $1.8 \times 10^{-3}$ gallons per day per square feet (gpd/ft$^2$).
- There was no significant response in any of the shallow monitoring wells at Site 12 during the pump testing of deep wells. This indicates phosphorus in the overburdened and shallow bedrock are unlikely to migrate deeper into bedrock.
- Complete source removal is infeasible at Site 12 because phosphorus has migrated into the shallow bedrock and any attempt to recover phosphorus from the shallow bedrock will only drive the phosphorus deeper.
- A combined clay and concrete cap with long-term monitoring of groundwater and surface water is the preferred alternative for Site 12.
- If quarterly monitoring data for Site 12 indicates migration of elemental phosphorus towards Greenlick Creek, then a pump and treat system for remediation of contaminated groundwater may be needed.
- No action with long-term monitoring of groundwater is the preferred alternative for Sites 3 and 4.
- No action with long-term monitoring of groundwater and surface water is the preferred alternative for Site 5.

# REFERENCES

# REFERENCES

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# APPENDIX A
# DRILLING, DECONTAMINATION, WELL CONSTRUCTION, AND TESTING PROCEDURES
# MONSANTO CHEMICAL COMPANY
# COLUMBIA, TENNESSEE

# APPENDIX A
# DRILLING, DECONTAMINATION, WELL CONSTRUCTION, AND TESTING PROCEDURES
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All three wells were conventionally cored from the top of bedrock to total depth. Core data and the results of geophysical logging of well 12-9, were used to establish the relative depths and thicknesses of the various limestone formations penetrated by the deep wells. The conventional core was also used to identify secondary openings in the rock including fractures and solution features. These openings represent possible water entry zones in the wells. Identifying these zones provided data which was useful in determining screen depth intervals and, in the case of well 12-9, determining which intervals to later isolate with packers and sample. The locations of the three new monitoring wells are shown in Figure 2.1. Unless otherwise specified, all depths referred to in the following text are measured from the ground surface.

Several safety measures were undertaken to provide personnel with protection from exposure to elemental phosphorus during drilling operations. Rainsuits with hoods were worn by all personnel involved during drilling and coring operations. Other personal safety equipment included face shields, gloves, safety glasses, ear plugs, and steel toed boots. A large trough of water suitable for immersing the entire body was positioned next to the drilling rig in case of accidental exposure to phosphorus. Water hoses were available for spraying off exposed personnel and contaminated tools. A portable eye washing station was available at all times. After one member of the drilling crew experienced heat exhaustion due to wearing rain suits in the hot weather, the decision was made to work at night to minimize heat stress.

Special measures were undertaken to prevent accidental phosphorus contamination of deeper portions of the new wells from contaminated tools and equipment. After a deep isolation casing was set in each well, complete decontamination of all drilling equipment including the drilling rig was performed using a high pressure steam cleaner prior to drilling the final portion of the hole. The area around each well location was prepared to avoid any accidental contamination by setting wooden pallets around the well to walk on and to lay drilling equipment on. Additionally, wash tubs for cleaning and rinsing work boots

were set up and used by all personnel prior to approaching the well. No equipment was allowed to touch the ground. The wells were sealed with fresh plastic at the end of each working period to avoid any airborne contamination.

The drilling contractor for this project was Miller Drilling, Inc. of Lawrenceburg, Tennessee. Miller Drilling also supported ES during the packer sampling and pump test operations.

## A.1 MONITORING WELL 19-10

Monitoring well 19-10, located near Greenlick Creek (Figure 2.1), was drilled to a depth of 111 feet. Using mud rotary a 12-inch hole was drilled through the overburden, which consisted of alluvium and roadfill, to a depth of 19.5 feet where competent bedrock was encountered. The well was drilled an additional 1.5 feet into bedrock and a 6-inch temporary steel casing was set.

Coring operations began at this point and a 4-inch conventional core was obtained from 21 feet to 58 feet. The onsite ES geologist examined and described the core. While reaming the hole to 10 inches, the well experienced a serious lost circulation problem. A decision was made to run a 10-inch casing to 20 feet and cement grout the lower open hole and the 10 inch casing in place. After the grout cured, the hole was reamed to 58 feet. A 6-inch casing was installed in the hole and cement grouted in place. All equipment including the drilling rig were then moved to the Decon Area for decontamination using a high pressure steam cleaner. The equipment was brought back to the drill site, the grout was drilled out from inside the 6-inch casing and the well was flushed with fresh water until the returns were clear.

Coring was resumed and the well was conventionally cored from 58 feet to 88 feet. The onsite ES geologist described and examined the core. After switching the swivel to filtered air and noting the well was not making any water, the decision was made to continue drilling with the air rotary to 110 feet. At 93 feet, the well appeared to be making about 0.5 gallon/minute. At 111 feet, the well was making about 10 gallons/minute and the decision was made to stop drilling. The drilling rig and equipment were then moved to the Decon Area for decontamination. The decontaminated equipment was then moved to Site 12.

While waiting for the grout to cure in the 12-inch surface casing of well 12-9, the drilling personnel returned to well 19-10 to install the final casing. A two-inch PVC screen and riser were installed by hand in well 19-10 with the screened interval set from 90.3 feet to 110.3 feet and the riser set from 90.3 to the surface with a 3.2 foot stickup. The well was sand packed from 110.3 feet to 86.6 feet and an 8.1 feet dry bentonite seal was installed on top of the pack. The remainder of the casing was grouted in place with a cement grout.

## A.2 MONITORING WELL 12-9

Monitoring well 12-9, located in Site 12 near the former location of the phosphorus storage tanks (Figure 2.1), was drilled to a depth of 225 feet. The well will be plugged back with cement grout to a depth of 130 feet.

Using mud rotary, an 8-inch hole was drilled through the overburden to about 3 feet where significant phosphorus was encountered. Sparking and smoking cuttings were quite abundant. A phosphine drager tube sample and pH paper sample were collected from directly over and in the mud tub. Phosphine concentrations were in the 0.2 to 0.4 ppm range and pH was 7 to 7.5. A high velocity fan was installed in the area owing to the observed phosphine concentration. After setting up the fan, a breathing zone drager tube sample was collected and no detectable phosphine concentration was noted. Drilling was resumed, and at 3.5 feet, the top of bedrock was encountered. The well was deepened to 6 feet and reamed to 14½ inches. Some loss of drilling fluid was experienced during this initial drilling and reaming. Drilling fluid runoff flowed directly into a collection ditch which led to a sump located nearby. The wastewater collected in the sump is treated at the Monsanto wastewater treatment facility which is located within the facility boundaries. Twelve-inch casing was set at 6 feet and cement grouted in place. The grout was allowed to cure, then drilled out from inside the 12-inch casing.

Coring operations, were initiated and a 4-inch conventional core was obtained from 6 feet to 46 feet. The on-site ES geologist examined and described the core. The well was drilled with a 9½ inch roller cone bit for an additional 4 feet and a 6-inch steel casing was set at 50 feet, then cement grouted in place. The grout was allowed to cure, then drilled out from inside the 6-inch casing. The hole was flushed with clean water. At this point, all equipment was moved to the Decon Area for decontamination. The drilling rig was steam cleaned at the drill site. Runoff was collected in the collection ditch and discharged into the sump. The decontaminated drilling equipment was returned to the drill site.

Coring was resumed and the well was conventionally cored from 50 feet to 140 feet. The core was examined and described by the on-site ES geologist. After switching the swivel to filtered air and noting the well was not making any water, a decision was made to continue drilling with the air rotary until measurable water was detected.

The well was drilled to 222 feet, stopping every 20 feet and attempting air development. At 222 feet, the well was allowed to recover until the next day. Upon returning, the water level was measured (inside 4½ drill pipe) and was found to be approximately 62 feet below the ground surface. As no conventional core was obtained from 140 feet to 222 feet, a 3-foot core from 222 feet to 225 feet was obtained to determine what formation was present and to describe any water entry zones which may exist. After coring, the drilling rig and equipment were moved to the Decon Area for decontamination. The equipment was then moved to the 19-9

drill site. Monitoring well 12-9 was left with a 6-inch open hole from 50 feet to 225 feet to facilitate packer sampling operations which were performed after completion of well 19-9.

### A.2.1 Geophysical Logging of Well 12-9

A series of geophysical logs were run in well 12-9 to establish the relative depths and thicknesses of the various limestone formations which were penetrated and to identify possible fracture zones suitable for groundwater sampling. Data from logs which included a caliper log, gamma ray log, and electric resistivity log was used in conjunction with the conventional core data to identify possible fracture zones.

P.E. La Moreaux and Associates ran the logs for well 12-9 under the supervision of the onsite ES geologist. All logging tools and the wireline were thoroughly decontaminated with Liquinox and deionized water before and after logging.

The caliper log (Figure 2.2) indicates a series of washouts occurring from 75 feet to 89 feet, 136 feet to 145 feet, and from 182 feet to 220 feet. These washouts are minor ranging from 0.1 feet to 0.5 feet over gauge size, which is 6 inches. The washouts are believed to occur during drilling, the result of hydraulic stresses in less competent rock. Conventional core data suggests the rock is less competent due to fracturing or jointing and advanced solution channelling. There is a good correlation between where the washouts occurred and where the less competent rock was observed in core (Figure 2.2). Less competent rock also forms the primary pathways for groundwater movement as evidenced by the results from the packer sampling of these zones which is discussed in the next section.

The electric resistivity log (Figure 2.2) indicated the depths and thicknesses of the various formations penetrated by the well. The contact between the Hermitage Formation and the Carters Formation is clearly indicated at 85 feet where the resistivity of both the 64-inch and 16-inch curves increases dramatically from about 10,000 ohms in the Hermitage to over 30,000 ohms in the Carters. At 153 feet, the resistivity on both curves drops again to less than 10,000 ohms at the probable contact between the Carters Formation and the Lebanon Formation. The upper contact between the Hermitage and the Carters on the electric log is confirmed by the conventional core data which indicates a very sharp change in lithology at similar depth (within 1 foot). The lower contact between the Carters and the Lebanon on the electric log was not substantiated by coring data as cores were obtained from 140 to 222 feet. However, the 3-foot conventional core taken from 222 to 225 feet exhibited similar lithologic properties as the Lebanon Formation. Both the Hermitage and Lebanon Formations are interlayered limestone and calcareous shale units, which typically would exhibit suppressed resistivity due to the relatively high shale content in the rock (20 to 30%) because shale is a good electrical conductor relative to limestone. The Carters Formation, on the other hand, is a dense limestone unit with almost no shale and would

typically exhibit very high resistivity. Based on the electric log the Carters Formation is 68 feet thick in well 12-9.

The gamma ray log in well 12-9 was unusable as it indicated no change in response due to a suspected problem with the tool calibration.

### A.2.2 Packer Sampling of Well 12-9

Inflatable packers were used to isolate and sample groundwater from discrete fracture zones in monitoring well 12-9. A two-inch submersible pump was used for purging and sampling the packer isolated zones. Unless otherwise noted, the sample was taken directly from the end of the pump hose after purging.

Packer sampling was attempted on four zones (Figure 2.2). Three were successful and one was dry. After sampling each zone (Zone B was dry) the pump was decontaminated by pumping a minimum of 15 gallons of deionized water through it. The hose was decontaminated by washing with Liquinox soap and water and rinsing with deionized water. Additionally, the hose was washed and rinsed with sponges as the pump was lowered in the well prior to sampling.

Zone A (Figure 2.2) straddles the contact between the Hermitage and the Carters Formations and was the most prolific groundwater producing zone. During sampling the zone yielded about 0.6 gallons/minute. As mentioned in the previous section, both the caliper log and core data indicated this zone was probably a good groundwater entry zone due to the fracturing and solution channelling in the rock. A total of 95 gallons or nearly 10 volumes was purged prior to sampling. The 10 volumes were purged before the pH stabilized indicating that the groundwater was coming directly from the adjacent bedrock and was not being influenced by mixing effects from shallower groundwater.

After the water column in Zone B (Figure 2.2) were pumped out the zone was dry. Zone B is situated in the Carter's Formation. After one hour it was still dry. Apparently fractures and solution channels and cavities observed in the core did not possess any lateral continuity. Although the caliper log did not indicate any washouts in this zone, an attempt was made to sample the zone anyway because of the positive core data.

Zone C (Figure 2.2) in the Carters Formation was sampled successfully. After purging 36 gallons (1 volume = 21 gallons) the pump failed. At this point pH had nearly stabilized. During purging the zone yielded about 0.04 gallons/minute. A bailer was used to continue purging. The plan was to continue bailing until at least 2 well volumes had been purged. After an additional 1.5 gallons had been purged the nitrogen line to the packers ruptured and the packers deflated. Since the hydraulic seal was gone the decision was made to use the final 1.5 gallons of purged water for the sample. The pump was repaired and thoroughly decontaminated using the procedure previously described, then used to prepare the filtered samples for analysis.

Zone D (Figure 2.2) in the Lebanon Formation was sampled successfully after modifying the depth interval. Because Zone D extended from 182 to the bottom of the hole, only one packer was used to hydraulically isolate Zone D from the rest of the hole. After 21 gallons (1 volume = 76 gallons) was purged the yield from Zone D dropped to about .013 gallons/minute. Due to the extremely slow recharge rate, the decision was made to move the packer downhole to 220 feet and purge and sample the very bottom of the hole. Doing this substantially reduced the necessary wellbore volume required for purging purposes. As the pump failed again, a decision was made to bail one complete volume (39 gallons) from the well and sample. After approximately 13 hours and 149 bailing runs, the well was sampled successfully. The sample was taken to the Monsanto laboratory for analysis.

## A.3 MONITORING WELL 19-9

Monitoring well 19-9 is located near Greenlick Creek (Figure 2.1). An original hole (19-9A) was abandoned after numerous attempts to retrieve a broken cone from the hole were unsuccessful. The cone was lost during a 6-inch reaming run at about 29 feet. One 10-foot conventional core from 19 to 29 feet was recovered prior to losing the cone. After grouting and abandoning the original hole, the drilling rig was moved about 5 feet south and a new well, 19-9 was started. Well 19-9 was drilled to a depth of 103 feet.

Using mud rotary a 12-inch hole was drilled through the overburden to a depth of 16 feet where competent bedrock was encountered. The well was drilled an additional 1 foot into bedrock, then reamed to 14½ inches. A 12-inch casing was set at 17 feet and cement grouted in place. The grout was allowed to cure, then drilled out from inside the 12-inch casing. The hole was drilled with mud rotary to 29 feet.

Coring operations began at this point and a 4-inch conventional core was obtained from 29 feet to 58 feet. The onsite ES geologist examined and described the core. The hole was reamed to 11-7/8 inches and 10-inch casing was set at 58 feet and cement grouted in place. The drilling equipment was then moved to the Decon Area for decontamination. Because of the very low levels of phosphorus detected in nearby monitoring wells, it was decided that the drill rig could be steam cleaned on location without creating a contaminant problem from the steam cleaner runoff. Two rinsate samples were collected from the rig during steam cleaning and analyzed by Monsanto for phosphorus. Phosphorus concentration detected in the rinsate samples was below its detection limit (0.008 ppb). The grout was drilled from inside the 10-inch casing, and the well was flushed with fresh water until the returns were clear.

Coring was resumed and the well was conventionally cored from 58 feet to 103 feet. The swivel was switched to filtered air to see if the well would make water. The well appeared to be making about 1 gallon/minute. The decision was made to

stop the well at this point. The hole was reamed to 9½ inches. After air development, 6-inch PVC blank, screen, and riser were installed to 102.0 feet. Blank was set from 102.0 feet to 92.0 feet. The screen was set from 92.0 feet to 72.0 feet and a 6 inch riser was set from 72.0 feet to the ground surface with a 4.0 feet stick up. The well was sand packed from 103.0 feet to 65.8 feet and an 8.0 feet dry bentonite seal was installed on top of the rock. The remainder of the casing was cement grouted in place. The drill rig and all the equipment were moved to the Decon Area for decontamination before the drilling contractor left the site.

## A.4 CONVENTIONAL CORING

As described in the previous sections, the three new monitoring wells were conventionally cored from the top of competent bedrock to total depth of 103 feet, 110 feet, and 225 feet. The cores were used to determine formational contacts and thicknesses and to describe secondary openings in the rock such as fractures, joints, solution channels, and cavities.

A stratigraphic section for well 12-9 is provided in Figure 2.3 which describes the lithologies and textures observed in the three formations. The lithologic descriptions provided for well 12-9 are representative of the core examined in the other two wells. The Hermitage Formation was lithologically consistent in the three wells and is best described as interbedded light grey to light blue, fossiliferous fine to very grained limestone and dark grey, micritic shale. A number of textural variations occur vertically within the formation (Figure 2.3). Shale interbeds are typically thinner than the limestone beds. Total shale in the Hermitage ranges from 10 to 30 percent. Common secondary openings of hydrogeologic significance include narrow bedding plane fractures, vertical fractures or joints, and poor to moderately developed solution cavities. Fractures and joints are often filled with secondary calcite and gypsum.

The Carters Formation was lithologically very consistent in the three wells and is best described as cream to light grey, fine to very fine grained limestone with mottled bands of light brown, fine grained, sugary dolomite. The mottled texture appears to be the result of worm burrowing which occurred shortly after deposition. Chert is a common accessory mineral. The Carter's lithology is very consistent vertically. Total shale in the Carters Formation is less than one percent. Common secondary openings include solution cavities and to a lesser extent vertical and bedding plane fracturing and jointing. Fractures and joints are often filled with secondary minerals in a fashion analogous to the Hermitage Formation.

The fracturing mostly occurs at the contact between the Hermitage and Carters Formation and appears to provide a good pathway for groundwater movement. Further discussion of the hydrogeologic significance of this contact is provided Sections 2.3 and 2.6.

The Lebanon Formation, where observed, is best described as interbedded light blue, fine grained limestone and dark grey micritic shale. The Lebanon is very similar to the Hermitage as both are interlayered limestone and shale units. Three feet of core from the Lebanon was recovered and described from well 12-9. The Lebanon was not reached in Well 19-9. Well 19-10 was cored to 88 feet below ground surface. Based on core data from well 19-9, Well 19-10 should have penetrated the Carters Formation at approximately 75 feet; but it did not. Additionally, no change in the appearance of the cuttings was noted as the well was drilled to its total depth of 111 feet. This change, when it occurs, is quite distinctive. Two possible explanations exist which can explain the absence of the Carters in well 19-10. The first explanation is that the Carters is faulted out. This is unlikely due to the regional geologic setting and the general lack of faulting observed in road cuts and other outcrops in and around the Monsanto and the Columbia area. The second more likely explanation is that most or all of the Carters was eroded away prior to deposition of the Hermitage. As mentioned earlier, the contact between the two formations is erosional in nature. In the vicinity of well 19-10 the erosion was apparently much more extensive.

# *APPENDIX D*
# COST ESTIMATES FOR REMEDIAL ALTERNATIVES
# MONSANTO CHEMICAL COMPANY
# COLUMBIA, TENNESSEE

# APPENDIX D
# COST ESTIMATES FOR REMEDIAL ALTERNATIVES
# MONSANTO CHEMICAL COMPANY
# COLUMBIA, TENNESSEE

## C.1 COST ESTIMATES FOR SITES 3, 4, AND 5

The recommended alternative for Sites 3, 4, and 5 is comprised of long-term monitoring of groundwater and surface water (only at Site 5). The cost estimate for implementing this alternative at each site was prepared on the basis of the following assumptions:

- Sampling of monitoring wells at Sites 3, 4, and 5 will be performed during the same sampling event.
- Labor and analytical costs will be proportioned to each site based on the ratio of number of monitoring wells at the site to the total number of monitoring wells sampled during the sampling event.
- Analytical Cost for QC samples will be divided equally among sites.
- The duration of each sampling event will be 2 days. Four such sampling events will be conducted each year.
- Sampling team will consist of two individuals.
- Parameters include pH, temperature, specific conductivity, lead, chromium, arsenic, cyanide, fluoride, soluble $PO_4$, and elemental phosphorus.
- Analytical cost per sample (including sample container and preservative costs) is approximately $225.00.
- Monitoring will continue for 10 years
- Interest Rate = 8%

**Annual Labor Costs**

Labor Cost = 2 persons x 2 days/event x 10 hrs/person-day x $50/hr.
= $2000/event

Yearly Labor Cost = $2000/event x 4 events/year
= $8,000/year

**Annual Analytical Costs**

Analytical Cost = $225/Sample x 8 samples/event x 4 events/yr
= $7,200/year

Total Labor and Analytical Cost per annum = $15,200
Contingency (5% of Total Cost) = $800

| | | |
|---|---|---|
| TOTAL ANNUAL COST | = | $16,000 |

| | | |
|---|---|---|
| ANNUAL COST FOR SITE 3 | = | $2,300 |
| ANNUAL COST FOR SITE 4 | = | $9,000 |
| ANNUAL COST FOR SITE 5 | = | $4,700 |

Capital Cost for each site is negligible as monitoring program is currently in place.

| | | |
|---|---|---|
| PRESENT WORTH (P/A, i = 8%, n=10) for Site 3 | = | $15,500 |
| PRESENT WORTH (P/A, i = 8%, n = 10) for Site 4 | = | $61,000 |
| PRESENT WORTH (P/A, i = 8%, n = 10) for Site 5 | = | $31,500 |

## C.2 COST ESTIMATES FOR SITE 12

The following alternatives for Site 12 were retained for a detailed analysis:

- Alternative 1 - No Action with the exception of long-term monitoring of groundwater and surface water.
- Alternative 2 - Covering the site with either a clay cap or a multi-media cap and long-term monitoring of groundwater and surface water.
- Alternative 3 - Covering the site with either a clay cap or a multi-media cap, extraction of shallow groundwater, treatment of extracted groundwater, and long-term monitoring of groundwater and surface water.

### C.2.1 Cost Estimate for Alternative 1

A cost estimate has been developed using the assumptions outlined in Subsection C.1. For this site, the monitoring cost does not need to be proportioned.

**Annual Labor Cost**

Labor Cost = 2 persons x 2 days/event x 10 hours/person-day x $50/hour
= $2000/event

Yearly Labor Cost = $2000/event x 4 events/year
= $8000/year

**Annual Analytical Cost**

Yearly Analytical Cost = \$225/Sample x 1 sample/event x 4 events/year
= \$9,900

Contingency (5% of total cost) = \$895

| TOTAL ANNUAL COST = \$18,800 |
|---|

| PRESENT WORTH (P/A, i = 8%, n=10) = \$126,000 |
|---|

## C.2.2 Cost Estimate for Alternative 2

Total Annual Cost for Monitoring = \$18,800

**Capping Cost** (Approximate Area = 5 acres)

Assumptions

Unit Costs:

Clay Cap = \$8.50/yd$^3$ (ES Files)
Surface Liner (Synthetic) = \$1.25/ft$^2$ (ES Files)
Geotextile Fabric = \$1.5/yd$^2$

| | | |
|---|---|---|
| Appurtenances | = | 20% of construction cost |
| Supervision and Administration | = | 8% of construction cost |
| Engineering and Design | = | 10% of construction cost |
| Bid Contingency | = | 15% of construction cost |
| Change Orders and Claims | = | 10% of construction cost |

**Clay Cap**

Cap Construction Cost = 5 acres x 43,560 ft$^2$/acre x 3 ft x $\frac{1\ yd^3}{27\ ft^3}$ x \$8.50/yd$^3$

| | | |
|---|---|---|
| | = | \$205,700 |
| | ≃ | \$206,000 |
| Appurtenances | = | \$41,200 |
| Supervision & Administration | = | \$16,500 |
| Engineering & Design | = | \$20,600 |
| Bid Contingency | = | \$30,900 |
| Change Orders & Claims | = | \$20,600 |
| TOTAL CAPITAL COST | = | \$335,800 |
| | ≃ | \$336,000 |

| | | |
|---|---|---|
| Annual O&M Cost for Cap Maintenance | = | $500/acre x 12 acres |
| | = | $6,000 |
| Total Annual O&M Costs | = | $18,800 + $6,000 |
| | = | $24,800 |

| |
|---|
| TOTAL CAPITAL COST = $336,000<br>ANNUAL O&M COSTS = $24,800 |

Present Worth = $336,000 + A (P/A, i = 8%, n=10)

= $336,000 + 24,800 (P/A, i = 8%, n=10)

= $336,000 + 167,000

= $503,000

| |
|---|
| PRESENT WORTH OF COSTS FOR ALTERNATIVE 2 (CLAY CAP) = $503,000 |

**Multi-Media Cap**

Cap Construction Cost = Cost of Clay Cap + Cost of Fabric + Cost of Synthetic Liner

= $206,000 + $36,300 + $272,250

= $514,550

≈ $515,000

| | | |
|---|---|---|
| Supervision and Administration | = | $41,200 |
| Engineering & Design | = | $51,500 |
| Bid Contingency | = | $77,300 |
| Change Orders & Claims | = | $51,500 |
| Appurtenances | = | $103,000 |
| Total Capital Cost | = | $839,500 |
| | ≈ | $840,000 |
| Annual O&M Cost for Cap Maintenance | = | $500/acre x 12 acre |
| | = | $6,000 |

Present Worth of Cost = $840,000 + 20,800 (P/A, i = 8%, n=10)

= $840,000 + 167,000

= $1,007,000

| PRESENT WORTH OF COST FOR A MULTI-MEDIA CAP = $1,007,000 |
|---|

### *C.2.3 Cost Estimate for Alternative 3*

The cost estimate for Alternative 3 includes the cost for covering the site with a cap and the cost for a pump and treat system for groundwater. The cost estimate for covering Site 12 with a cap is same as the cost estimate for Alternative 2. The cost estimate for a pump and treat system for contaminated groundwater will be prepared on the basis of a design of a well recovery system. The well recovery system will be designed if quarterly monitoring data indicates the occurrence of contaminant migration from Site 12. Consequently, the cost estimate for a pump and treat system will be prepared in conjunction with the design of a well recovery system.

# APPENDIX E
# PROCEDURE FOR ESTIMATING METHOD DETECTION LIMIT FOR PHOSPHORUS IN WATER SAMPLES

# APPENDIX E
# PROCEDURE FOR ESTIMATING METHOD DETECTION LIMIT FOR PHOSPHORUS IN WATER SAMPLES

The elemental phosphorus content in groundwater samples was determined with a Varian Model 3700 Gas Chromatograph equipped with packed column and flame photometric detector. The analytical method detection limit was determined as follows.

Sample standards of iso-octane containing various concentrations of elemental phosphorus were processed through the chromatograph to determine the lowest elemental phosphorus concentration which produced a distinct, measurable, and repeatable peak. An elemental phosphorus concentration of 0.1 parts per billion (ppb) was determined to be the lowest concentration which produced the above mentioned condition. To maximize the sensitivity of the analytical method, elemental phosphorus from groundwater samples was concentrated through extraction with iso-octane. Ninety milliliters of each groundwater sample was placed with 10 milliliters of iso-octane and agitated vigorously to allow absorption of the phosphorus into the iso-octane. The iso-octane was then withdrawn and analyzed with the gas chromatograph. With the chromatograph detection limit of 0.1 ppb the minimum detection limit for phosphorus in the groundwater samples calculates to 8.0 parts per trillion (ppt.)

Chromatograph elemental phosphorus peaks of less than 0.1 ppb phosphorus concentration appear repeatable but are difficult to distinguish. Groundwater phosphorus concentrations equivalent to these peaks have been reported in the quarterly monitoring data.

NFO

REFERENCE 9

# STATE OF TENNESSEE
# DIVISION OF SUPERFUND
# RECORD OF DECISION

Remedial Alternative Selection
for
Monsanto Chemical Company
Site ID # 60-534

## I. SITE:

Monsanto Chemical Company, Maury County, Tennessee

## II. DOCUMENTS REVIEWED:

- Site Investigation, Engineering Science, December 1985
- Hydrologic Monitoring Report, ES, October 1986
- Supplementary Site Investigation-Site 20, ES, September 1986
- Ground-Water Investigation, ES, May 1986
- Supplementary Site Investigation, ES, March 1986
- Remedial Action Plan, March 1986
- Hazard Evaluation/Remedial Alternatives Report, ES, September 1990

## III. DESCRIPTION OF THE SELECTED REMEDY:

The selected alternative is protective of human health, safety, and the environment as described in the Hazard Evaluation/Remedial Alternatives Report, September 1990.

The selected remedy for Sites 3, 4 and 5 is Alternative 1, which includes:

1. No action with the exception of long term monitoring of ground and surface water. This alternative is in light of the fact that a clay cap has already been installed on the sites.

2. Specifications on the caps are to be forwarded to the Department.

The selected remedy for Site 12 is Alternative 2, which includes:

1. Clay fill used to cover the waste, compacted to achieve a low-permeability (10-7 cm/sec) cover.

2. Place a four (4) to six (6) inch thick lift of top soil over the site and seed to produce a good permanent grass cover.

3. Long term monitoring of ground and surface water.

4. A retaining wall is already in place down gradient of the site to intercept phosphorus migration in ground water.

5. Seepage from the retaining wall is collected and treated on-site in a wastewater treatment plant designed for this purpose.

The long term operation and maintenance (O&M) activities are projected to include:

1. Inspect and maintain the integrity of the cover on a periodic basis. The schedule will be established in the Final Report.

2. Quarterly ground and surface water monitoring and reporting.

3. Annual reporting to summarize pertinent site activities and/or details.

**Declarations:**

Consistent with Part 2 of The Hazardous Waste Management Act as amended 1986 (the State Superfund Law), I have determined that the selected remedial action at the Monsanto sites are a cost effective remedy that will provide adequate protection to the public health, welfare and the environment.

Sept 10, 1992
Date

Kenneth W. Bunting, Acting Director
Division of Superfund
Tennessee Department of Environment
and Conservation

## Record of Decision

**Monsanto Chemical Company**
**Columbia, Maury County, Tennessee**
**State ID# 60-534**

## SITE BACKGROUND AND HISTORY

The Monsanto property is located off Highway 50, west of Columbia, Tennessee and encompasses approximately 6400 acres. Monsanto began operating an elemental phosphorus plant at Columbia in 1936. Phosphorus ore was mined and processed at this facility to produce elemental phosphorus. Production activities at the plant were terminated in approximately 1985 and the plant is currently being dismantled. Some structures will remain after the dismantling process including the office building and an operations building where phosphorus , which is shipped in from Monsanto's Idaho plant, is packaged in drums and prepared for shipment.

While the plant was in operation, waste fluids and materials were stored or disposed of at several locations within the facility boundaries. Twenty-one such sites have been identified and investigated. A preliminary evaluation was conducted in 1985 at each site with respect to site characteristics and potential impact to groundwater. A program for monitoring groundwater was established at eleven of the sites. The program included drilling test borings, installing groundwater monitoring wells, measuring water levels and sampling and analyzing ground water. As a result of the findings of these initial investigations, four of the sites were placed on the Tennessee Superfund Promulgated List in 1985. The four sites include the Old Phosphorus Disposal Area (Site 3), Phosphorus Slurry Disposal (Site 4), No.1 Pond Disposal Facility (Site 5), and the Old Tank Farm (Site 12)[See Table 1.1 attached]. A detailed description of each site follows:

Site 3 was a phosphorus barrel dump. Drums of phosphorus containing material were reportedly brought here for disposal from 1950 until 1978. The area was closed and capped in 1978.

Site 4 is a closed phosphorus slurry dump. The site received phosphorus containing material, coke, dust, and slurry from the phosphorus still and centrifuge from the mid-1950's to 1978. The site was closed and covered with a clay cap (approximately three feet thick) in 1978. The site also includes an area where asbestos containing phosphorus was placed, an area where treater oil waste was placed, and an area where some large equipment containing phosphorus was buried.

Site 5 is a closed sanitary and solid waste disposal area. This site, previously referred to as Tailings Pond No. 1, was used for sanitary and solid waste disposal from the 1950's to 1978. The site was closed in 1978. In addition, the site was covered with a three foot thick clay cap in 1986.

Site 12 is located in the plant area to the west of the phosphorus storage and shipping area. Twelve gunite (concrete) storage tanks, which were built partially

below grade, were used to store phosphorus and phossy water from 1948 to 1955. Materials stored in the tanks leaked to underlying rocks and soil. The tanks were emptied, filled with slag and covered with soil. Elemental phosphorus was recovered downgradient and drummed. A retaining wall was constructed downgradient of the site to intercept phosphorus migration in the groundwater. Seepage from the retaining wall is collected in sumps and treated in the on-site wastewater treatment plant.

## PROBLEM DEFINITION

### Contaminants of Concern

The following contaminants in groundwater, soils, and surface water have been analyzed for: Lead, Chromium, Arsenic, Cyanide, Fluoride, Phosphate (PO4 soluble) and Elemental Phosphorus (P4). Only elemental phosphorus has been found at significantly high levels.

Elemental phosphorus is a waxy solid, normally pale yellow to straw colored. It ignites spontaneously on contact with air at temperatures at or above 86 degrees F. The melting point of phosphorus is 11 degrees F and the solubility is 3 mg/L (at 54 degrees F).

### Groundwater Quality

Monsanto submitted a Hydrologic Monitoring Plan to the State of Tennessee in 1986. In accordance with the plan, Monsanto has conducted quarterly monitoring of groundwater and surface water since 1987. Every quarter, groundwater samples are collected from 38 monitoring wells and the groundwater level is recorded.

The concentrations of lead, chromium, arsenic and fluoride in the groundwater at the 4 sites are less than the Safe Drinking Water Act (SDWA) maximum contaminant levels (MCL's). Phosphate and Cyanide do not have a MCL but are not considered major contaminants of concern. Elemental phosphorus also does not have a MCL but is considered the major contaminant of concern.

Doesn't mention cadmium which is over MCLs and I see levels of chromium lead and Fluoride above MCLs in 12/4/92 report that dated the samples in 1985

Site 3. Groundwater beneath this site is monitored quarterly utilizing well #3 east. Elemental phosphorus levels have been consistently low and have not been over 0.01 ppb since the fourth quarter of 1987.

Site 4. Groundwater beneath this site is monitored quarterly utilizing wells 4-5, 4-6, 4-7 and 4-8. Elemental phosphorus levels have been consistently low and have not been over 0.03 ppb since 1987 with the exception of one quarter.

Site 5. Groundwater beneath this site is monitored quarterly utilizing wells 5-15 and 5-16. Elemental phosphorus levels have been fairly low over the three and a half year monitoring period fluctuating between 0.002 ppb and 0.205 ppb.

Site 12. Groundwater beneath Site 12 is monitored quarterly utilizing wells 12-1, 12-2 and, 12-4. Elemental phosphorus levels have fluctuated significantly between 0.003 ppb and 265 ppb in two of the wells (12-1 and 12-4). Most significantly, levels in well 12-4 have demonstrated an increasing trend. Levels have been consistently high in the other well (12-2) ranging between 1.48 ppb and 1,140 ppb with an average of approximately 905 ppb.

Because the shallow groundwater generally flows from the site towards Greenlick Creek, monitoring wells 17-5, 19-1, 19-3, 19-4, 19-5, and 19-7 are sampled quarterly to detect any movement of elemental phosphorus towards Greenlick Creek. The four wells between Site 12 and Greenlick Creek (17-5, 19-1, 19-4 and 19-3) have shown highly fluctuating ranges of phosphorus from 0.001 to 110 ppb with no significant trends up or down. The two wells nearer Greenlick Creek (19-5 and 19-7) have shown less moderate levels of phosphorus ranging between 0.002 to 7.8 ppb.

Three deep wells (well depth greater than 100 feet), namely 12-9, 19-9, and 19-10, were installed and monitored during the HE/RA study to evaluate the potential for phosphorus to migrate deeper into the bedrock. Well 12-9 is located near the highly contaminated shallow well (12-2) and has shown no phosphorus contamination at the detection limit of 0.008 ppb. Wells 19-9 and 19-10 have likewise shown no contamination at the detection limit.

In summary, significant migration of phosphorus in the shallow unconfined aquifer is not occurring at Sites 3, 4 and 5. There does appear to be some migration in the deeper semi-confined aquifer at Site 12. With groundwater flow towards Greenlick Creek, it is important to note that wells between Site 12 and the creek have fluctuated in levels of phosphorus and wells near the creek have shown lesser amounts. The deep wells have not shown evidence of contamination.

### Surface Water Quality

As part of the Supplementary Site Investigation performed in 1986, surface water samples were collected from nine locations. These included an on-site pond and spring effluent, one location on Gin Creek, four locations on Greenlick Creek and two locations on the Duck River. According to the Hydrologic Monitoring Plan, surface water samples at seven of these locations have been monitored on a quarterly basis since 1987.

The concentrations of lead, chromium, arsenic and fluoride in surface water have been less than the SDWA MCL's. Point source discharges to Greenlick Creek and the Duck River are presently regulated by NPDES permit through the Tennessee Division of Water Pollution Control. Two outfalls (002 and 011) discharge to the Duck River and two outfalls (005 and 009) discharge to Greenlick Creek. Parameters monitored include: Total Suspended Solids, Total Phosphates, Soluble Fluoride, Elemental Phosphorus, Cyanide, Chlorine and pH. An acceptable discharge level of 5 ppb of elemental phosphorus has been established. All effluent limitations are presently being met.

## REMEDIAL ACTION

### Objectives

Remedial action objectives include:

* Stabilizing the amount of phosphorus leaching into the groundwater.

* Reducing the migration of phosphorus from the sites.

## Options

The following alternatives were developed for the Old Phosphorus Disposal Area (Site 3), the Phosphorus Slurry Disposal (Site 4), and the No. 1 Pond Disposal Facility (Site 5):

**Alternative 1** - No action with the exception of long term monitoring of groundwater (Sites 3, 4 and 5) and surface water (Site 5).

**Alternative 2** - Excavation of contaminated material, placement of excavated material in the on-site permitted landfill, backfill excavated area with clean fill, cap, regrade, and long term monitoring of ground water (Sites 3, 4 and 5) and surface water (Site 5).

**Alternative 3** - Excavation of contaminated material, treatment of excavated material in ERCO still, backfill excavated area with clean fill, cap, regrade, and long term monitoring of ground water (Sites 3, 4 and 5) and surface water (Site 5).

The following alternatives were developed for the Old Tank Farm (Site 12):

**Alternative 1** - No action with the exception of long term monitoring of ground water and surface water.

**Alternative 2** - Covering the site with either a clay cap or a multi-media cap and long term monitoring of ground water and surface water.

**Alternative 3** - Covering the site with either a clay cap or a multi-media cap, extraction of shallow ground water, treatment of extracted ground water, and long term monitoring of ground water and surface water.

**Alternative 4** - Excavation of contaminated material, placement of excavated material in the on-site permitted landfill, backfill excavated area with clean fill, cap, regrade, and long term monitoring of ground water and surface water.

**Alternative 5** - Excavation of contaminated material, treatment of excavated material in ERCO still, backfill excavated area with clean fill, cap, regrade, and long term monitoring of groundwater and surface water.

## Selected Alternatives

Sites 3, 4 and 5. The alternative for these sites are comprised of no action with the exception of long term monitoring of groundwater at site 3 and 4 and long term monitoring of groundwater and surface water at site 5. Sites 3 and 4 were covered with a clay cap in 1978 and Site 5 was covered in 1986. Specifications on the caps are to be forwarded to the Department. Quarterly groundwater and surface water monitoring data indicates no significant increases in phosphorus concentrations since 1987.

Site 12. The alternative for this site is comprised of capping with long term monitoring of groundwater and surface water. A clay cap will be utilized on Site 12 in conjunction with asphalt and concrete capping of the adjacent drum handling area. A retaining wall is already in place downgradient of the site to

intercept phosphorus migration in groundwater. Seepage from the retaining wall is collected in sumps then treated in the onsite wastewater treatment plant.

## COMMUNITY RELATIONS

Public Announcements concerning proposed site activities were placed in "The Daily Herald," a local newspaper, for three consecutive issues in December of 1990. No questions or comments were received; therefor, a Public Meeting was not considered necessary and was not held.

## OPERATION AND MAINTENANCE

Operation and maintenance requirements will be outlined in the Final Report which will also outline future monitoring requirements. Continued monitoring of groundwater on a periodic basis will allow evaluation of whether or not migration of phosphorus continues. In the event of migration in the future, the feasibility of shallow ground- water recovery using pump and treat systems (or other systems) will have to be examined.

TABLE 1.1[a]
SITE SUMMARY
MONSANTO CHEMICAL COMPANY
COLUMBIA, TENNESSEE

| Site No. | Site Name on State of Tennessee's Promulgated List | Site Name at Monsanto | Approximate Years of Operation | Status | Monitoring Program |
|---|---|---|---|---|---|
| 3 | Old Phosphorus Disposal Area | Barrel Dump | 1950-1978 | Inactive and covered | One shallow well |
| 4 | Phosphorus Slurry Disposal | Phosphorus Slurry Dump | 1955-1978 | Inactive and covered | Four shallow wells |
| 5 | No. 1 Pond Disposal Facility | Sanitary/Solid Waste Dump | 1950-1978 | Inactive and covered | Two shallow wells |
| 12 | Old Tank Farm | Phosphorus Tank Farm | 1948-1955 | Inactive | Nine shallow wells; three deep wells |

(a) - Modified Table 1.1, Site Investigation Report (ES 1985).



ENGINEERING-SCIENCE, INC.
57 Executive Park South
Suite 590
Atlanta, Georgia 30329

REFERENCE 10

STATE OF TENNESSEE

DEPARTMENT OF CONSERVATION

DIVISION OF GEOLOGY

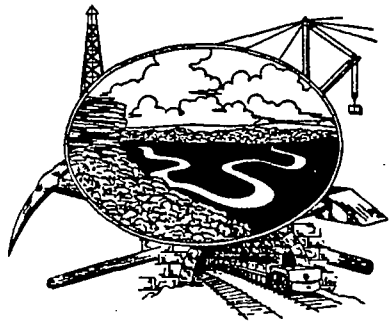
REPORT OF INVESTIGATIONS No. 4

# GROUND WATER IN THE CENTRAL BASIN OF TENNESSEE

*A Progress Report*

By

ROY NEWCOME, JR.



Prepared in cooperation with the U. S. Geological Survey

NASHVILLE, TENNESSEE

1958

# GROUND WATER IN THE CENTRAL BASIN OF TENNESSEE

*A Progress Report*

By

Roy Newcome, Jr.*

## ABSTRACT

Ground water in the Central Basin of Tennessee occurs chiefly in solution channels in limestones of Ordovician age. Physiographically, the area is a basin, but structurally it is a low dome. Because the dip of the beds in the dome is so gentle, the occurrence of ground water is related more closely to the stratigraphy than to the structure. The rock formations in the Central Basin differ in the extent to which solution by subsurface water takes place. Factors influencing the occurrence of ground water are topography, depth, and the chemical composition of the rocks. Solution occurs more rapidly under valleys than under hills. In general, as depth increases the amount of ground water decreases. The purer limestones seem to be more soluble than those containing clay and shale.

Wells in the Central Basin are of low yield, few of them furnishing more than 20 gallons per minute and many yielding less than 1 gallon per minute. About one-fifth of the wells drilled fail to yield water. All the water is hard and much of it contains hydrogen sulfide and other chemical compounds in objectionable quantities. Chemical analyses of the water from several wells in each formation are given with the description of the formation.

This report contains in tabular form the records of more than 600 wells in the Central Basin of Tennessee. The locations of the wells are shown on the accompanying county maps.

*Geologist, U. S. Geological Survey.

# INTRODUCTION

Since July 1947 the United States Geological Survey and the Tennessee Division of Geology have been engaged in a cooperative program of ground-water studies in Tennessee.* The physiography of the State suggested a subdivision into three regions for the purposes of the investigation. (See fig. 1.) East Tennessee is that part of the State east of the Cumberland Plateau and includes the Valley and Ridge and Great Smoky Mountains physiographic provinces. Middle Tennessee lies between the eastern escarpment of the Cumberland Plateau and the northward-flowing section of the Tennessee River. It includes a part of the Western Valley of the Tennessee River, the Highland Rim Plateau, the Central Basin, and the Cumberland Plateau physiographic provinces. West Tennessee is that part of the State west of the northward-flowing section of the Tennessee River. It includes the Mississippi River Alluvial Plain, the Plateau Slope of West Tennessee, and a part of the Western Valley of the Tennessee River physiographic provinces.

This report is concerned with the Central Basin portion of Middle Tennessee, known also as the Nashville Basin. The Central Basin, province 5 in figure 1, is an area of roughly elliptical shape centering very near the State's geographic center. It is about 120 miles long and 60 miles wide and comprises about 5,000 square miles. The major axis of the ellipse has the general northeast trend of Applachian structure.

The gently rolling surface of the Central Basin has an average elevation of 700 feet above sea level, about 300 feet lower than the surrounding Highland Rim Plateau. Throughout the Central Basin, especially in the outer reaches, many hills stand as erosional remnants of the Highland Rim Plateau surface which formerly extended over the whole region.

Only three major streams traverse the Central Basin. The Cumberland River enters at the northeastern edge and leaves at the northwestern edge of the province. The Duck and Elk Rivers, which have their sources on the eastern Highland Rim Plateau, have outlets on the western and southwestern edges, respectively, of the Central Basin.

The Central Basin has a temperate climate. The mean annual temperature is 60°F. The temperature does not often exceed 100° or drop below zero. July and January are the hottest and coldest months, respectively.

The average annual precipitation in the Central Basin is about 45 inches, of which the maximum monthly of 5.3 inches occurs in March and the minimum monthly of 2.5 inches occurs in October.

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**The 1957 Tennessee General Assembly created a Water Resources Division within the Department of Conservation.*

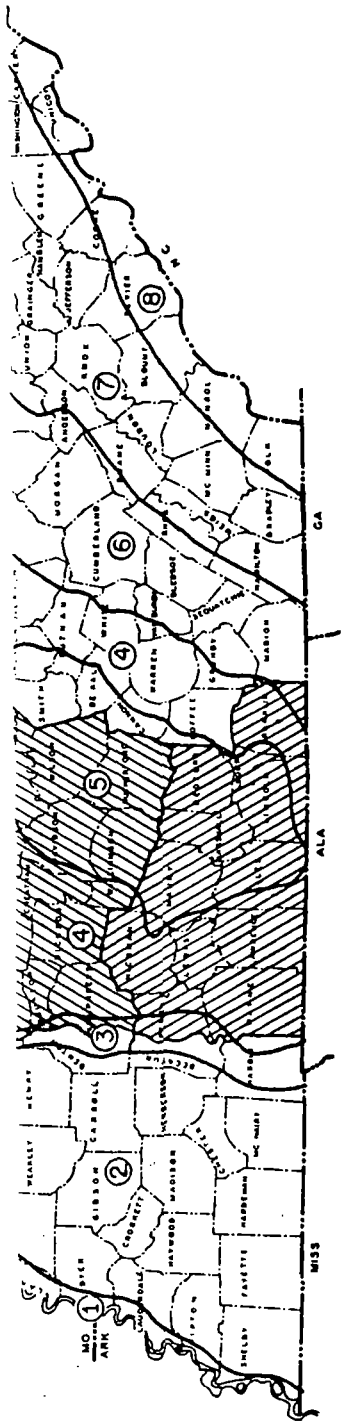



FIGURE 1.—PHYSIOGRAPHIC PROVINCES OF TENNESSEE.



### Previous Investigations

The first systematic investigation of ground water in Tennessee was begun in 1927 under the joint sponsorship of the U. S. Geological Survey and the Tennessee Division of Geology. As a result of the investigation a report entitled *Ground water in north-central Tennessee,* by Arthur M. Piper, was published in 1932 as U. S. Geological Survey Water-Supply Paper 640. The report describes the geology and ground-water resources of the northern parts of the Central Basin and western Highland Rim Plateau.

Water-Supply Paper 677, *Ground water in south-central Tennessee,* by C. V. Theis, was published in 1936 by the U. S. Geological Survey. It describes the geology and ground-water resources of the southern parts of the Central Basin and western Highland Rim Plateau.

### Present Investigation

The present study of the ground-water resources of Tennessee was begun in July 1947 by the U. S. Geological Survey and the Tennessee Division of Geology as a cooperative program under the direction of A. N. Sayre, Chief, Ground Water Branch, U. S. Geological Survey, and H. B. Burwell, former State Geologist. Work has been carried on under the supervision of E. M. Cushing, District Engineer, U. S. Geological Survey, H. W. Ferguson, former State Geologist, and W. D. Hardeman, present State Geologist.

Ground-water studies in Middle Tennessee were undertaken in 1947 by F. M. Alexander, Assistant State Geologist, Tennessee Division of Geology. The writer was assigned to the region in June 1949.

This report presents the information gained from a study of the records of many wells drilled since the earlier ground-water investigations of Piper and Theis. The great amount of drilling, particularly deep-well drilling, in recent years has added much significant ground-water information to that available at the time of the earlier reports. Compilation of well data and preparation of this report was completed in 1953.

### Acknowledgments

The writer wishes to acknowledge the aid and advice given by his colleagues in the Ground Water Branch and the Tennessee Division of Geology.

He wishes to acknowledge also the cooperation of the many well drillers and well owners who furnished the information from which the well records in the report were assembled.

Final editing and proofreading was done by F. M. Alexander, Assistant State Geologist.

# GEOLOGY

## Structure of the Rocks

Physiographically, the Central Basin is the result of erosion of a low structural dome whose crest is in southern Rutherford County. The dome represents the southern end of the Cincinnati Arch, an elongated area of upwarped rocks extending northward through Central Kentucky into Ohio and Indiana. During the upwarping and doming the rocks at the crest of the dome were stretched, resulting in the formation of joints. The weakened carbonate rocks were readily subject to solution and erosion, with the result that a topographic basin now occupies the top of the structural dome.

Although jointing is a prominent feature of Central Basin rocks, there is little evidence of differential movement along the joints. The formations lie in the same relative positions in which they were deposited. Minor folding of the rocks is not unusual, but it is of a local nature only.

## Rock Formations of the Central Basin

The rock formations of the Central Basin are almost entirely limestones of Ordovician age. They differ greatly in color, texture, and chemical purity. Erosion of the structural dome has resulted in the exposure of concentric rings of progressively younger rocks as distance from the center of the Central Basin increases. The formations dip away from the center at about 15 feet per mile.

The oldest rocks exposed are those of the Murfreesboro limestone, which consists of about 400 feet of fine-grained bluish-gray limestone. The upper 100 feet of the Murfreesboro has been removed at the locality of deepest erosion. The youngest rock exposed that is of hydrologic signifiicance in the basin is the Catheys limestone. Outcrops of formations younger than the Catheys are restricted largely to the hills that remain as erosional remnants of the Highland Rim Plateau.

Between the Murfreesboro and Catheys limestones is approximately 500 feet of limestone of six formations, as represented in the accompanying columnar section. (See table 1.) C. W. Wilson, Jr., (1949) has described in detail the stratigraphy of Central Tennessee.



# GROUND WATER

## Occurrence

An evaluation of the water-yielding properties of the rock formations of the Central Basin should consider two important factors, depth and solubility of the rocks. Nearly all the ground water in the region is contained in cavities formed, or enlarged, by solution of the limestone. These cavities, termed "solution channels," had their origin, for the most part, in openings along joints and bedding planes, through which water was provided relatively easy access to the rocks below the land surface. With such a start, water containing carbonic and organic acids derived from the air or leached from the soil has formed by solution of the limestone a network of water-carrying subterranean channels which are common in limestone regions.

Solution of the rocks has not progressed everywhere at the same rate nor to the same extent. The composition of the rocks greatly affects the rate of solution. Generally, the purer limestones are more easily dissolved than rocks containing appreciable amounts of nearly insoluble silty and clayey material, especially those in which the insoluble material is concentrated in layers.

Solution proceeds more slowly as depth increases. Crevices, that are open and of appreciable size near the surface, become less pronounced with depth, owing both to the less severe stretching undergone by the deeper rocks at the time of uplift and to the weight of overlying rocks. In most places in the basin substantial solution has not progressed beyond a depth of 300 feet. Records of the depth or depths of occurrence of water in 650 wells, totaling 700 occurrences, show that 75 percent of the water-bearing openings occur at depths of less than 100 feet and 90 percent at depths of less than 300 feet.

## Water-Yielding Properties of the Rocks

The results of this study indicate that the individual rock formations of the Central Basin differ in their ability to transmit and yield water. Information on these differences, together with information on the thickness of the rocks and the areal distribution of their outcrops and on the topography, forms the basis for a prediction of the ground-water prospects and the maximum feasible depth of drilling at any specific locality.

Many wells in the Central Basin have been drilled several hundred feet below the depth at which water could reasonably be expected.

wells yielded less than 1 gallon per minute (gpm), 25 wells yielded 1 to 5 gpm, 5 wells yielded 6 to 10 gpm, and only 2 wells yielded more than 10 gpm. Probably none of the water-bearing zones in the Knox furnishes more than 15 gpm to a well.

The quality of water obtained from wells in the Knox dolomite depends largely upon well location; those wells near the center of the Basin yield water of better quality than do wells near the margin. The amount of dissolved mineral matter in water from the Knox is seldom less than 500 parts per million (ppm) and it often exceeds 1,000 ppm. The greatest concentration of wells yielding water from the Knox dolomite is in northern Williamson County and southern Davidson County. In that area 13 wells yield water ranging from 500 to 2,500 ppm in dissolved-solids content.

The fluoride content of water from 35 wells yielding water from the Knox dolomite in Bedford, Davidson, Giles, Marshall, Maury, Rutherford, and Williamson Counties ranged from 2 to 6.5 ppm. In view of the fact that continual use of water having fluoride in excess of 1.5 ppm may cause mottled enamel on children's teeth (Dean, 1936), it may be desirable to have fluoride tests made before using water from these wells.

## WELLS CREEK DOLOMITE

Directly overlying the Knox dolomite is the easily drilled, very silty dolomite and dolomitic limestone of the Wells Creek dolomite. It is not exposed at the surface but is usually conspicuous in well cuttings because of the striking green color imparted to the rock by the mineral glauconite. In places glauconite is absent from part or all of the unit, and in those places the rock is similar in color to the underlying Knox. The Wells Creek dolomite ranges in thickness from less than 5 feet in the eastern part of the Central Basin to 80 feet in the west. It is not known to yield water to wells in the Central Basin.

## MURFREESBORO LIMESTONE (Om)

Although the Murfreesboro limestone is 400 feet thick and contains many easily dissolved beds, the formation in most places is a poor source of water. This probably is due to the Murfreesboro being covered nearly everywhere by 100 to 600 feet of younger rocks. Exceptions are small areas where the formation crops out in central Rutherford County and at Wilhoite Mills in Marshall County. In the outcrop areas the Murfreesboro yields water to most wells. Records of 47 wells drilled into the formation in Rutherford County show that the Murfreesboro yielded water to 34 of them. However, elsewhere in the



Central Basin where the Murfreesboro is more deeply buried it yielded water to only 20 of 100 wells.

In the vicinity of Murfreesboro several industries make use of ground water in their processes. In that locality there are at least 12 wells that yield more than 100 gpm each from the Murfreesboro limestone. Most of this water is of good quality. Elsewhere in the Central Basin the Murfreesboro seldom yields water that is not highly mineralized. The formation is a poor source of water except in the areas where it crops out or is very near the land surface.

## PIERCE LIMESTONE (Op)

The Pierce is a thin silty limestone overlying the Murfreesboro limestone. As it has a thickness of only 25 feet, its area of outcrop is very small, usually restricted to a thin border about the outcrops of the Murfreesboro. The rock contains 15 percent of insoluble material,* twice as much as the Murfreesboro. Most of the insoluble material is clay and shale occurring as thin partings.

The Pierce limestone is a very poor source of water. Records of 153 wells penetrating the formation show that only 9 obtained water from it.

The thinness of the formation and its high content of insoluble matter, together with its deeply buried position in most places, are probable reasons for its poor water-yielding properties. Water, when encountered in the Pierce limestone, is generally too highly mineralized to be potable.

## RIDLEY LIMESTONE (Or)

Probably the most reliable water-bearing formation above the Knox dolomite is the Ridley limestone. The rocks of this formation crop out over a greater area than those of any of the other formations in the Central Basin. Large exposures of the Ridley occur in Rutherford, Bedford, Marshall, and Maury Counties. In those counties the formation is topographically expressed as extensive plains.

The Ridley limestone is a massively bedded formation about 100 feet thick. It contains the purest limestone in the Central Basin, the average content of insoluble material being only 5 percent. The large areas of exposure and the chemical purity of the rock afford favorable conditions for the development of solution channels.

Records are available for 240 wells penetrating the Ridley limestone. The formation yielded water to 113 of the wells. In 65 percent of the

*Percentages of insoluble material expressed in this report are based on a study of insoluble residues on file at the Tennessee Division of Geology, Nashville, Tenn*

## TABLE 3.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE MURFREESBORO LIMESTONE

(parts per million)

| County | Well No. | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Carbonate ($CO_3$) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BEDFORD | 9 | 0.1 | 97 | 1 | 4 | 13 | 172 | 70 | 7 | 0.5 | 266 | 244 |
| LINCOLN | 7 | 2.3 | 1,080 | 236 | 4,470 | 21 | 196 | 3,160 | 6,880 | ..... | 16,200 | 3,660 |
| MARSHALL | 1 | .7 | 78 | 6 | 4 | 0 | 258 | 3 | 6 | ..... | 236 | 219 |
| RUTHERFORD | 17 | 2.0 | 92 | 3 | 9 | 0 | 252 | 31 | 14 | ..... | 282 | 242 |
| RUTHERFORD | 30 | .1 | 92 | 1 | 2 | 10 | 246 | 21 | 3 | 1.5 | 258 | 234 |
| RUTHERFORD | 58 | .1 | 84 | 3 | 2 | 0 | 254 | 16 | 3 | .5 | 248 | 222 |

## TABLE 4.—CHEMICAL ANALYSIS OF WATER FROM A WELL IN THE PIERCE LIMESTONE

(parts per million)

| County | Well No. | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Carbonate ($CO_3$) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WILLIAMSON | 1 | 1.3 | 1,340 | 54 | 2,880 | 0 | 248 | 3,260 | 4,430 | ..... | 12,900 | 3,560 |

## TABLE 5.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE RIDLEY LIMESTONE

(parts per million)

| County | Well No. | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Carbonate ($CO_3$) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAVIDSON | 29 | 0.1 | 154 | 2 | 2 | 0 | 344 | 102 | 3 | ..... | 474 | 393 |
| DAVIDSON | 33 | .2 | 52 | 1 | 2 | 12 | 108 | 21 | 4 | 0 | 178 | 132 |
| RUTHERFORD | 14 | 1.0 | 110 | 3 | 9 | 0 | 322 | 18 | 14 | ..... | 336 | 287 |
| RUTHERFORD | 56 | 2.7 | 204 | 4 | 9 | 0 | 462 | 135 | 14 | ..... | 634 | 526 |
| WILLIAMSON | 6 | .5 | 342 | 37 | 42 | 0 | 198 | 823 | 64 | ..... | 1,640 | 1,000 |

## TABLE 6.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE LEBANON LIMESTONE

(parts per million)

| County | Well No. | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Carbonate ($CO_3$) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAVIDSON | 74 | 0.1 | 147 | 3 | 18 | 0 | 368 | 77 | 28 | 0 | 512 | 379 |
| RUTHERFORD | 53 | .3 | 128 | 3 | 2 | 0 | 386 | 16 | 2 | .5 | 367 | 332 |
| WILLIAMSON | 33-2 | .1 | 196 | 3 | 13 | 0 | 280 | 215 | 18 | 3.0 | 660 | 498 |
| WILSON | 22 | .1 | 214 | 3 | 12 | 0 | 370 | 238 | 18 | .2 | 738 | 547 |
| WILSON | 39 | .1 | 96 | 1 | 2 | 29 | 206 | 8 | 4 | 0 | 261 | 242 |

yielding wells, however, the quantity of water obtained from the Ridley is less than 5 gpm. Only 5 percent of the wells yield more than 20 gpm.

Water from the Ridley limestone is usually potable, although in one-third of the wells yielding water from the formation there is a detectable odor of hydrogen sulfide.

## LEBANON LIMESTONE (Olb)

The Lebanon limestone is well exposed in the Central Basin. It is about 115 feet thick. In general, the Lebanon outcrops form a border around the large exposures of the Ridley limestone. In addition, there are many outliers of the Lebanon limestone within the outcrop areas of the Ridley. The Lebanon is usually distinguished by its thin-bedded flaggy appearance and by the abundant growth of cedar trees that it supports.

Although the content of insoluble material in the Lebanon averages only 5.5 percent, the material occurs in the form of very thin, closely spaced, shale partings. As a result, the formation has a thin-bedded appearance.

Records of 293 wells penetrating the Lebanon show that this formation yielded water to 107 of them, a somewhat lower average than that for the underlying Ridley limestone. This lower average probably is due to the resistance to solution provided by the shale partings. This is suggested by the fact that half the wells starting in the Ridley yield water from that formation, whereas only one-fifth of the wells starting in the Lebanon yield water from the Lebanon.

The quantity of water to be expected from wells in the Lebanon is about the same as that yielded by wells in the Ridley. About 60 percent of the wells yield less than 5 gpm and 5 percent yield more than 20 gpm.

Water from the Lebanon limestone is usually of good quality except that it is very hard. Hydrogen sulfide is detected in about one-fourth of the wells. It can usually be removed by aeration. Salty water has been encountered in about 5 percent of the wells yielding water from the Lebanon.

## CARTERS LIMESTONE (Oc)

The Carters limestone is one of the best known formations in the Central Basin. Well drillers commonly refer to it as the "brown lime." Its light-brown color contrasts sharply with the dark-blue beds of the overlying Hermitage formation. The Carters is 65 feet thick and consists



mostly of massively bedded limestone. The outcrops are often seen as steep risers between the steps produced by erosion of the Lebanon and Hermitage formations. In the eastern part of the Central Basin the Carters contains four thin beds of altered bentonite (Wilson, 1949, p. 62-65), the uppermost bed being at or near the top of the formation. In the remainder of the Central Basin only the three lower bentonite beds are present. If the calcareous shale partings in the Lebanon limestone are disregarded, the Carters and the Lebanon contain about the same amount of insoluble material. However, the thicker bedding of the Carters makes possible a better development of solution channels where water has access to the rock.

The Carters limestone is restricted as a water-bearing formation, however, by the overlying argillaceous Hermitage formation, which acts as an almost impervious cap preventing the downward seepage of water. For this reason the Carters does not have as good a record for yielding water as its chemical purity and massive bedding would suggest. Throughout the Central Basin the Carters has yielded water to 94 of 313 wells on which records are available. In three-fourths of the yielding wells water was encountered at depths of less than 100 feet. As the Hermitage formation restricts vertical seepage, the Carters must depend upon recharge at the outcrop. It seems that the chances of obtaining a water supply from the Carters are not favorable except where the formation is close enough to the surface to crop out near the area being drilled.

The quantity of water yielded to wells in the Carters limestone is, on the average, slightly greater than that yielded by the Ridley and Lebanon limestones. About 60 percent of the wells yield less than 5 gpm, and 6 percent yield more than 20 gpm.

Water from the Carters is similar in quality to that obtained from the Lebanon limestone. About one-fourth of the wells yield water that contains some hydrogen sulfide.

## HERMITAGE FORMATION (Oh)

The Hermitage formation, ranging in thickness from 60 feet in the southern part of the Central Basin to 100 feet in the northern part, contains several members which intergrade laterally. Its identification in the field must take into account the locality, as outcrops of each member have characteristics differing from those of the other members. Wilson (1949, p. 82-102) defines the limits of occurrence of each member. The members differ in their content of fossils, phosphate, silt, and clay. In general, the strata of the Hermitage are very dark blue and are

TABLE 7.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE CARTERS LIMESTONE

(parts per million)

| County | Well No. | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Carbonate ($CO_3$) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAVIDSON | 9 | 0.2 | 179 | 18 | 27 | 22 | 242 | 286 | 42 | ..... | 838 | 519 |
| DAVIDSON | 19 | .4 | 932 | 40 | 317 | 0 | 756 | 1,900 | 489 | 2.0 | 4,350 | 2,490 |
| DAVIDSON | 94 | .1 | 121 | 1 | 5 | 0 | 332 | 33 | 7 | 0 | 330 | 304 |
| WILLIAMSON | 30 | .1 | 100 | 1 | 4 | 0 | 270 | 30 | 6 | 0 | 261 | 254 |
| WILLIAMSON | 31 | .3 | 116 | 2 | 2 | 21 | 270 | 36 | 3 | 0 | 335 | 298 |
| WILSON | 8 | .3 | 136 | 1 | 23 | 0 | 274 | 107 | 35 | 0 | 464 | 344 |

TABLE 8.—CHEMICAL ANALYSES OF WATER FROM WELLS IN THE HERMITAGE FORMATION

(parts per million)

| County | Well No. | Iron (Fe) | Calcium (Ca) | Magnesium (Mg) | Sodium (Na) | Carbonate ($CO_3$) | Bicarbonate ($HCO_3$) | Sulfate ($SO_4$) | Chloride (Cl) | Fluoride (F) | Dissolved solids | Hardness as $CaCO_3$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DAVIDSON | 7 | 0.4 | 144 | 2 | 2 | 31 | 306 | 68 | 3 | 0 | 433 | 368 |
| DAVIDSON | 121 | .1 | 102 | 1 | 8 | 0 | 258 | 39 | 12 | 0 | 348 | 259 |
| GILES | 1 | .4 | 98 | 5 | 7 | 12 | 162 | 123 | 11 | ..... | 401 | 256 |
| WILLIAMSON | 1 | .7 | 104 | 7 | 3 | 19 | 296 | 5 | 4 | ..... | 328 | 268 |
| WILLIAMSON | 32 | .1 | 86 | 7 | 5 | 0 | 220 | 54 | 6 | .5 | 260 | 243 |



easily distinguished from the light-colored underlying Carters limestone. Much of the Hermitage is thinly laminated with shale partings, particularly the lower part.

The shaly nature of the Hermitage formation makes it a poor water bearer. It also forms an effective seal, greatly restricting the downward seepage of water into the underlying formations. Acting as an impervious cap, the Hermitage is responsible for many of the areas of ground-water deficiency near the outer limits of the Central Basin.

Occasionally water is encountered in the Hermitage, usually near the top of the formation in areas where a zone of coquina made up largely of the fossil brachiopod *Dalmanella* is present. This zone is a massively bedded, very fossiliferous, limestone restricted to the western half of the Central Basin.

Available records show that the Hermitage has yielded water to 68 of 267 wells penetrating the formation. About 60 percent of the yielding wells in the Hermitage yield less than 5 gpm. Ten percent yield more than 20 gpm.

Water from the Hermitage formation is generally of good quality, although that from about one-fifth of the wells contains some hydrogen sulfide.

Because of the impervious nature of the Hermitage it is inadvisable to drill into the formation where it lies at a depth exceeding 100 feet. Of the 68 wells yielding water from the Hermitage, only 14 encountered water in the Hermitage at depths of more than 100 feet.

## BIGBY-CANNON LIMESTONE (Oby-Ocn) *

The interval between the Hermitage and Catheys formations, ranging from 60 to 100 feet in the Central Basin, is occupied by the Bigby (Oby), Cannon (Ocn), and Dove-colored facies of the Bigby-Cannon limestone. West of a north-south line from Davidson County to Giles County the Hermitage-Catheys interval is occupied by the Bigby facies. East of a north-south line from Sumner County to Lincoln County, the Cannon facies occupies the interval. Between the two lines the facies intergrade.

The Bigby facies is the well-known phosphate rock horizon of Central Tennessee. It is an impure limestone containing about 20 percent of insoluble material. The rock is dark blue when fresh, weathering

**The classification of the Bigby-Cannon limestone in this report is in accord with recent published reports and usage by the Tennessee Division of Geology, but it does not coincide with the classification used by the U. S. Geological Survey.*

## TABLE 25.—RECORDS OF WELLS IN MAURY COUNTY

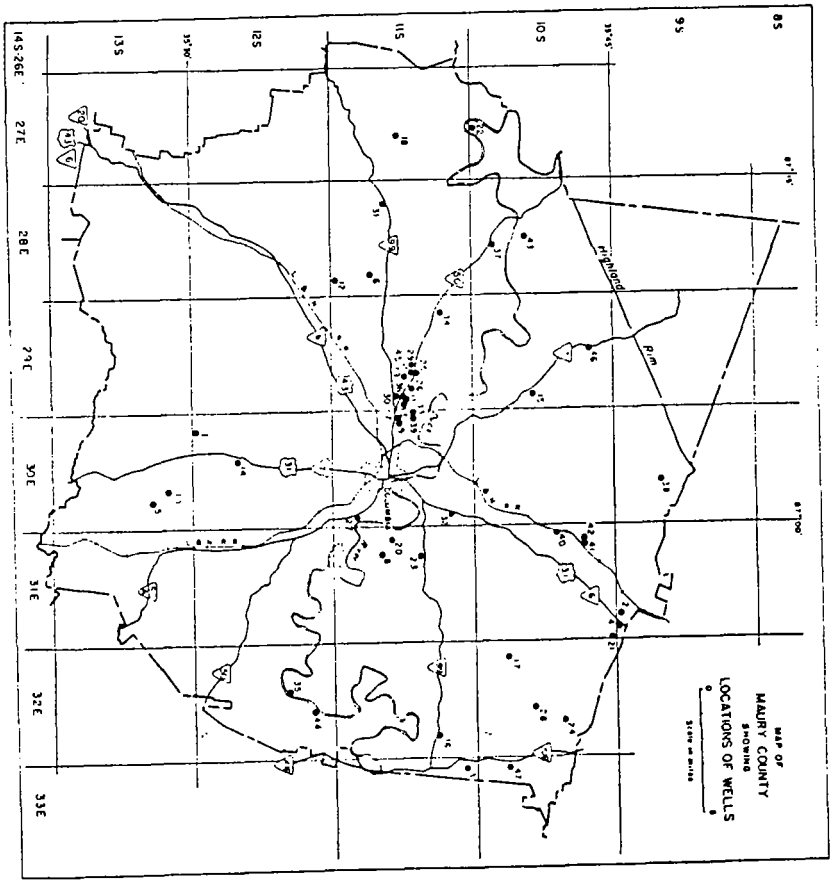
| Well No. | Location | Owner | Topographic situation | Altitude (feet) | Surface unit | Depth of well (feet) | Length of casing (feet) | Depth to water zones (feet) | Source | Yield (gallons per minute) | Depth to water level (feet) | Date of measurement | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SE, SE, 25, 12S-30E | Jerry Dowling | Valley | 710 | Oc | 100 | ..... | 98 | Olb | 20 | Flowing | 1950 | Overflows 3 gpm. |
| 2 | SE, SE, 22, 9S-31E | J. W. Howard | Hillside | 740 | Oby | 130 | ..... | 122 | Oc | ..... | 30 | 5-49 | |
| 3 | SE, NW, 5, 11S-33E | K. L. Osteen | Low hill | 641 | Or | 530 | ..... | 520 | O-€k* | ..... | 20 | 11-50 | |
| 4 | SE, SW, 21, 9S-31E | Town of Spring Hill | Hillside | 762 | Oh | 410 | 110 | 95 | Oc | 4 | 67 | 7-48 | Hydrogen sulfide odor. |
| 5 | SE, NE, 9, 13S-30E | James Scott | Valley | 900 | Oh | 267 | 18 | 40 | Oh | Seep | ..... | ..... | |
| 6 | NW, SW, 20, 11S-28E | Hugh Patton | Hilltop | 650 | Oby | 81 | ..... | ..... | ..... | Dry | ..... | ..... | |
| 7 | NE, SW, 15, 18S-30E | R. E. Ikard | Low hill | 635 | Oby | 100 | ..... | 84 | Oh | 25+ | 75 | 7-51 | Turbid. |
| 8 | Cen., NW, 17, 11S-31E | Raymond Holoomb | Valley | 680 | Oc | 142 | 5 | 35 | Oc | Seep | | | |
| | | | | | | | | 142 | Olb or Or | 10+ | 40 | 6-51 | |
| 9 | NW, SE, 15, 11S-30E | Preston Osborn | Hillside | 610 | Oby | 120 | ..... | 120 | Oc | 8 | 90 | 7-51 | |
| 10 | SE, SW, 2, 13S-30E | Mrs. A. B. Scott | Valley | 900 | Oby | 252 | ..... | 40 | Oby or Oh | 1½ | ..... | ..... | |
| 11 | SW, NE, 11, 11S-29E | R. G. Curtis | Hillside | 600 | Olb | 48 | 4 | 35 | Olb | Seep | ..... | ..... | |
| 12 | SE, SW, 21, 11S-28E | Howard Ewing | do. | 650 | Oh | 166 | 11 | 156 | Olb | 1 | ..... | ..... | |
| 13 | SE, NE, 11, 11S-29E | Buster Greer | do. | 700 | Olb | 68 | 8 | 67 | Olb | 5 | 28 | 8-51 | |
| 14 | SW, NW, 18, 12S-30E | Lester Hickman | do. | 1,040 | Ol | 100 | 12 | 30 | Ocy | ¼ | ..... | ..... | |
| 15 | SE, SW, 11, 10S-29E | M. C. Woodall | do. | 800 | Ocy | 100 | 70 | 72 | Oby | Seep | 65 | 7-52 | |
| 16 | SE, NE, 9, 11S-32E | Thomas Gooch | Low hill | 620 | Or | 100 | 15 | 65 | Or | do. | ..... | ..... | |
| | | | | | | | | 96 | Or or Op | do. | ..... | ..... | Hydrogen sulfide odor. |
| 17 | SW, SE, 16, 10S-32E | B. E. Barnett | Valley | 820 | Oh | 120 | ..... | 20 | Oh | 1/6 | ..... | ..... | Do. |
| 18 | NW, SW, 12, 11S-27E | Cecil Cathey | do. | 800 | Ol | 82 | 9 | 81 | Ocy | 8 | 25 | 9-51 | |
| 19 | SW, NE, 12, 11S-29E | Clay Miller | Hillside | 680 | Oby | 1,040 | 12 | 140 | Oc* | 1 | | | |
| | | | | | | | | 933 | O-€k* | 1½ | 123 | 10-52 | Do. |
| 20 | SW, SE, 15, 11S-31E | Hershel White | do. | 720 | Oh | 340 | ..... | 210 | Olb | Seep | | | |
| | | | | | | | | 275 | Or | ..... | | | |
| | | | | | | | | 300 | Or | ..... | 60 | 9-51 | |
| 21 | NE, NE, 1, 10S-31E | Buck Wiley | Hilltop | 765 | Oh | 826 | ..... | 815 | O-€k | 4 | ..... | ..... | |
| 22 | SE, SE, 23, 10S-27E | Wilse Thompson | Bluff | 600 | Ocy | 83 | 26 | 65 | Oby | 10 | 42 | 3-52 | |
| 23 | SE, SW, 7, 11S-31E | W. H. Matheny | Hillside | 695 | Oh | 209 | 19 | 45 | Oc | Seep | ..... | ..... | |
| 24 | SE, SW, 9, 10S-32E | B. A. Neil | Rolling | 780 | Olb | 500 | 15 | 30 | Olb | do. | | | |
| | | | | | | | | 475 | Om | do. | 10 | 1-53 | |

* *Chemical analysis is available from the Tennessee Division of Geology.*

TABLE 25.—RECORDS OF WELLS IN MAURY COUNTY—Continued

| Well No. | Location | Owner | Topographic situation | Altitude (feet) | Surface unit | Depth of well (feet) | Length of casing (feet) | Depth to water zones (feet) | Source | Yield (gallons per minute) | Depth to water level (feet) | Date of measurement | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 25 | NE, NW, 12, 11S-29E | R. S. Brown | Rolling | 620 | Oby | 163 | 7 | 135 | Oh or Oc | do. | 40 | 6-52 | Hydrogen sulfide odor. |
| 26 | NW, NW, 11, 11S-29E | Elbert Burgess | do. | 700 | Oby | 200 | 4 | 110 | Oh | 1 | 70 | 6-52 | |
| 27 | NW, NE, 21, 11S-30E | R. S. Compton | Hillside | 660 | Oc | 350 | ..... | 145 | Olb | Seep | ..... | ..... | |
| 28 | SE, SE, 13, 10S-32E | Ed Dalton | Rolling | 730 | Olb | 218 | 10 | 32 | Olb | do. | ..... | ..... | |
| 29 | NW, NW, 12, 11S-29E | Harry Napier | do. | 610 | Oh | 70 | 7 | 52 | Oh | 8 | 37 | 7-52 | |
| 30 | NE, SW, 11, 11S-29E | Malcolm Lents | do. | 750 | Oby | 41 | 18 | 35 | Oh | 10 | 23 | 7-52 | |
| 31 | NW, NW, 17, 11S-28E | J. B. Sisk | Valley | 580 | Ocy | 97 | 6 | 60 | Oby | ¾ | 6 | 7-52 | Salty. Hydrogen sulfide odor. |
| 32 | SE, SW, 1, 11S-30E | T. G. Wilkins | Rolling | 700 | Oh | 100 | 21 | 50 | Oh | 10 | 40 | 7-52 | |
| 33 | NW, NW, 15, 11S-30E | George Williams | Low hill | 600 | Olb | 100 | 11 | 60 | Olb or Or | 1 | 40 | 7-52 | |
| | | | | | | | | 95 | Or | 10 | | | |
| 34 | NE, NE, 6, 11S-29E | J. R. Baker | Rolling | 700 | Oby | 158 | 27 | 154 | Oc | 10+ | 40 | 5-52 | |
| 35 | NW, SW, 8, 12S-32E | N. P. Cheek | Bluff | 600 | Or | 92 | 24 | 88 | Or | 8 | 25 | 7-52 | |
| 36 | NE, SW, 11, 11S-29E | Will Dale | Rolling | 740 | Oh | 142 | 6 | 134 | Oc | 10+ | 112 | 5-52 | |
| 37 | SE, NE, 23, 10S-28E | Elmer Wise | do. | 630 | Oby | 123 | 18 | 120 | Oh or Oc | 10 | 60 | 7-52 | |
| 38 | SW, NW, 19, 9S-30E | M. E. Fitzgerald | do. | 850 | Ocy | 83 | ..... | 75 | Ocy or Oby | ½ | 48 | 8-52 | |
| 39 | NE, NW, 15, 11S-30E | Thomas Gray | Low hill | 610 | Olb | 100 | 8 | 43 | Olb | Seep | 35 | 7-52 | |
| 40 | NE, NW, 15, 10S-31E | W. E. Hale | Valley | 640 | Oc | 48 | 4 | 43 | Oc or Olb | ½ | 27 | 8-52 | |
| 41 | NE, NE, 6, 10S-31E | W. T. Hardison | Rolling | 660 | Oh | 82 | ..... | 70 | Oc or Olb | 1+ | 47 | 8-52 | |
| 42 | NW, NE, 6, 10S-31E | Hale Johnson | do. | 660 | Oh | 62 | ..... | 60 | Oc | 3 | ..... | ..... | |
| 43 | NW, NE, 18, 10S-28E | G. E. Ladd | do. | 600 | Ocy | 72 | 24 | 55 | Oby* | 6 | 35 | 7-52 | |
| 44 | NE, SE, 3, 12S-32E | L. J. Linsley | Bluff | 620 | Or | 102 | 39 | 96 | Or or Op | 10+ | 40 | 7-52 | Hydrogen sulfide odor. |
| 45 | NE, NW, 12, 11S-29E | John Luster | Rolling | 630 | Oby | 157 | 5 | 152 | Oc | 10+ | 45 | 7-52 | |
| 46 | SE, SW, 3, 10S-29E | Lex Potts | Valley | 700 | Ol | 60 | 5 | 30 | Ocy* | 1 | 20 | 8-52 | |
| 47 | SE, SW, 16, 10S-33E | George Warren | Plain | 700 | Or | 84 | 6 | 18 | Or | Seep | 18 | 7-52 | |
| | | | | | | | | 80 | Or | 50 | | | |

* *Chemical analysis is available from the Tennessee Division of Geology.*



REFERENCE 11

# PRELIMINARY GEOLOGIC INVESTIGATIO

# FOR THE COLUMBIA DAM SITE -

# DUCK RIVER MILE 136.9

John M. Kellberg
Robert W. Allen

## SUMMARY

Core drilling operations have proven the geologic feasibility of a dam site at mile 136.9 on the Duck River. The rims and west abutment contain near-vertical solution cavities associated with joint controlled weathering in the Carters Limestone. Rock beneath the river, flood plains, and lower abutments consists of thinly interbedded limestone and shale of the Lebanon Limestone. Partial deterioration of the Lebanon along some shale horizons is indicated.

A fault zone 20 to 60 feet wide with vertical displacement of 10 to 14 feet was encountered beneath the east flood plain. Even though this zone will require special consideration, it is not serious enough to eliminate the site.

## INTRODUCTION

### Site Location

The Columbia dam site is at mile 136.9 on the Duck River in Maury County, Tennessee. The site is approximately two airline miles east-southeast of the courthouse in Columbia, Tennessee, and access is by Iron Bridge Road from Columbia.

## Scope of Investigations

Initial geologic studies at this site were started in March 1966, when seismic and surface investigations were made for a site at mile 136.7, some 1200 feet downstream. Drilling with wire line drills was started in June 1966 along the right, or east, rim of the lower site. Two potential rim lines were considered: (1) A prolongation of the axis along range C and (2) an offset line 1200 feet upstream along range P. Initial drilling along these lines indicated that rim treatment would be required at least as deep as the Carters-Lebanon contact. Along the C range this depth averaged 96.8 feet while along the P range drilling showed the depth to be an average of only 38.2 feet. With this information the recommendation was made to use the upstream or P range alignment for rim cutoff. Concurrently it was decided to shift the axis upstream to mile 136.9 and realign it slightly. Drilling continued along this new alignment on the right rim and dam axis. Along the left rim drilling was done upstream and essentially normal to the axis along the flank of the ridge forming the left abutment. In order to delineate a fault zone under the right flood plain, drill ranges were added 200 feet upstream and downstream from the baseline. When drilling ended on February 3, 1967, 161 holes totalling 17,709.4 linear feet had been drilled and logged (exhibit 1). Electric resistivity and gamma ray logs were run in selected holes to aid between-hole correlation of key stratigraphic horizons and potential clay seams. One hole on the left flood plain was inspected with Corps of Engineers borehole television equipment.

# REGIONAL GEOLOGY

## Physiography

The Columbia site lies in the Nashville Basin section of the Interior Low Plateau province as defined by Fenneman.[1] This ovoid basin is some 60 miles wide and 120 miles long with its major axis in a direction parallel to the Appalachian folds. It has a gently undulating surface whose altitude is about 600 feet above sea level, and is entirely surrounded by a more or less deeply dissected plateau known as the Highland Rim. The outline of the basin is extremely irregular, for outliers from the Highland Rim extend far out into the basin in the form of spurs and isolated hills.

A study of the topography of the area shows that the present surface of the basin is the result of the dissection of a nearly level or gently undulating plain, which, if restored, would have an altitude of between 900 and 1000 feet. This restored surface coincides with the summits of the hills and spurs and with the surface of the Highland Rim.

At some time in the geologic past accelerated erosion accompanying uplift along the northeast-southwest trending axis of the Cincinnati arch breached the cherty limestones flooring the old erosion surface and permitted more rapid erosion of the more soluble and softer underlying limestones. In this way the topographic basin was initially developed and gradually enlarged to its present size. The uplift of the region to its present altitude was not continuous, but occurred at several periods, separated by intervals of repose. The downward cutting of the streams was correspondingly interrupted.

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1. Fenneman, N. M., Physiography of the Eastern United States, McGraw-Hill Book Company, 1938.

Thus Duck River cut a rather broad valley down to about 400 feet below the surface of the old plain; and, when the region was again uplifted, cut a much narrower valley within this broad one. The remnants of the higher, broader valley are now found as terraces around elevation 630 in the Columbia area.

Structure

The Nashville topographic basin is an erosional reflection of an underlying structural dome. Running in a general northeast direction through central Kentucky and central Tennessee is a broad fold in the strata known as the Cincinnati arch. When contrasted with the highly folded rocks of east Tennessee, the strata of this structural feature may be classed as essentially horizontal. In reality, however, they are in very few places strictly horizontal but are generally slightly inclined away from the axis at dips varying from 10 to 15 feet to the mile. This regional dip is often modified or obscured by minor warping and cross folding. Minor faulting is not uncommon in the Nashville Basin area, but no large or extensive fault systems are present. To all appearances, the small normal faults are the result of adjustment to the warping and cross folding. They usually have displacements of less than 50 feet and normally do not exceed a mile in length. Jointing is the most prominent structural feature observable in rock outcrops. Normally there are two major sets of high-angle joints nearly at right angles to each other. The joint sets along with the bedding control the development of solution cavities in the limestones.

# SITE GEOLOGY

## Topography

At the dam site the bed of the Duck River is about elevation 552 and the channel is 300 feet wide. The axis is just upstream from the head of an island and the channel here is about 100 feet wider than normal as it spreads out to surround the island. Banks nearly 20 feet high flank both sides of the river and from the top of these a high flood plain or first-level terrace extends for approximately 400 feet on the right bank and 500 feet on the left bank to the base of the abutments. The right abutment rises steeply from elevation 575 to elevation 620, then flattens and gradually approaches elevation 650 along the right rim. This higher surface probably represents an older terrace level. The left abutment rises sharply from elevation 600 to nearly elevation 700 at the crest of the narrow north-south ridge forming the left rim of the reservoir. This ridge extends south from the axis nearly two miles forming the divide between Duck River and Lytle Creek.

## Stratigraphy

Four limestone formations of Ordovician age make up the bedrock that would be directly involved with construction of a dam at the Columbia site. These are the Hermitage, Carters, Lebanon, and Ridley Formations. Overlying bedrock are thicknesses of alluvial and residual material varying from nothing to over 33 feet. A brief description of the unconsolidated deposits and of the various limestones follows.

Overburden--The unconsolidated materials overlying bedrock can be divided into two categories: (1) Alluvial clays, silts, sands, and gravels deposited by the Duck River, and (2) residual clay and weathered rock derived

from the decomposition of the underlying limestone. Alluvial materials blanket the flood plain or low-level terrace extending from the river banks to the foot of the abutment slopes. The majority of the alluvial deposits is composed of silty to sandy clay containing lenses of gravel scattered near the base. The thickness of this material encountered in drilling varied from a minimum of 10.5 feet to a maximum of 33.5 feet and averaged 30 feet on the east and 17 feet on the west. Above flood plain level the overburden consists of residual clay derived from weathering of the underlying limestone. Pinnacles and detached boulders of partially weathered limestone are common throughout the overburden. The residuum was found to vary from a feather edge to a maximum of 32 feet and averaged 17.5 feet in thickness on the east rim, whereas the west rim had considerably more rock exposed at the surface.

Hermitage Formation--The Hermitage Formation has a total thickness of slightly over 70 feet in the vicinity of the Columbia dam site. Of this total a maximum of 67 feet was penetrated in drilling along range C on the right rim. The portion of the Hermitage encountered in the drilling is made up of thin-bedded to laminated argillaceous limestone and shale. The individual beds of limestone vary between 1 and 10 inches in thickness. These are separated by fissile, dark-gray to black shale partings ranging from paper thin laminae up to discrete beds as much as a foot thick. Because of the numerous shale partings, cores from the Hermitage soon break down into "poker chips" after a few weeks exposure.

Carters Limestone--An erosional unconformity separates the Hermitage Formation from the underlying Carters Limestone. Some time after the Carters was laid down, and prior to the deposition of the Hermitage, the area was uplifted slightly and the upper 10 feet or so of the Carters, including a

prominent bentonite bed, was removed by erosion. The average thickness based on drill holes that penetrated the entire formation is 67 feet. The rock varies from dark-gray to dove-gray colored. The texture varies from fine to medium or coarse grained. Much of the fine-grained limestone is very dense, dove colored, and characterized by extreme brittleness and conchoidal fracture. The remainder of the fine-grained limestone is subcrystalline and less dense. Medium-grained limestone may be either granular or crystalline. Fine- and medium-grained limestone seem to alternate with each other laterally and vertically. Dolomitic and fucoidal casts are common as are lenselike stringers and nodules of white to dark-gray chert. Bedding is commonly massive, much of it consisting of beds that vary between 1 and 4 feet in thickness. Some of the beds are separated by thin clay seams, possibly bentonitic. Sinkholes are common in the outcrop area of the Carters in the right rim as indicated on exhibit 7.

Lebanon Limestone--Drilling at the Columbia site indicates that the Lebanon Limestone averages 105 feet thick in this area. In contrast to the overlying Carters and the underlying Ridley, the Lebanon is a thin-bedded unit. Beds of blue to gray, fine- to coarse-grained, mottled, and banded limestone averaging from 2 to 3 inches in thickness are separated by partings of gray calcareous shale that range from a film up to 2 inches in thickness. Near the surface many of the shale partings are weathered sufficiently to be incipient clay seams. In cores obtained from depth, thin, persistent gypsum seams have developed in the shales. Approximately 45 feet below the top of the Lebanon, a prominent 0.8-foot-thick calcareous siltstone or claystone zone is present that was used as a key horizon--designated "LK"--for correlation between drill holes.

Ridley Limestone--The lowest geologic unit that will be directly involved in construction of a dam at the Columbia site is the Ridley Limestone. Drilling shows this formation to be 90 feet thick. In appearance the Ridley is very similar to the Carters; and if it were not for the intervening thin-bedded Lebanon Limestone, they would be practically indistinguishable. The Ridley consists chiefly of gray to bluish-gray, fine- to coarse-grained limestone. Some dolomitic beds are medium grained with a "sugary" texture. Thin shale partings are common between the massive--up to 4 feet thick--limestone beds. The Ridley is not exposed at the surface at the dam site, but the top of the formation is about 28 feet below the top of rock in the river channel, and it would be involved in curtain grouting under the dam. A key limestone horizon designated "R-2" was used in correlation between drill holes. The "R-2" horizon is the second of two distinctive layers at the top of the Ridley which are singularly free of shaly bands. It consists of a 0.5-foot unit at a depth of 6.5 to 7.5 feet below the Lebanon-Ridley contact.

## Structure

With the exception of the east rim area, the attitude of the bedding is essentially horizontal, being controlled by very gentle, broad undulations with dips usually less than one degree. The following dips were measured from control horizons on the geologic sections (exhibits 2, 3, 4, and 5).

Left flood plain - 0.2'/100' east; 0.87'/100' downstream

Right flood plain - 0.5'/100' west; horizontal upstream/downstream

Spillway:

Upstream of baseline - 1.0'/100' west; 1.0'/100' downstream
Downstream of baseline - 0.6'/100' east; 3.5'/100' downstream

Left Rim - 0.2'/100' east; horizontal upstream/ downstream

Right Rim - 0.7'/100' west; 4° to 6° downstream (northerly)

The most prominent structural feature at the site is a fault zone on the east side of the river. This zone was first recognized on the baseline between stations 40+00 and 41+33. Subsequent additional drilling allowed definition of the fault zone within the following limits:

| Drill Line Location | Station Limits of Fault Zone | Vertical Displacement |
|---|---|---|
| 200' upstream of baseline | 39+75 to 39+95 | 10' |
| Baseline | 40+64 to 41+30 | 10' |
| 200' downstream of baseline | 41+75 to 41+95 | 14' |

Measured vertical movement was defined from displacement of formation contacts and key horizons. On the geologic sections, the feature is defined as a "multiple fault zone." This term was chosen because of evidence of associated faulting, especially on the baseline, which indicated additional movement in a general north-northwest to south-southeast direction.

A very important structural feature at the site is jointing. These near-vertical fractures are particularly prominent in the Carters Limestone on the left abutment and rim. The following joint readings were observed at the site.

Carters Limestone - left (west) side:

Primary - N 55° - 60° W
N 40° - 50° E

Secondary - N 65° - 75° E

Carters Limestone - right (east) side:

Primary - N 60° - 70° W
N 80° - 85° E

Secondary - N 70° - 75° E
N 25° - 30° E

Lebanon Limestone - right (east) side:

Primary - N 70° - 72° E
N 10° - 12° W

Secondary - N 50° - 60° W
east-west

## ENGINEERING CONSIDERATIONS

### Quality of Rock

Physical quality of rock at the site varies considerably and must be related to the formation under consideration, whether the rock has been exposed to severe weathering, and how the rock is to be used. The following general comments apply to the formations most directly involved in the project.

Carters Limestone--The Carters Limestone is fine to coarse grained with shaly bands. Compressive strength normal to the bedding should range in excess of 9000 psi. Tensile strength will be moderate, depending on the location of shaly partings or other bedding weakness relative to the zone of greatest stress. Shear strength should be moderate to high in unweathered material. A specific gravity in the range of 2.6 to 2.7 will place its weight at an average 165 pounds per cubic foot in monolithic units. Quarry-run rock should average close to 96 pounds per cubic foot.

As a foundation material at the Columbia site, the Carters will create problems because of its weathered condition. In areas where it is no longer protected by the overlying Hermitage Formation, a deep, rectilinear, joint-controlled solution pattern is present. An example may be noted on the left (west) rim, where primary solution has developed along near-vertical joints with secondary weathering on bedding planes. The results of such weathering are massive pinnacles and isolated monoliths. Extensive treatment will be required to prevent leakage beneath any portion of the dam founded directly on this material (illustration 1).

The Carters may be satisfactory for riprap and concrete aggregate, but should be tested--see remarks under Construction Materials - Rock.

Lebanon Limestone--The Lebanon is composed of thinly interbedded limestone and shale (illustration 2). Where the formation is covered by 15 or more feet of Carters, weathering is usually limited to partial decomposition of a few thin shales. In areas of greater exposure, such as the flood plain, a more pronounced deterioration of shales and limestones was observed to the extent that some clay may be present on the bedding. Areas of total decomposition represented by clay-filled cavities were generally limited to the fault zone under the right flood plain. On all three drill lines which crossed the fault, weathering and cavities were more extensive on the east side of the zone. Observation of drill cores indicates that from 40 to 54 feet and 60 to 91 feet below the top of the formation, the physical character of the rock will allow rapid mechanical decomposition with alternate wetting and drying. The uppermost of these two zones includes the 6- to 8-inch-thick "LK Horizon" used as a key stratigraphic horizon to correlate between drill holes.

Specific physical characteristics of four core samples from the Lebanon are indicated on "Results of Rock Core Testing" supplied by the Singleton Laboratory (appendix A). Velocity readings on the list were determined by use of the laboratory "V" scope.

As a foundation material, the Lebanon should be carefully evaluated relative to the type structure and depth at which the structure is to be founded. Numerous isolated bedding planes contain a very thin film which becomes slippery when wet. Shear values on some "weak" or partially weathered shales may be quite low. Some cores contained gypsum layers ranging from a thin film up to one-tenth inch thick.

Where the Lebanon is covered by the Carters and can be quarried, the top 30 feet of the formation may be used for road, select filter or fill material. No portion of the Lebanon is suitable for use as exposed riprap.

Ridley Limestone--The lowest unit which might be involved in any construction is the Ridley Limestone. Core drill data indicate that this formation is 90 feet thick, and very similar in appearance to the Carters. It consists of fine- to coarse-grained, slightly banded limestone containing some chert.

The Ridley is not exposed at the surface in the immediate vicinity of the dam site, but will be involved in grouting operations beneath the flood plain and into the lower portions of the abutments. A key horizon in the Ridley is noted on the geologic sections as the "R-2 Horizon." Approximately 3 feet below "R-2," the formation contains a very persistent 0.1- to 0.2-foot weathered bedding plane. In some cases an open or filled cavity is associated with this horizon. Borehole television inspection of hole 47+00, 100' U. S. indicated an irregular, partially open cavity of less than 0.1 foot vertical dimension (illustration 3).

## Earthquake Potential

The Columbia area is considered to be seismically stable. Records published by Moneymaker[1] covering the earthquake history of Tennessee from 1699 to 1950 indicate that the nearest epicenter of a major quake is the New Madrid area over 170 miles to the northwest, while the closest epicenter of a minor quake is in the vicinity of Huntsville, Alabama, some 60 miles to the south. From all indications infrequent shocks felt in the Columbia area have

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1. Moneymaker, B. C., Journal of the Tennessee Academy of Science, Vol. 29, No. 3, 1954; Vol. 30, No. 3, 1955; Vol. 32, No. 2, 1957; Vol. 33, No. 3, 1958.

not exceeded an intensity of 5 on the Wood-Newman scale. That is, "Felt by most people, some breakage of dishes, windows, and plaster; disturbance of tall objects." Acceleration equivalents for this range approximate 20-30 $cm/sec^2$ or 0.02 g - 0.03 g.

Construction Materials

Rock--The Carters Limestone is widely used in the middle Tennessee area for all types of aggregate. It was used as coarse aggregate and sand for all concrete at the Gallatin Steam Plant. Normally there is no question as to its stability; however, results of tests performed on samples of the Carters from the quarry of the Columbia Rock Products Corporation raise some questions. The underground quarry is located approximately four miles northwest of the dam site near Godwin. Physical tests made in 1960 by the Tennessee Department of Highways gave the following results:

| | |
|---|---|
| Specific Gravity | 2.66 |
| Los Angeles Abrasion Loss | 23.8 percent |
| Sodium Sulphate Loss | 7.31 percent |

The losses indicated by these tests are somewhat higher than normal and it is suggested that any proposed source of aggregate from the Carters in this area be thoroughly tested before it is accepted.

Rock overlying the Carters--namely the Hermitage-- would not be suitable, and only the upper 30 feet of the underlying Lebanon would be selectively suitable for use on construction.

Soil--Soil investigations were carried out by the Singleton Laboratory and are covered in a report entitled "Upper Duck River - Columbia Project - Soil Investigation" issued November 28, 1966, by J. C. McCraw.

## RECOMMENDATIONS

The following recommendations are made concerning the site at mile 136.9.

Main Dam:

1. Between stations 37+00 and 50+00 the Lebanon Limestone has many horizons which imply low shear values. It is suggested that the entire thickness of Lebanon between these stations should be considered as a questionable unit rather than attempting to evaluate the integrity and continuity of any given individual horizon.

2. Irrespective of the type structure which may be built, a grout curtain is recommended if the hydrostatic head is to exceed 25 feet. From station 37+00 to station 50+00, the curtain should extend a minimum of 40 feet into the Ridley Limestone.

3. Any portion of the Lebanon Limestone which may be exposed in foundation preparation for a concrete dam should be covered with concrete or "gunite" as soon as possible to avoid detarioration.

4. The Carters Limestone in the left abutment, if beneath pool level, should be treated with a grouted cutoff curtain to a distance of at least 100 feet beyond the end of the structure.

Spillway:

1. Where the Lebanon Limestone is to be exposed to high volume, high velocity flow or a hydraulic jump, severe erosion may be anticipated. If a side-hill spillway is considered, paving may be required in the Lebanon. For geologic section along station 35+00, see exhibit 6.

Right (East) Rim:

1. If pool level is to exceed elevation 610, and especially if an earth dike is to be constructed on the right rim, it is recommended that the Carters Limestone should be thoroughly treated with angle grout holes. This grout curtain should extend at least 10 feet into the Lebanon.

2. Two springs situated on the north flank and at the base of the right rim should be continuously gauged during and after construction to evaluate possible leakage.

Left (West) Rim:

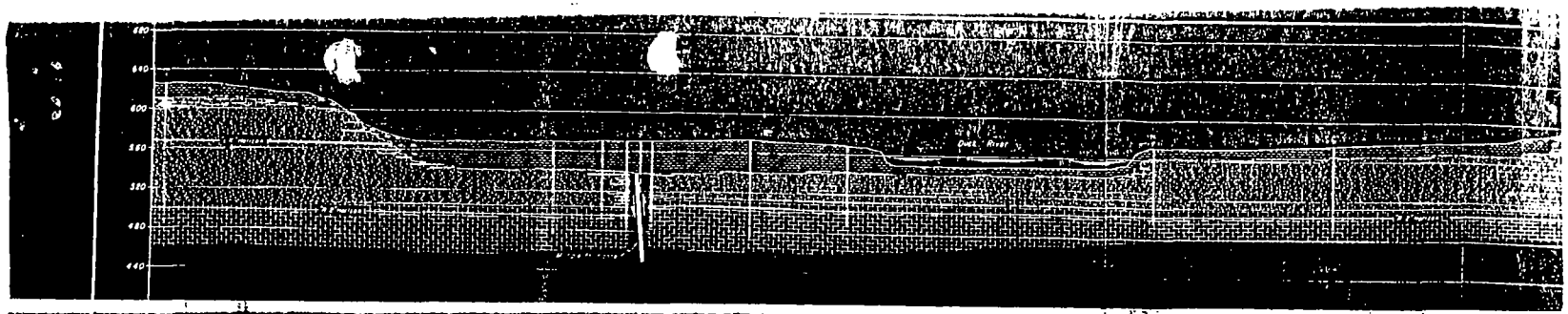
1. Much of the left rim is capped by the Hermitage Formation. When this is the case, solution in the underlying Carters Limestone is considerably reduced. It is suggested that, for a pool level at elevation 630 or 640, no grout curtain should be required on the left rim except where the distance through the rim at pool level is less than 1000 feet.

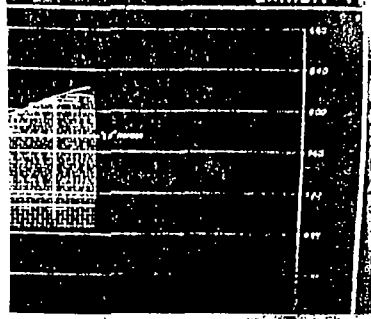
## CONCLUSION

There is no apparent physical reason why the Columbia site at mile 136.9 could not sustain a properly designed hydro structure. Physical quality of the rock will remain very similar within several thousand feet upstream or downstream of mile 136.9. The fault zone would probably move into the east abutment or rim area at 2000 feet upstream, but it appears to follow the river downstream for a considerably greater distance.

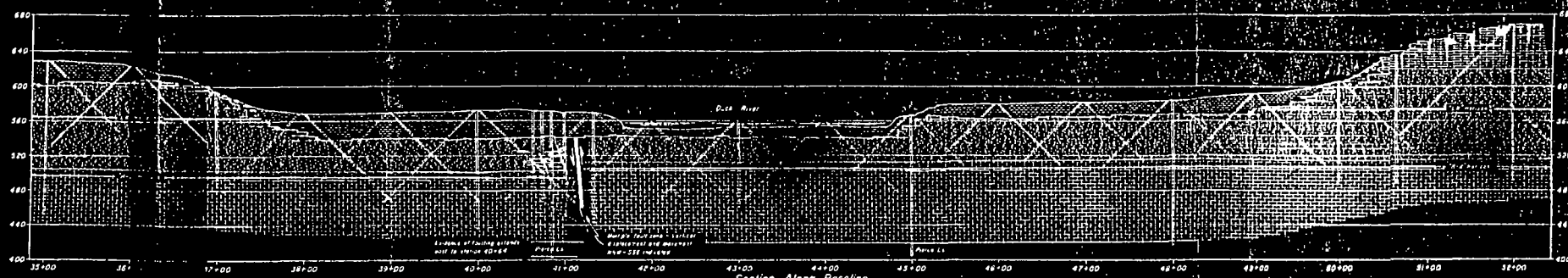
Graphic logs of all baseline drill holes are included in exhibits 8 to 21. These logs indicate weathering and structural features, and are intended for correlation of data between holes.

EXHIBIT

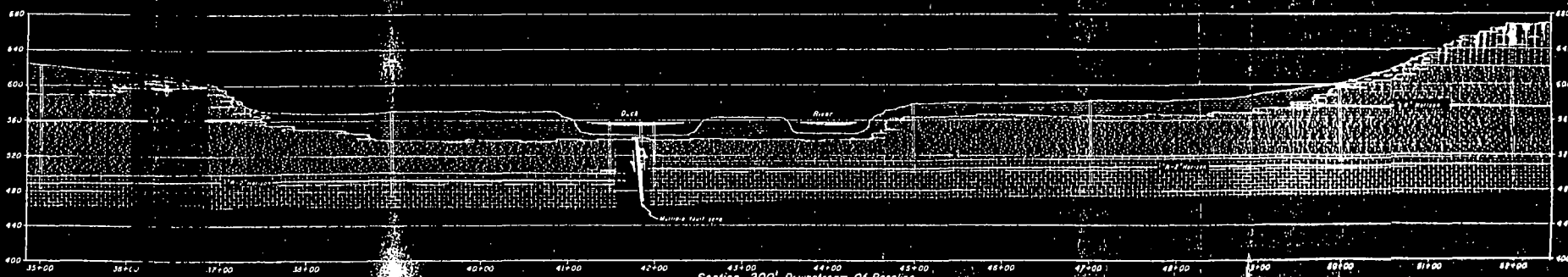


Section 200' Upstream Of Baseline




Section Along Baseline




Section 200' Downstream Of Baseline

LEGEND:

- Soil — Residuum / Alluvium
- Carters Formation — Light gray, coarse to fine-grained limestone.
- Lebanon Formation — Dark gray, thinly interbedded limestone and shale. "L.K." is a key shale horizon.
- Ridley Formation — Medium to light gray, fine to coarse-grained limestone. "R-2" is a key limestone horizon.

Pierce Formation — Gray limestone - 80' ±

Mechanicsburg Formation — Thick-bedded limestone

NOTES:

1. The Carters limestone exhibits many steep joint controlled, solution crevices.
2. The Lebanon formation contains many very thin, partially decomposed, shale horizons and a number of gypsum layers from 0.1' to 0.01' thick. From 40' to 54' and 60' to 81' below the Carters contact, the physical character of the rock will allow rapid mechanical decomposition on exposure.
3. The Ridley limestone contains a very persistent 0.1' bedding plane cavity, partially clay filled, at approximately 3.0' below the "R-2" horizon.
4. The zone of major vertical displacement associated with the fault is indicated on the sections; however, additional secondary faults with vertical and horizontal displacement and associated weathering will be encountered, principally to the east.
5. Only features of major weathering are indicated on these sections.
6. For drill hole location, see drawing # DR1 dwg. 1246.

SCALE: 40 0 40 80 120 Feet

COLUMBIA UNIT
DUCK RIVER-MILE 136.9

# GEOLOGIC SECTIONS BASELINE, 200' U.S. & 200' D.S.

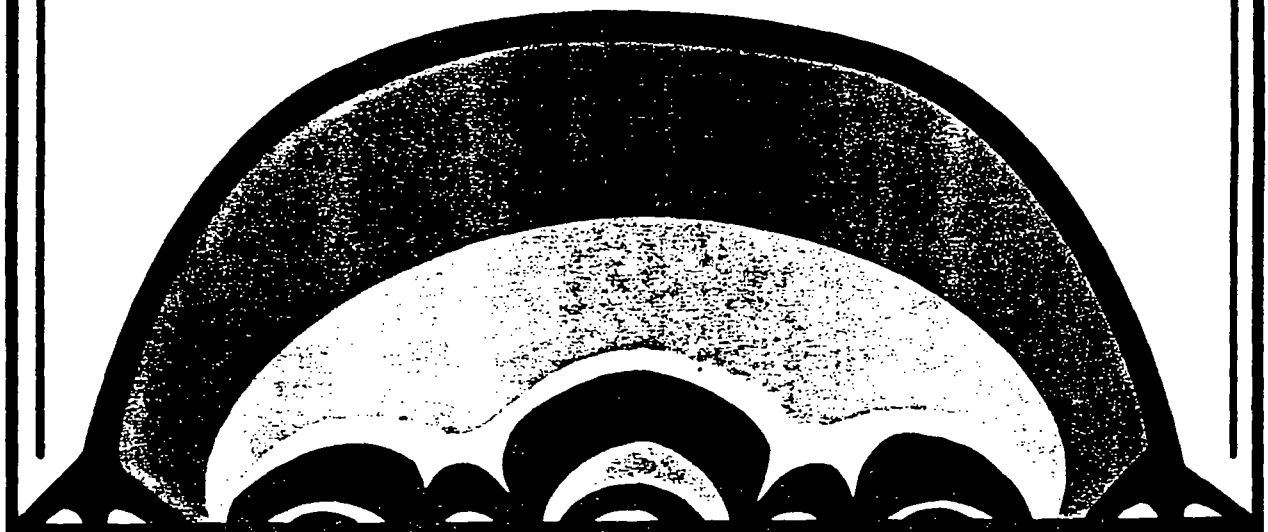
DUCK RIVER PROJECT
TENNESSEE VALLEY AUTHORITY
DIVISION OF ENGINEERING DESIGN

| SUBMITTED | RECOMMENDED | APPROVED |
|---|---|---|
| [illegible] | [illegible] | [illegible] |

19

REFERENCE 12

# GROUNDWATER



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# GROUNDWATER

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**Table 2.2 Range of Values of Hydraulic Conductivity and Permeability**

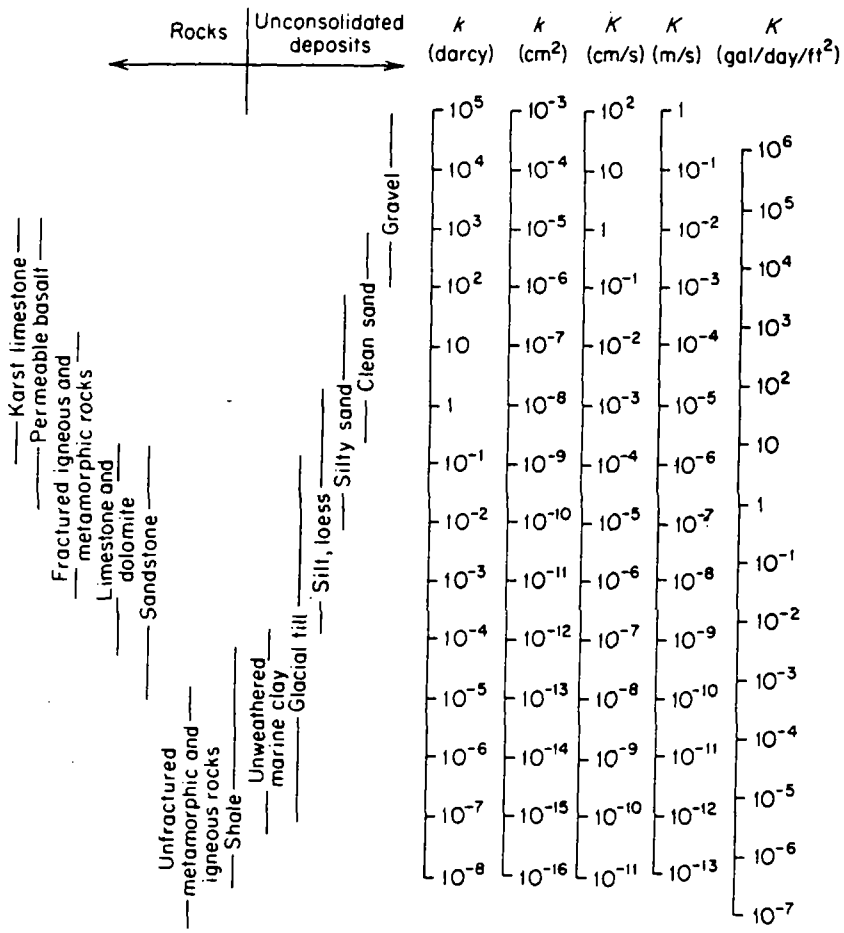


**Table 2.3 Conversion Factors for Permeability and Hydraulic Conductivity Units**

| | Permeability, $k$* | | | Hydraulic conductivity, $K$ | | |
|---|---|---|---|---|---|---|
| | cm² | ft² | darcy | m/s | ft/s | gal/day/ft² |
| cm² | 1 | $1.08 \times 10^{-3}$ | $1.01 \times 10^{8}$ | $9.80 \times 10^{2}$ | $3.22 \times 10^{3}$ | $1.85 \times 10^{9}$ |
| ft² | $9.29 \times 10^{2}$ | 1 | $9.42 \times 10^{10}$ | $9.11 \times 10^{5}$ | $2.99 \times 10^{6}$ | $1.71 \times 10^{12}$ |
| darcy | $9.87 \times 10^{-9}$ | $1.06 \times 10^{-11}$ | 1 | $9.66 \times 10^{-6}$ | $3.17 \times 10^{-5}$ | $1.82 \times 10^{1}$ |
| m/s | $1.02 \times 10^{-3}$ | $1.10 \times 10^{-6}$ | $1.04 \times 10^{5}$ | 1 | 3.28 | $2.12 \times 10^{6}$ |
| ft/s | $3.11 \times 10^{-4}$ | $3.35 \times 10^{-7}$ | $3.15 \times 10^{4}$ | $3.05 \times 10^{-1}$ | 1 | $5.74 \times 10^{5}$ |
| gal/day/ft² | $5.42 \times 10^{-10}$ | $5.83 \times 10^{-13}$ | $5.49 \times 10^{-2}$ | $4.72 \times 10^{-7}$ | $1.74 \times 10^{-6}$ | 1 |

*To obtain $k$ in ft², multiply $k$ in cm² by $1.08 \times 10^{-3}$.

REFERENCE 13

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Information about Maury County Water System.

BVWST Project 52012.081
BVWST File
October 5, 1992
1:30 p.m.

To: Linda Dunn
Company: Maury County Water System
Phone No.: (615) 381-3690

Recorded by: Kenneth Lemons

The Maury County Water System does not have any water lines within 5 miles of the Monsanto site. That area is served by the Columbia Water Department.

U.S. EPA REGION IV

# SDMS

## Unscannable Material Target Sheet

DocID: 10707665 Site ID: TND004048104

Site Name: Monsanto Co. Inc.

Nature of Material:

| | | | |
|---|---|---|---|
| Map: | ☑ | Computer Disks: | ☐ |
| Photos: | ☐ | CD-ROM: | ☐ |
| Blueprints: | ☐ | Oversized Report: | ☐ |
| Slides: | ☐ | Log Book: | ☐ |

Other (describe): Radius Map (Ref. 14)

Amount of material:

* Please contact the appropriate Records Center to view the material *

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

REFERENCE 15

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company
Connections to Main Water Lines.

BVWST Project 52012.081
December 4, 1992
9:20 a.m.

To: Kelly Powell
Company: Columbia Water System
Phone No.: (615) 388-4833

Recorded by: Ken Lemons

Mr. Powell told me that, though there will be exceptions in both directions, it is safe to assume that houses within 800 to 1000 feet of a main water line are connected to the system, and houses further out are not connected. Large subdivisions and nearly all of Columbia itself are connected to the water system.

## Table 6. Household, Family, and Group Quarters Characteristics: 1990

[For definitions of terms and meanings of symbols, see text]

| State County Place and [In Selected States] County Subdivision | Persons in households | All households | Family households: Total | Family households: Married-couple family | Family households: Female householder, no husband present | Nonfamily households: Total | Householder living alone: Total | Householder living alone, 65 years and over: Total | Householder living alone, 65 years and over: Female | Persons per—: Household | Persons per—: Family | Persons in group quarters: Total | Persons in group quarters: Institutionalized persons | Persons in group quarters: Other persons in group quarters |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| The State | 4 748 056 | 1 853 725 | 1 348 019 | 1 059 548 | 232 600 | 505 706 | 442 128 | 178 877 | 143 108 | 2.56 | 3.06 | 129 129 | 65 389 | 63 740 |
| COUNTY | | | | | | | | | | | | | | |
| Anderson County | 67 985 | 27 384 | 19 844 | 16 181 | 2 958 | 7 538 | 6 911 | 3 117 | 2 547 | 2.47 | 2.98 | 655 | 578 | 77 |
| Bedford County | 30 031 | 11 808 | 8 768 | 7 087 | 1 280 | 2 840 | 2 536 | 1 280 | 1 017 | 2.59 | 3.01 | 380 | 343 | 37 |
| Benton County | 14 255 | 5 784 | 4 333 | 3 732 | 465 | 1 451 | 1 348 | 751 | 603 | 2.46 | 2.90 | 269 | 228 | 41 |
| Bledsoe County | 8 608 | 3 261 | 2 522 | 2 104 | 300 | 739 | 670 | 320 | 240 | 2.64 | 3.06 | 1 081 | 1 051 | 30 |
| Blount County | 84 463 | 33 624 | 25 344 | 21 284 | 3 237 | 8 280 | 7 400 | 3 387 | 2 661 | 2.51 | 2.94 | 1 506 | 1 044 | 462 |
| Bradley County | 72 043 | 27 604 | 21 157 | 17 518 | 2 841 | 6 447 | 5 714 | 2 277 | 1 826 | 2.61 | 3.02 | 1 669 | 539 | 1 130 |
| Campbell County | 34 783 | 13 150 | 10 158 | 8 036 | 1 702 | 2 992 | 2 788 | 1 466 | 1 192 | 2.65 | 3.07 | 294 | 285 | 11 |
| Cannon County | 10 354 | 3 980 | 3 035 | 2 574 | 351 | 945 | 872 | 470 | 375 | 2.60 | 3.03 | 111 | 111 | - |
| Carroll County | 28 860 | 10 727 | 8 013 | 6 612 | 1 092 | 2 714 | 2 531 | 1 435 | 1 148 | 2.50 | 2.95 | 654 | 366 | 288 |
| Carter County | 50 225 | 20 189 | 14 979 | 12 280 | 2 134 | 5 210 | 4 779 | 2 314 | 1 839 | 2.49 | 2.94 | 1 280 | 749 | 531 |
| Cheatham County | 26 840 | 9 515 | 7 748 | 6 679 | 776 | 1 767 | 1 534 | 587 | 436 | 2.82 | 3.15 | 300 | 180 | 120 |
| Chester County | 11 791 | 4 558 | 3 505 | 2 833 | 446 | 1 053 | 963 | 514 | 422 | 2.59 | 3.01 | 1 028 | 187 | 841 |
| Claiborne County | 25 533 | 9 629 | 7 579 | 6 286 | 1 007 | 2 050 | 1 910 | 935 | 772 | 2.65 | 3.08 | 604 | 210 | 394 |
| Clay County | 7 158 | 2 856 | 2 144 | 1 748 | 301 | 711 | 649 | 318 | 214 | 2.51 | 2.93 | 80 | 71 | 9 |
| Cocke County | 28 840 | 11 191 | 8 483 | 6 551 | 1 500 | 2 708 | 2 470 | 1 138 | 882 | 2.58 | 3.00 | 301 | 270 | 31 |
| Coffee County | 39 855 | 15 500 | 11 727 | 9 693 | 1 558 | 3 773 | 3 431 | 1 588 | 1 284 | 2.57 | 3.01 | 484 | 452 | 32 |
| Crockett County | 13 103 | 5 183 | 3 866 | 3 141 | 567 | 1 327 | 1 257 | 706 | 623 | 2.53 | 3.00 | 275 | 275 | - |
| Cumberland County | 34 207 | 13 426 | 10 451 | 8 842 | 1 286 | 2 975 | 2 688 | 1 288 | 1 038 | 2.55 | 2.92 | 529 | 529 | - |
| Davidson County | 489 680 | 207 530 | 131 395 | 95 592 | 29 555 | 76 135 | 62 830 | 18 288 | 14 980 | 2.36 | 2.97 | 21 096 | 10 317 | 10 779 |
| Decatur County | 10 330 | 4 216 | 3 109 | 2 600 | 391 | 1 107 | 1 032 | 607 | 481 | 2.45 | 2.91 | 142 | 142 | - |
| DeKalb County | 14 237 | 5 696 | 4 316 | 3 574 | 584 | 1 380 | 1 280 | 692 | 563 | 2.50 | 2.93 | 123 | 106 | 17 |
| Dickson County | 34 532 | 13 019 | 10 099 | 8 188 | 1 530 | 2 920 | 2 648 | 1 285 | 1 007 | 2.65 | 3.06 | 529 | 389 | 140 |
| Dyer County | 34 343 | 13 617 | 9 823 | 7 888 | 1 643 | 3 694 | 3 380 | 1 773 | 1 435 | 2.52 | 3.01 | 511 | 474 | 37 |
| Fayette County | 25 110 | 8 453 | 6 717 | 5 038 | 1 334 | 1 736 | 1 576 | 765 | 556 | 2.97 | 3.40 | 449 | 436 | 13 |
| Fentress County | 14 558 | 5 511 | 4 258 | 3 415 | 665 | 1 253 | 1 165 | 585 | 439 | 2.64 | 3.07 | 110 | 110 | - |
| Franklin County | 33 429 | 12 680 | 9 903 | 8 412 | 1 135 | 2 777 | 2 530 | 1 312 | 1 061 | 2.64 | 3.04 | 1 296 | 314 | 982 |
| Gibson County | 45 568 | 18 361 | 13 472 | 10 708 | 2 240 | 4 889 | 4 573 | 2 580 | 2 114 | 2.48 | 2.98 | 747 | 644 | 103 |
| Giles County | 25 336 | 9 832 | 7 454 | 6 038 | 1 116 | 2 378 | 2 218 | 1 166 | 981 | 2.58 | 3.02 | 405 | 205 | 200 |
| Grainger County | 16 912 | 6 394 | 5 076 | 4 281 | 591 | 1 318 | 1 217 | 580 | 450 | 2.64 | 3.02 | 183 | 146 | 37 |
| Greene County | 54 175 | 21 482 | 16 280 | 13 280 | 2 295 | 5 202 | 4 747 | 2 120 | 1 687 | 2.52 | 2.94 | 1 378 | 727 | 651 |
| Grundy County | 13 157 | 4 784 | 3 743 | 3 048 | 534 | 1 041 | 976 | 522 | 412 | 2.75 | 3.18 | 205 | 193 | 12 |
| Hamblen County | 49 750 | 19 428 | 14 795 | 11 886 | 2 314 | 4 634 | 4 138 | 1 628 | 1 313 | 2.56 | 2.97 | 730 | 525 | 205 |
| Hamilton County | 279 044 | 111 799 | 78 964 | 60 780 | 15 042 | 32 835 | 29 005 | 11 591 | 9 488 | 2.50 | 3.02 | 6 492 | 3 622 | 2 870 |
| Hancock County | 6 371 | 2 464 | 1 904 | 1 505 | 321 | 560 | 532 | 269 | 212 | 2.65 | 3.07 | 168 | 168 | - |
| Hardeman County | 22 599 | 8 276 | 6 190 | 4 534 | 1 358 | 2 086 | 1 887 | 964 | 751 | 2.73 | 3.22 | 786 | 770 | 16 |
| Hardin County | 22 350 | 8 726 | 6 633 | 5 400 | 882 | 2 093 | 1 940 | 976 | 784 | 2.56 | 3.00 | 283 | 263 | 20 |
| Hawkins County | 44 232 | 17 167 | 13 223 | 11 100 | 1 624 | 3 944 | 3 638 | 1 671 | 1 334 | 2.58 | 2.98 | 333 | 299 | 34 |
| Haywood County | 19 240 | 7 014 | 5 150 | 3 566 | 1 320 | 1 864 | 1 708 | 905 | 703 | 2.74 | 3.28 | 197 | 59 | 138 |
| Henderson County | 21 630 | 8 527 | 6 466 | 5 383 | 820 | 2 061 | 1 922 | 975 | 765 | 2.54 | 2.97 | 214 | 212 | 2 |
| Henry County | 27 458 | 11 362 | 8 216 | 6 743 | 1 126 | 3 146 | 2 928 | 1 616 | 1 282 | 2.42 | 2.89 | 432 | 388 | 44 |
| Hickman County | 15 715 | 5 979 | 4 608 | 3 863 | 526 | 1 368 | 1 229 | 619 | 505 | 2.63 | 3.04 | 1 038 | 1 038 | - |
| Houston County | 6 642 | 2 603 | 2 039 | 1 706 | 261 | 564 | 504 | 336 | 248 | 2.55 | 2.98 | 176 | 163 | 13 |
| Humphreys County | 15 551 | 6 063 | 4 593 | 3 844 | 561 | 1 470 | 1 373 | 665 | 514 | 2.56 | 3.01 | 244 | 110 | 134 |
| Jackson County | 9 178 | 3 642 | 2 782 | 2 303 | 334 | 860 | 806 | 475 | 368 | 2.52 | 2.94 | 121 | 119 | 2 |
| Jefferson County | 31 415 | 12 329 | 9 510 | 8 018 | 1 144 | 2 819 | 2 530 | 1 192 | 940 | 2.55 | 2.94 | 1 601 | 445 | 1 156 |
| Johnson County | 13 809 | 5 406 | 4 081 | 3 280 | 599 | 1 325 | 1 230 | 610 | 464 | 2.52 | 2.96 | 157 | 145 | 12 |
| Knox County | 323 400 | 133 639 | 90 961 | 71 679 | 15 479 | 42 678 | 36 861 | 12 982 | 10 642 | 2.42 | 2.97 | 12 349 | 3 288 | 9 061 |
| Lake County | 6 067 | 2 418 | 1 735 | 1 328 | 323 | 683 | 625 | 343 | 282 | 2.50 | 3.00 | 1 072 | 1 051 | 21 |
| Lauderdale County | 22 906 | 8 433 | 6 361 | 4 846 | 1 259 | 2 072 | 1 888 | 1 059 | 842 | 2.68 | 3.16 | 893 | 884 | 9 |
| Lawrence County | 34 892 | 13 336 | 10 265 | 8 665 | 1 291 | 3 073 | 2 884 | 1 566 | 1 317 | 2.62 | 3.06 | 311 | 302 | 9 |
| Lewis County | 9 098 | 3 530 | 2 606 | 2 179 | 329 | 927 | 850 | 451 | 363 | 2.58 | 3.06 | 149 | 136 | 13 |
| Lincoln County | 27 910 | 10 881 | 8 230 | 6 812 | 1 087 | 2 651 | 2 455 | 1 376 | 1 090 | 2.57 | 3.01 | 367 | 359 | 8 |
| Loudon County | 30 926 | 12 158 | 9 289 | 7 667 | 1 304 | 2 869 | 2 636 | 1 327 | 1 006 | 2.54 | 2.96 | 329 | 329 | - |
| McMinn County | 41 710 | 16 361 | 12 458 | 10 275 | 1 751 | 3 903 | 3 600 | 1 795 | 1 425 | 2.55 | 2.98 | 673 | 446 | 227 |
| McNairy County | 22 180 | 8 834 | 6 678 | 5 382 | 824 | 2 156 | 2 014 | 1 073 | 863 | 2.51 | 2.96 | 342 | 342 | - |
| Macon County | 15 617 | 6 188 | 4 711 | 4 027 | 522 | 1 448 | 1 356 | 707 | 577 | 2.57 | 3.00 | 89 | 56 | 33 |
| Madison County | 75 515 | 29 609 | 21 301 | 15 850 | 4 504 | 8 308 | 7 387 | 3 226 | 2 554 | 2.55 | 3.06 | 2 467 | 841 | 1 626 |
| Marion County | 24 645 | 9 215 | 7 171 | 5 638 | 1 032 | 2 044 | 1 873 | 963 | 781 | 2.67 | 3.08 | 215 | 206 | 9 |
| Marshall County | 21 246 | 8 266 | 6 120 | 4 980 | 861 | 2 146 | 1 954 | 980 | 779 | 2.57 | 3.04 | 291 | 229 | 62 |
| Maury County | 54 073 | 20 606 | 15 552 | 12 280 | 2 622 | 5 054 | 4 554 | 2 052 | 1 680 | 2.62 | 3.07 | 739 | 688 | 51 |
| Meigs County | 7 921 | 2 996 | 2 333 | 1 958 | 261 | 663 | 592 | 255 | 194 | 2.64 | 3.00 | 112 | 112 | - |
| Monroe County | 29 940 | 11 383 | 8 761 | 7 231 | 1 163 | 2 592 | 2 385 | 1 167 | 917 | 2.63 | 3.06 | 601 | 317 | 284 |
| Montgomery County | 93 516 | 34 345 | 26 914 | 22 284 | 3 712 | 7 431 | 6 228 | 2 071 | 1 639 | 2.72 | 3.09 | 6 982 | 472 | 6 510 |
| Moore County | 4 714 | 1 734 | 1 391 | 1 222 | 112 | 343 | 327 | 160 | 136 | 2.72 | 3.11 | 7 | 7 | - |
| Morgan County | 16 011 | 5 841 | 4 621 | 3 746 | 680 | 1 220 | 1 119 | 564 | 432 | 2.74 | 3.13 | 1 289 | 1 289 | - |
| Obion County | 31 399 | 12 412 | 9 219 | 7 624 | 1 279 | 3 193 | 2 950 | 1 586 | 1 280 | 2.53 | 3.00 | 310 | 290 | 20 |
| Overton County | 17 435 | 6 734 | 5 288 | 4 404 | 645 | 1 446 | 1 368 | 745 | 591 | 2.59 | 2.99 | 201 | 192 | 9 |
| Perry County | 6 480 | 2 512 | 1 905 | 1 600 | 196 | 607 | 568 | 300 | 232 | 2.57 | 3.02 | 152 | 152 | - |
| Pickett County | 4 484 | 1 788 | 1 330 | 1 105 | 189 | 454 | 430 | 239 | 184 | 2.52 | 2.99 | 54 | 49 | 5 |
| Polk County | 13 530 | 5 092 | 4 010 | 3 373 | 455 | 1 082 | 980 | 519 | 418 | 2.66 | 3.05 | 106 | 106 | - |
| Putnam County | 48 419 | 19 753 | 13 994 | 11 578 | 1 913 | 5 759 | 4 737 | 1 945 | 1 580 | 2.45 | 2.93 | 2 954 | 534 | 2 420 |
| Rhea County | 23 630 | 9 186 | 6 985 | 5 606 | 1 088 | 2 200 | 2 022 | 984 | 779 | 2.57 | 3.00 | 706 | 410 | 296 |
| Roane County | 46 747 | 18 453 | 13 987 | 11 612 | 1 831 | 4 466 | 4 126 | 1 970 | 1 582 | 2.53 | 2.98 | 480 | 434 | 46 |
| Robertson County | 41 045 | 14 801 | 11 886 | 9 903 | 1 537 | 2 915 | 2 623 | 1 283 | 980 | 2.77 | 3.14 | 449 | 449 | - |
| Rutherford County | 113 372 | 42 118 | 31 225 | 25 678 | 4 272 | 10 893 | 8 545 | 2 671 | 2 136 | 2.69 | 3.14 | 5 198 | 1 458 | 3 740 |
| Scott County | 18 188 | 6 534 | 5 128 | 4 130 | 765 | 1 406 | 1 311 | 694 | 563 | 2.78 | 3.21 | 169 | 169 | - |
| Sequatchie County | 8 778 | 3 287 | 2 565 | 2 087 | 363 | 732 | 656 | 322 | 252 | 2.67 | 3.05 | 85 | 85 | - |
| Sevier County | 50 384 | 19 520 | 15 091 | 12 708 | 1 653 | 4 429 | 3 935 | 1 581 | 1 239 | 2.58 | 2.96 | 649 | 582 | 67 |
| Shelby County | 803 085 | 303 571 | 212 078 | 144 773 | 56 404 | 91 493 | 77 690 | 25 382 | 20 395 | 2.65 | 3.22 | 23 245 | 12 160 | 11 085 |
| Smith County | 13 598 | 5 358 | 4 151 | 3 578 | 447 | 1 207 | 1 127 | 643 | 512 | 2.61 | 3.03 | 145 | 134 | 11 |
| Stewart County | 9 285 | 3 678 | 2 812 | 2 462 | 251 | 866 | 793 | 444 | 344 | 2.53 | 2.93 | 104 | 96 | 8 |
| Sullivan County | 141 440 | 56 729 | 42 516 | 36 372 | 5 532 | 14 213 | 13 048 | 5 674 | 4 680 | 2.49 | 2.93 | 2 147 | 1 361 | 786 |
| Sumner County | 102 086 | 36 850 | 29 511 | 24 907 | 3 545 | 7 339 | 6 384 | 2 579 | 2 083 | 2.77 | 3.13 | 1 216 | 637 | 579 |
| Tipton County | 37 301 | 13 035 | 10 345 | 8 119 | 1 780 | 2 690 | 2 410 | 1 190 | 924 | 2.86 | 3.27 | 267 | 267 | - |
| Trousdale County | 5 786 | 2 261 | 1 715 | 1 402 | 241 | 546 | 512 | 285 | 207 | 2.56 | 3.01 | 125 | 100 | 25 |
| Unicoi County | 16 318 | 6 621 | 4 938 | 4 074 | 653 | 1 683 | 1 566 | 864 | 700 | 2.46 | 2.91 | 231 | 220 | 11 |
| Union County | 13 573 | 4 932 | 3 992 | 3 325 | 506 | 940 | 841 | 395 | 300 | 2.75 | 3.10 | 121 | 90 | 31 |
| Van Buren County | 4 841 | 1 799 | 1 461 | 1 199 | 190 | 348 | 322 | 146 | 105 | 2.69 | 3.06 | 5 | 5 | - |
| Warren County | 32 597 | 12 681 | 9 601 | 7 961 | 1 386 | 3 080 | 2 834 | 1 404 | 1 152 | 2.57 | 3.01 | 395 | 381 | 14 |
| Washington County | 67 881 | 28 823 | 18 375 | 14 537 | 3 790 | 10 448 | 9 004 | 3 632 | 2 945 | 2.45 | 2.95 | 4 424 | 2 017 | 2 407 |
| Wayne County | 13 700 | 5 174 | 4 079 | 3 448 | 482 | 1 095 | 1 011 | 551 | 448 | 2.65 | 3.00 | 226 | 206 | 20 |
| Weakley County | 29 860 | 11 992 | 8 589 | 7 194 | 1 076 | 3 403 | 2 928 | 1 473 | 1 200 | 2.49 | 2.96 | 2 403 | 479 | 1 924 |
| White County | 19 880 | 7 722 | 5 986 | 4 889 | 765 | 1 736 | 1 622 | 915 | 725 | 2.57 | 2.99 | 210 | 192 | 18 |
| Williamson County | 80 309 | 27 989 | 23 906 | 20 255 | 2 228 | 4 083 | 3 146 | 1 389 | 1 117 | 2.86 | 3.20 | 713 | 699 | 14 |
| Wilson County | 67 110 | 24 070 | 19 610 | 16 719 | 2 249 | 4 460 | 3 810 | 1 688 | 1 336 | 2.79 | 3.13 | 565 | 271 | 294 |



NOTE: The population counts set forth herein are subject to possible correction for undercount or overcount. The United States Department of Commerce is considering whether to correct these counts and will publish corrected counts, if any, not later than July 15, 1991.

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

REFERENCE 17

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company
Girl Scout Camp on Monsanto Property

BVWST Project 52012.081
BVWST File
November 17, 1992
10:45 a.m.

To: Susan Shields
Company: Girl Scouts Service Center
Phone No.: (615) 388-0439

Recorded by: Ken Lemons

The Girl Scouts use the camp on Monsanto Road between March and September every year. There are 700 Girl Scouts in Maury County, but only a small portion are using the camp at any given time. The camp serves as a day camp for 125 girls at most.

When the camp is in use, water is hauled in for drinking water purposes, and the well water is used only for washing.

Monsanto

REFERENCE 18

W. W. PERDUE
Plant Manager

Monsanto Chemical Company
Columbia, Tennessee 38401
Phone: (615) 388-3431

January 16, 1991

CERTIFIED MAIL RETURN RECEIPT REQUESTED

Mr. Tom Tiesler, Director
Tennessee Division of Solid Waste Management
Department of Health and Environment
Fourth Floor, Customs House
Nashville, TN 37247-3530

Dear Mr. Tiesler:

Attached are the second quarter 1990 groundwater sampling results as required by the Monsanto Company, Columbia, Tennessee Plant Hydrologic Monitoring Plan.

Our groundwater sampling is performed by a contract firm, Post, Buckley, Schuh and Jernigan, Inc., located in Nashville, Tennessee. During the fourth quarter 1990 sampling episode, we discovered that a plastic graduated cylinder, used by PBSJ for sample collection, was causing elemental phosphorus contamination of water samples. The cylinder was immediately replaced with a glass cylinder which eliminated the problem.

Since the above problem was corrected at the beginning of the sampling episode, the fourth quarter elemental phosphorus analyses on water samples are correct; however, it appears that some of the second and third quarter elemental phosphorus analyses have been biased upward due to contamination from the plastic cylinder. The indicated higher phosphorus levels were noted in the Greenlick Creek and Ginn Creek water samples which, since mid-1988, had been running in the 2-5 parts per trillion range. During the 1990 second and third quarters, the phosphorus content in the samples became erratic ranging from 2-130 PPT. Following replacement of the plastic cylinder, the fourth quarter creek samples all indicated 2 PPT.

If you have questions concerning the above discussion or need further information, please contact me by telephone at 615-388-3431.

Sincerely,

William S. Richey
Environmental Superintendent

/st

Attachment

MONSANTO COMPANY
COLUMBIA, TENNESSEE PLANT
HYDROLOGIC MONITORING PLAN
GROUNDWATER SAMPLE
DATA TAKEN FOR FOURTH QUARTER 1990
(Samples Taken During Period 12/03/90 - 12/07/90)

| SITE NO. | SITE NAME* | WELL NO. | Elev. Top of WATER (Ft. Above S.L.) | Flow RATE (MGD) | TEMP. (C) | Sp. COND. (UMHOS) | PH (S.U.) | Sol. PO4 AS P4 (PPM) | Sol. F (PPM) | Sol. Pb (PPM) | Cr (PPM) | As (PPM) | Cn (PPB) | P4 (PPB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WELL WATER | | | | | | | | | | | | | | |
| 01 | ACTIVE PHOSPHORUS LANDFILL | 1-2A | 613.5 | - | 14 | 400 | 6.9 | 0.670 | 0.11 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 01 | ACTIVE PHOSPHORUS LANDFILL | 1-6 | WELL DRY | | | | | | | | | | | |
| 01 | ACTIVE PHOSPHORUS LANDFILL | 1-7 | WELL DRY | | | | | | | | | | | |
| 03 | CLOSED PHOSPHORUS BARREL DUMP | 3-EAST | 579.5 | - | 14 | 530 | 7.1 | 0.215 | 0.09 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 04 | PHOSPHORUS SLURRY DUMP | 4-5 | 647.9 | - | 15 | 1100 | 6.8 | < 0.025 | 1.09 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 04 | PHOSPHORUS SLURRY DUMP | 4-6 | 634.6 | - | 15 | 2700 | 6.5 | 88.700 | 0.40 | <0.003 | <0.010 | 0.030 | 6.0 | 0.013 |
| 04 | PHOSPHORUS SLURRY DUMP | 4-7 | WELL DRY | | | | | | | | | | | |
| 04 | PHOSPHORUS SLURRY DUMP | 4-8 | WELL DRY | | | | | | | | | | | |
| 05 | CLOSED SOLID/SANITARY WASTE DUMP | 5-15 | 539.3 | - | 15 | 680 | 6.6 | 0.302 | 0.33 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 05 | CLOSED SOLID/SANITARY WASTE DUMP | 5-16 | 538.5 | - | 15 | 810 | 6.8 | 0.279 | 1.45 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 06 | CLOSED TREATER OIL SITE | 6-2 | 595.9 | - | 17 | 1000 | 4.4 | 444.000 | 6.04 | <0.003 | <0.010 | <0.010 | 245.0 | 72.000 |
| 09 | PROCESS POND NO. 3 | 9-3 | 565.2 | - | 15 | 1600 | 6.0 | 0.442 | 0.50 | <0.003 | <0.010 | <0.010 | 6.0 | 0.002 |
| 09 | PROCESS POND NO. 3 | 9-4 | 586.1 | - | 16 | 4200 | 6.2 | 0.178 | 1.25 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 09 | PROCESS POND NO. 3 | 9-6 | 557.1 | - | 15 | 470 | 6.6 | 0.596 | 2.46 | <0.003 | <0.010 | <0.010 | 6.0 | 0.002 |
| 09 | PROCESS POND NO. 3 | 9-7 | 559.5 | - | 17 | 400 | 7.4 | - | - | - | - | - | - | - |
| 09 | PROCESS POND NO. 3 | 9-8 | 552.2 | - | 18 | 2000 | 7.3 | - | - | - | - | - | - | - |
| 10 | ACTIVE SANITARY LANDFILL | 10-1 | 595.6 | - | 14 | 460 | 6.6 | 0.676 | 0.51 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 10 | ACTIVE SANITARY LANDFILL | 10-2 | 596.0 | - | 15 | 300 | 6.2 | 0.461 | 0.46 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 10 | ACTIVE SANITARY LANDFILL | 10-3 | 564.6 | - | 15 | 350 | 6.6 | 0.198 | 0.39 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 12 | TANK FARM | 12-1 | 591.3 | - | 19 | 760 | 6.4 | 3.710 | 1.11 | <0.003 | <0.010 | <0.010 | 5.1 | 0.[illegible] |
| 12 | TANK FARM | 12-2 | 594.1 | - | 19 | 1400 | 6.4 | 30.400 | 0.91 | <0.003 | <0.010 | <0.010 | 3.8 | 750.[illegible] |
| 12 | TANK FARM | 12-4 | 587.2 | - | 20 | 1200 | 7.0 | 0.950 | 0.22 | <0.003 | <0.010 | <0.010 | < 5.0 | 79.[illegible] |
| 13 | NEW PHOSPHORUS LANDFILL | 13-1 | 561.5 | - | 15 | 550 | 7.3 | 0.179 | 0.10 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.013 |
| 13 | NEW PHOSPHORUS LANDFILL | 13-2 | 562.0 | - | 15 | 360 | 6.8 | 1.160 | 0.22 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 13 | NEW PHOSPHORUS LANDFILL | 13-3 | WELL DRY | | | | | | | | | | | |
| 13 | NEW PHOSPHORUS LANDFILL | 13-4 | 574.6 | - | 14 | 500 | 6.3 | 0.131 | 0.11 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 16 | CWS BUILDING | 16-DS2-1 | 587.2 | - | 16 | 620 | 6.4 | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-DS2-2 | 580.2 | - | 14 | 380 | 6.6 | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-DS2-3 | 543.2 | - | 14 | 4200 | 12.0 | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-DS2-4 | 572.7 | - | 16 | 370 | 6.4 | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-DS2-5 | 576.7 | - | 16 | 1100 | 6.4 | - | - | - | - | - | - | - |

NOTES: *(1) SAMPLES TAKEN AS SPECIFIED IN COLUMBIA PLANT HYDROLOGIC MONITORING PLAN DATED OCTOBER 1986 AND SUBMITTED TO STATE OF TENNESSEE ON 11/17/86.
*(2) DASH MARKS IN COLUMNS INDICATE DATA NOT REQUIRED BY HYDROLOGIC MONITORING PLAN.
*(3) < INDICATES LESS THAN DETECTION LIMIT.

MONSANTO COMPANY
COLUMBIA, TENNESSEE PLANT
HYDROLOGIC MONITORING PLAN
GROUNDWATER SAMPLE
DATA TAKEN FOR FOURTH QUARTER 1990
(Samples Taken During Period 12/03/90 - 12/07/90)

| SITE NO. | SITE NAME | WELL NO. | Elev. Top of WATER (Ft. Above S.L.) | Flow RATE (MGD) | TEMP. (C) | Sp. COND. (UMHOS) | PH (S.U.) | Sol. PO4 AS P4 (PPM) | Sol. F (PPM) | Sol. Pb (PPM) | Cr (PPM) | As (PPM) | Cn (PPB) | P4 (PPB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WELL WATER | | | | | | | | | | | | | | |
| 17 | FURNACE DEPARTMENT | 17-5 | 585.9 | - | 22 | 600 | 6.0 | 1.310 | 25.70 | <0.003 | <0.010 | <0.010 | 71.8 | 112.000 |
| 19 | FURNACE RAILROAD YARD | 19-1 | 568.4 | - | 18 | 360 | 6.8 | 0.054 | 9.52 | <0.003 | <0.010 | <0.010 | 8.0 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-3 | 570.0 | - | 19 | 580 | 7.0 | 0.071 | 12.70 | <0.003 | <0.010 | 0.020 | 47.0 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-4 | 563.5 | - | 18 | 2100 | 6.5 | 0.109 | 1.54 | <0.003 | <0.010 | <0.010 | 100.0 | 0.010 |
| 19 | FURNACE RAILROAD YARD | 19-5 | 567.8 | - | 18 | 380 | 7.2 | 0.109 | 10.60 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-7 | 568.0 | - | 18 | 520 | 7.2 | 0.403 | 5.97 | 0.011 | <0.010 | <0.010 | 6.0 | 0.004 |
| 20 | MILLION GALLON TANK | 20-8 | 602.9 | - | 12 | 280 | 6.6 | 125.000 | 20.10 | <0.003 | <0.010 | 0.060 | < 5.0 | 3.350 |
| SURFACE WATER | | | | | | | | | | | | | | |
| POINT 1 | GREG'S SPRING | P1 | - | 0.031 | 7 | 360 | 8.4 | 13.900 | 0.78 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 2 | GIN CREEK | P2 | - | 1.389 | 7 | 660 | 7.6 | 0.589 | 0.49 | 0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 3 | UPPER GREENLICK CREEK | P3 | - | 17.443 | 8 | 360 | 7.4 | 0.333 | 0.24 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 4A | SOUTH NO. 13 BASIN | P4A | - | - | 8 | 360 | 7.1 | 0.310 | 0.54 | 0.004 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 4B | MIDDLE NO. 13 BASIN | P4B | - | - | 8 | 380 | 7.4 | 0.305 | 1.05 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 4C | NORTH NO. 13 BASIN | P4C | - | - | 8 | 360 | 7.8 | 0.311 | 1.27 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 5 | GREENLICK CREEK | P5 | - | 24.681 | 8 | 390 | 6.0 | 0.306 | 0.58 | <0.003 | <0.010 | <0.010 | 6.7 | 0.002 |

NOTES: (1) SAMPLES TAKEN AS SPECIFIED IN COLUMBIA PLANT HYDROLOGIC MONITORING PLAN DATED OCTOBER 1986 AND SUBMITTED TO STATE OF TENNESSEE ON 11/25/86.
(2) DASH MARKS IN COLUMNS INDICATE DATA NOT REQUIRED BY HYDROLOGIC MONITORING PLAN.
(3) < INDICATES LESS THAN DETECTION LIMIT.

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

REFERENCE 19

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Flow rate of Duck River

BVWST Project 52012.081
BVWST File
October 22, 1992
2:45 p.m.

To: Lori Mercer
Company: U.S. Geological Survey - Tennessee
Phone No.: (615) 736-5424

Recorded by: Kenneth Lemons

The annual mean flow rate of the Duck River is 2091 cfs at river mile marker 132.8. This is averaged over the period 1977 - 1991. The 7Q10 is 116 cfs, determined over the same 1977 - 1991 period.

U.S. EPA REGION IV

# SDMS

## Unscannable Material Target Sheet

DocID: 10707665 Site ID: TND004048104

Site Name: Monsanto Co. Inc.

Nature of Material:

| | | | |
|---|---|---|---|
| Map: | ☒ | Computer Disks: | ☐ |
| Photos: | ☐ | CD-ROM: | ☐ |
| Blueprints: | ☐ | Oversized Report: | ☐ |
| Slides: | ☐ | Log Book: | ☐ |

Other (describe): Environmental Geology Atlas (Ref. 20)

Amount of material: _____

* Please contact the appropriate Records Center to view the material *

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Monsanto water system.

BVWST Project 52012.081
BVWST File
October 5, 1992
1:50 p.m.

To: G.O. Clark
Company: Monsanto Company
Phone No.: (615) 380-9329

Recorded by: Kenneth Lemons

Monsanto has its own water system. It serves potable water to 35 employees and any guests on-site. Monsanto has its own system because there was not a system available when they first got here. Their intake is on Greenlick Creek, one-half mile upstream from where it says pumping station on the topo. For more information, call Sid Richey at (615) 380-9316.

REFERENCE 22

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Fishing on Duck River

BVWST Project 52012.081
BVWST File
October 22, 1992
11:05 a.m.

To: Doug Pelgrin
Company: Tennessee Wildlife Resources Agency
Phone No.: (615) 781-6622

Recorded by: Kenneth Lemons

Miles 108 to 123 on the Duck River are just downstream of Monsanto. There has been trouble with the release of phossy water causing fish kills in Greenlick Creek when Monsanto was open. It never affected the Duck River, though. Doug Pelgrin stocks that area of the Duck River with several varieties of game fish. Fishing in that area is moderate.

U.S. EPA REGION IV

# SDMS

## Unscannable Material Target Sheet

DocID: 10707665 Site ID: TND004048104

Site Name: Monsanto Co. Inc.

Nature of Material:

| | | | |
|---|---|---|---|
| Map: | ☑ | Computer Disks: | ☐ |
| Photos: | ☐ | CD-ROM: | ☐ |
| Blueprints: | ☐ | Oversized Report: | ☐ |
| Slides: | ☐ | Log Book: | ☐ |

Other (describe): Wetlands Inventory (Ref. 23)

Amount of material: _____

* Please contact the appropriate Records Center to view the material *

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

REFERENCE 24

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Endangered species in Maury County

BVWST Project 52012.081
BVWST File
September 15, 1992
12:00 p.m.

To: Steve Carter
Company: Tennessee Fish and Wildlife
Phone No.: (615) 528-6481

Recorded by: Kenneth Lemons

County-Wide Endangered Species for Maury County

Gray Bat
Indiana Bat
Birdwing Pearly Mussel
Cumberland Monkeyface Pearly Mussel
Yellow-Blossom Pearly Mussel
Turgid-Blossom Pearly Mussel
Tan Riffle Shell
Orange-Footed Pearly Mussel
Pale Lilliput Pearly Mussel
Leafy Prairie Clover

County-Wide Status Review Species for Maury County

Eastern Wood Rat
Copper Cheek Darter
Hellbinder
Ornate Rock Snail
Helmet Rock Snail
Rugnose Rock Snail
Muddy Rock Snail
Onyx Rock Snail
Pasture Glade Cress
Tennessee Glade Cress
Short's Blatterpod
Tennessee Milk Vetch
Gattinger's Lovelia
Water Stitchwort
Limestone Flameflower
Eggert's Sunflower

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

**REFERENCE 25**

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Wetlands, endangered species, and
recreation on the Duck River.

BVWST Project 52012.081
BVWST File
October 6, 1992
11:15 p.m.

To: Jim Widlak
Company: Tennessee Fish and Wildlife
Phone No.: (615) 528-6481

Recorded by: Kenneth Lemons

There are no endangered species along the Duck River between mile markers 123 and 108. The endangered species in the county are upstream from Columbia.

There are several areas of wetlands along the Duck River. Look at the wetlands maps at U.S. EPA. There is probably a lot of fishing on the Duck River in that area; call the Tennessee Wildlife Resources Agency to find out.

B&V WASTE SCIENCE AND TECHNOLOGY CORP.

REFERENCE 26

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company, Inc.
Physical conditions at the Monsanto site.

BVWST Project 52012.081
BVWST File
October 21, 1992
8:50 a.m.

To: Sid Richey
Company: Monsanto Company
Phone No.: (615) 380-9316

Recorded by: Kenneth Lemons

The site is 5300 acres. Most of the area has been strip mined since 1937, but has not been used for a long time. It now forms a green belt around the industrial area and is covered in vines, grass, and trees. The area is used for bird watching and is overrun with deer and other animals. The industrial area is the smaller area where the buildings are, and it is fenced in and closed to the public.

The manufacturing of phosphorus was stopped at this site in 1986, but the area is still used for repackaging phosphorus from tanks to barrels. The wastewater treatment plant is also still in operation.

TELEPHONE MEMORANDUM

U.S. EPA
Monsanto Company
NPDES limits on Cyanide

BVWST Project 52012.081
BVWST File
November 16, 1992
3:36 p.m.

To: Van Medlock
Company: Tennessee Water Pollution Control
Phone No.: (615) 741-7391

Recorded by: Ken Lemons

Monsanto's NPDES discharge limit for cyanide is 0.1 mg/L for their outfalls in the Duck River. They have no cyanide limit for discharges to Greenlick Creek.

REFERENCE 28

# Monsanto

Monsanto Chemical Company
Columbia, Tennessee 38401
Phone: (615) 388-3431

August 3, 1992

CERTIFIED MAIL

RETURN RECEIPT REQUESTED

NASHVILLE ENVIRONMENTAL
RECEIVED
AUG 7 1992
TENNESSEE DEPARTMENT

Mr. Rick Sinclair, Director
Superfund Division
Department of Health and Environment
Doctors Building, Second Floor
706 Church Street
Nashville, TN 37243-1538

Dear Mr. Sinclair:

Attached are the second quarter 1992 groundwater sampling results as required by the Monsanto Company, Columbia, Tennessee Plant Hydrologic Monitoring Plan.

If you have questions or need further information, please contact me by telephone at 615-380-9316.

Sincerely,

William S. Richey
Environmental Superintendent

/st

Attachment

MONSANTO COMPANY
COLUMBIA, TENNESSEE PLANT
HYDROLOGIC MONITORING PLAN
GROUNDWATER SAMPLE
DATA TAKEN FOR SECOND QUARTER 1992
(Samples Taken During Period 06/01/92 - 06/05/92)

| SITE NO. | SITE NAME | WELL NO. | Elev. Top of WATER (Ft. Above S.L.) | Flow RATE (MGD) | TEMP. (C) | Sp. COND. (UMHOS) | PH (S.U.) | Sol. PO4 AS P4 (PPM) | Sol. F (PPM) | Sol. Pb (PPM) | Cr (PPM) | As (PPM) | Cn (PPB) | P4 (PPB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WELL WATER | | | | | | | | | | | | | | |
| 01 | ACTIVE PHOSPHORUS LANDFILL | 1-2A | 611.7 | - | 16 | 500 | 6.6 | 0.320 | 0.07 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 01 | ACTIVE PHOSPHORUS LANDFILL | 1-6 | WELL DRY | | | | | | | | | | | |
| 01 | ACTIVE PHOSPHORUS LANDFILL | 1-7 | WELL DRY | | | | | | | | | | | |
| 03 | CLOSED PHOSPHORUS BARREL DUMP | 3-EAST | 581.7 | - | 15 | 730 | 6.6 | 0.200 | 0.07 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 04 | PHOSPHORUS SLURRY DUMP | 4-5 | 647.7 | - | 18 | 1000 | 6.2 | < 0.025 | 1.57 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 04 | PHOSPHORUS SLURRY DUMP | 4-6 | 635.6 | - | 17 | 1400 | 6.6 | 38.900 | 0.17 | 0.003 | <0.010 | 0.042 | < 5.0 | 0.004 |
| 04 | PHOSPHORUS SLURRY DUMP | 4-7 | WELL DRY | | | | | | | | | | | |
| 04 | PHOSPHORUS SLURRY DUMP | 4-8 | WELL DRY | | | | | | | | | | | |
| 05 | CLOSED SOLID/SANITARY WASTE DUMP | 5-15 | 537.2 | - | 17 | 800 | 6.4 | 0.310 | 0.22 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 05 | CLOSED SOLID/SANITARY WASTE DUMP | 5-16 | 529.0 | - | 17 | 600 | 6.4 | 0.310 | 2.22 | 0.008 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 06 | CLOSED TREATER OIL SITE | 6-2 | 595.8 | - | 18 | 1000 | 4.0 | 459.000 | 9.57 | <0.003 | <0.010 | <0.010 | 134.0 | 144.000 |
| 09 | PROCESS POND NO. 3 | 9-3 | 568.0 | - | 20 | 1700 | 6.8 | 0.530 | 0.56 | <0.003 | <0.010 | <0.010 | 35.0 | 0.002 |
| 09 | PROCESS POND NO. 3 | 9-4 | 588.3 | - | 18 | 4000 | 6.0 | 0.190 | 0.95 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 09 | PROCESS POND NO. 3 | 9-6 | 555.2 | - | 15 | 680 | 6.8 | 0.420 | 3.71 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 09 | PROCESS POND NO. 3 | 9-7 | 559.6 | - | 17 | 410 | 7.0 | - | - | - | - | - | - | - |
| 09 | PROCESS POND NO. 3 | 9-8 | 552.7 | - | 19 | 2100 | 7.0 | - | - | - | - | - | - | - |
| 10 | ACTIVE SANITARY LANDFILL | 10-1 | 595.8 | - | 15 | 460 | 6.0 | 0.500 | 0.34 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 10 | ACTIVE SANITARY LANDFILL | 10-2 | 596.5 | - | 15 | 500 | 6.0 | 0.330 | 0.58 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 10 | ACTIVE SANITARY LANDFILL | 10-3 | 565.3 | - | 16 | 360 | 6.6 | 0.240 | 0.58 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 12 | TANK FARM | 12-1 | 591.1 | - | 19 | 3200 | 6.5 | 1.270 | 1.20 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.047 |
| 12 | TANK FARM | 12-2 | 592.6 | - | 19 | 1900 | 6.5 | 11.600 | 0.07 | <0.003 | <0.010 | <0.010 | < 5.0 | 450.000 |
| 12 | TANK FARM | 12-4 | 582.2 | - | 20 | 1500 | 6.6 | 12.000 | 0.05 | <0.003 | <0.010 | <0.010 | 6.9 | 219.000 |
| 13 | NEW PHOSPHORUS LANDFILL | 13-1 | 561.5 | - | 18 | 540 | 6.4 | 0.190 | 0.09 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 13 | NEW PHOSPHORUS LANDFILL | 13-2 | 572.2 | - | 18 | 370 | 6.0 | 0.890 | 0.21 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 13 | NEW PHOSPHORUS LANDFILL | 13-3 | WELL DRY | | | | | | | | | | | |
| 13 | NEW PHOSPHORUS LANDFILL | 13-4 | 575.3 | - | 16 | 650 | 6.4 | 0.160 | 0.10 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 16 | CWS BUILDING | 16-OB2-1 | 587.8 | - | | | | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-OB2-2 | 574.5 | - | | | | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-OB2-3 | 546.8 | - | | | | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-OB2-4 | 573.3 | - | | | | - | - | - | - | - | - | - |
| 16 | CWS BUILDING | 16-OB2-5 | 587.6 | - | | | | - | - | - | - | - | - | - |

NOTES: (1) SAMPLES TAKEN AS SPECIFIED IN COLUMBIA PLANT HYDROLOGIC MONITORING PLAN DATED OCTOBER 1986 AND SUBMITTED TO STATE OF TENNESSEE ON 11/25/86.
(2) DASH MARKS IN COLUMNS INDICATE DATA NOT REQUIRED BY HYDROLOGIC MONITORING PLAN.
(3) < INDICATES LESS THAN DETECTION LIMIT.

MONSANTO COMPANY
COLUMBIA, TENNESSEE PLANT
HYDROLOGIC MONITORING PLAN
GROUNDWATER SAMPLE
DATA TAKEN FOR SECOND QUARTER 1992
(Samples Taken During Period 06/01/92 - 06/05/92)

| SITE NO. | SITE NAME | WELL NO. | Elev. Top of WATER (Ft. Above S.L.) | Flow RATE (MGD) | TEMP. (C) | Sp. COND. (UMHOS) | PH (S.U.) | Sol. PO4 AS P4 (PPM) | Sol. F (PPM) | Sol. Pb (PPM) | Cr (PPM) | As (PPM) | CN Cn (PPB) | P4 (PPB) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | ≤ 4.0 | .003 | .01 | .19 | 5.2 | 0.1 |
| WELL WATER | | | | | | | | | | | | | | |
| 17 | FURNACE DEPARTMENT | 17-5 | 586.5 | - | 18 | 3800 | 6.5 | 7.290 | 26.20 | <0.003 | <0.010 | <0.010 | < 5.0 | 680.000 |
| 19 | FURNACE RAILROAD YARD | 19-1 | 568.7 | - | 18 | 440 | 7.0 | 0.040 | 13.20 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-3 | 569.3 | - | 18 | 640 | 8.6 | 0.100 | 16.70 | <0.003 | <0.010 | 0.023 | 28.6 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-4 | 565.2 | - | 20 | 2300 | 6.5 | 0.080 | 2.28 | <0.003 | <0.010 | <0.010 | 31.2 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-5 | 565.6 | - | 18 | 480 | 7.4 | 0.180 | 6.11 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| 19 | FURNACE RAILROAD YARD | 19-7 | 565.7 | - | 19 | 1500 | 6.6 | 0.340 | 5.28 | <0.003 | <0.010 | <0.010 | 8.2 | 0.002 |
| 20 | MILLION GALLON TANK | 20-8 | 610.5 | - | 17 | 3000 | 6.2 | 10.600 | 17.40 | <0.003 | <0.010 | 0.048 | 13.1 | 1.490 |
| SURFACE WATER | | | | | | | | | | | | | | |
| POINT 1 | GREG'S SPRING | P1 | - | 0.031 | 15 | 410 | 7.1 | 7.320 | 0.60 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 2 | GIN CREEK | P2 | - | 0.898 | 18 | 500 | 7.0 | 0.530 | 0.54 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 3 | UPPER GREENLICK CREEK | P3 | - | 6.010 | 17 | 400 | 7.2 | 0.270 | 0.31 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.026 |
| POINT 4A | SOUTH NO. 13 BASIN | P4A | - | - | 20 | 400 | 7.1 | 0.240 | 0.91 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 4B | MIDDLE NO. 13 BASIN | P4B | - | - | 21 | 400 | 7.2 | 0.250 | 1.35 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 4C | NORTH NO. 13 BASIN | P4C | - | - | 19 | 350 | 7.2 | 0.240 | 1.50 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |
| POINT 5 | GREENLICK CREEK | P5 | - | 10.011 | 19 | 410 | 7.2 | 0.280 | 0.96 | <0.003 | <0.010 | <0.010 | < 5.0 | 0.002 |

NOTES: (1) SAMPLES TAKEN AS SPECIFIED IN COLUMBIA PLANT HYDROLOGIC MONITORING PLAN DATED OCTOBER 1986 AND SUBMITTED TO STATE OF TENNESSEE ON 11/25/86.
(2) DASH MARKS IN COLUMNS INDICATE DATA NOT REQUIRED BY HYDROLOGIC MONITORING PLAN.
(3) < INDICATES LESS THAN DETECTION LIMIT.